LARRY FLAY

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ROYAL CANADIAN AIR FORCE

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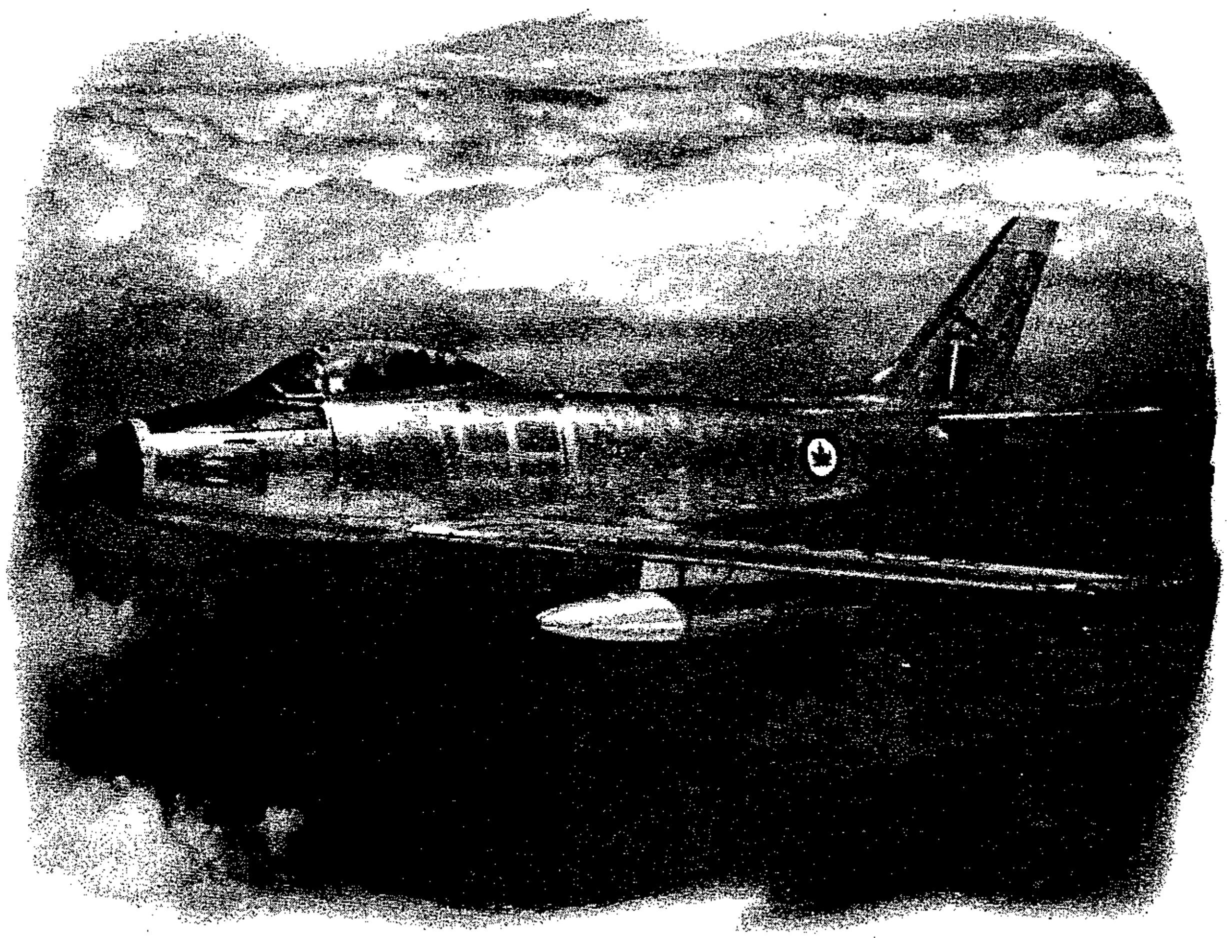
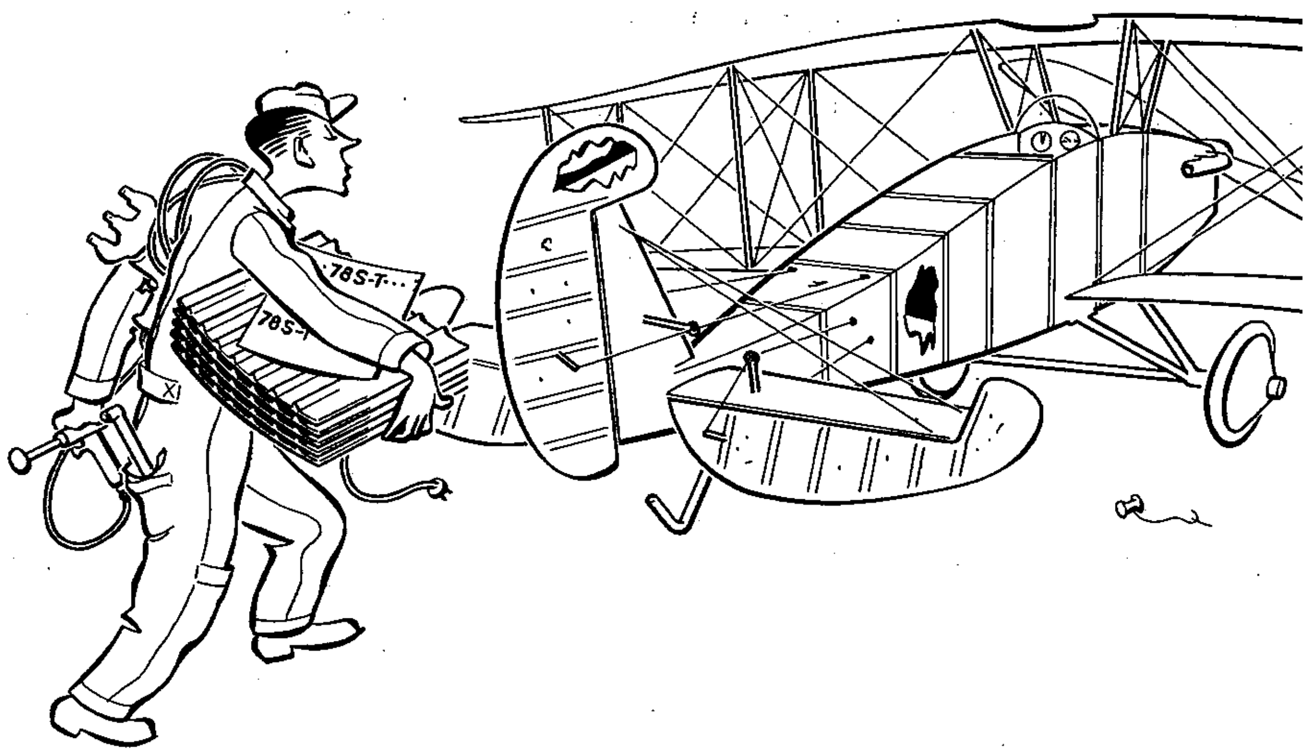
FOREWORD



PART 1

FOREWORD

The purpose of this manual is to assist RCAF personnel engaged in the maintenance and repair of RCAF aircraft. It provides information on materials, equipment, techniques and processes, and is to be used when specific repair schemes or Engineering Orders are not available. The manual will assist in retaining field engineering at a high level and enlarge the airmans knowledge of his work.



NOTE

The instructions in this manual shall be considered as general and applicable, except as otherwise specified in the Engineering Orders for the specific aircraft. In cases of conflict between this manual and Engineering Orders for the specific aircraft, such Engineering Orders will govern in all cases.

Personnel using this manual are to familiarize themselves with the following publications:

EO 00-1-5 - Index of Approved Specifications used by the RCAF

EO 00-25 - Series - Safety Publications

EO 00-35-1 - Shelf Life of RCAF Equipment and Related Materials

EO 00-50-1 - Mobile Repair Parties and Fly-in Repairs

EO 00-50-3 - Station Inspection Services

EO 05-1-2A - Hydraulic Systems - Precautionary Measures

EO 05-1-2B - Lubrication Instructions and Precautions

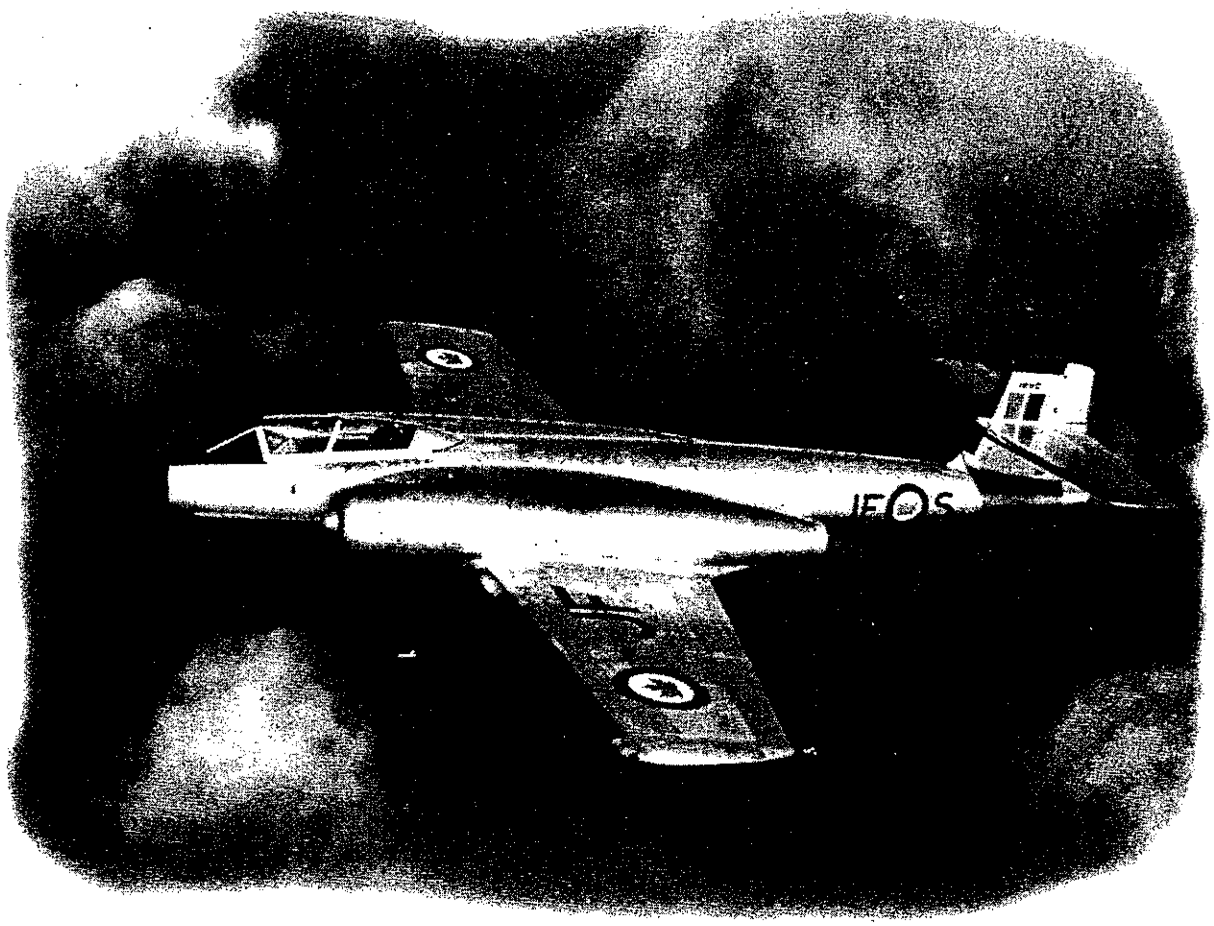
EO 05-1-2AK - Care and Assembly of Structural Members

EO 05-1-2U - Ground to Earth Conductivity for RCAF Aircraft

Unless otherwise stated, all dimensions are in inches.

PART 2

DESCRIPTION OF MAIN ELEMENTS OF AIRCRAFT STRUCTURE



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DESCRIPTION OF MAIN ELEMENTS OF AIRCRAFT STRUCTURE

DESCRIPTION OF MAIN ELEMENTS OF AIRCRAFT STRUCTURE

General

1 The main structural parts of an aircraft are fuselage, wings, empennage and undercarriage.

Fuselage Structure

2 Fuselages of most military aircraft are of all-metal construction, assembled in a modification of the monocoque design which relies largely on the strength of the skin or shell (covering) to carry the various loads. This design may be divided into three classes; monocoque, semi-monocoque, and reinforced shell. Different portions of the same fuselage may belong to any of these classes.

3 The monocoque has, as its only reinforcement, vertical rings, station frames and bulkheads. The semi-monocoque, in addition to these, has the skin reinforced by longitudinal members, that is, stringers and longerons, but has no diagonal web members. The reinforced shell has the skin reinforced by a complete framework of structural members. The cross-sectional shape is derived from bulkhead and station frames and longitudinal contour is developed with longerons and stringers.

4 The skin, which is fastened to all these members, carries, primarily, the shear load, and, together with the longitudinal members, the loads of tension and bending stresses. Station frames are built-up assemblies located at intervals to carry concentrated loads, and at points where fittings are used to attach external parts such as wings, landing gear and engine mounts. Longerons and stringers may be single pieces or built-up sections.

5 The metal in general use for aircraft construction is aluminum alloy, principally one or the other of the two alloys commercially known as 24S and 75S. These are about three times lighter than steel and, after being heat-treated, have a strength approximately equal to that of mild steel. For some uses, generally surface covering, this alloy is made in sheets with a thin covering of pure aluminum on both sides. In this form it is commonly known by the trade name Alclad. The pure aluminum serves as a protective coating to the base metal. Extrusions, widely used for stringers, are usually of the same alloy as the skin.

Wing Structure

6 Wings are usually all-metal stressed-skin construction, of cantilever design. The most frequent arrangement has two main spars with ribs placed at frequent intervals to form the wing contour and space the spars.

7 On aircraft of low wing loading, the wing covering merely transfers the applied air loads to the ribs and thence to the spars. The spars resist the main bending load resulting from the lift of the wings and the weight of the fuselage. The spars and ribs form a torque box to resist the various complex loads on a wing in flight and landing.

8 On aircraft with higher wing loading, the skin itself must resist much of the primary load. In order to do this without local deflection, it is stiffened most frequently with spanwise stringers of extruded or formed section. Corrugated sheet fastened to the outer skin may also be used. This concept is further developed in wings of double skin with corrugated sheet or continuous hat-section stringers between the skins.

9 Some recent aircraft wing skins are integral; that is, the wing skin is first extruded as a heavy slab and the space between the stringers is then milled out. These skins are well suited to resisting compression loads without wrinkling.

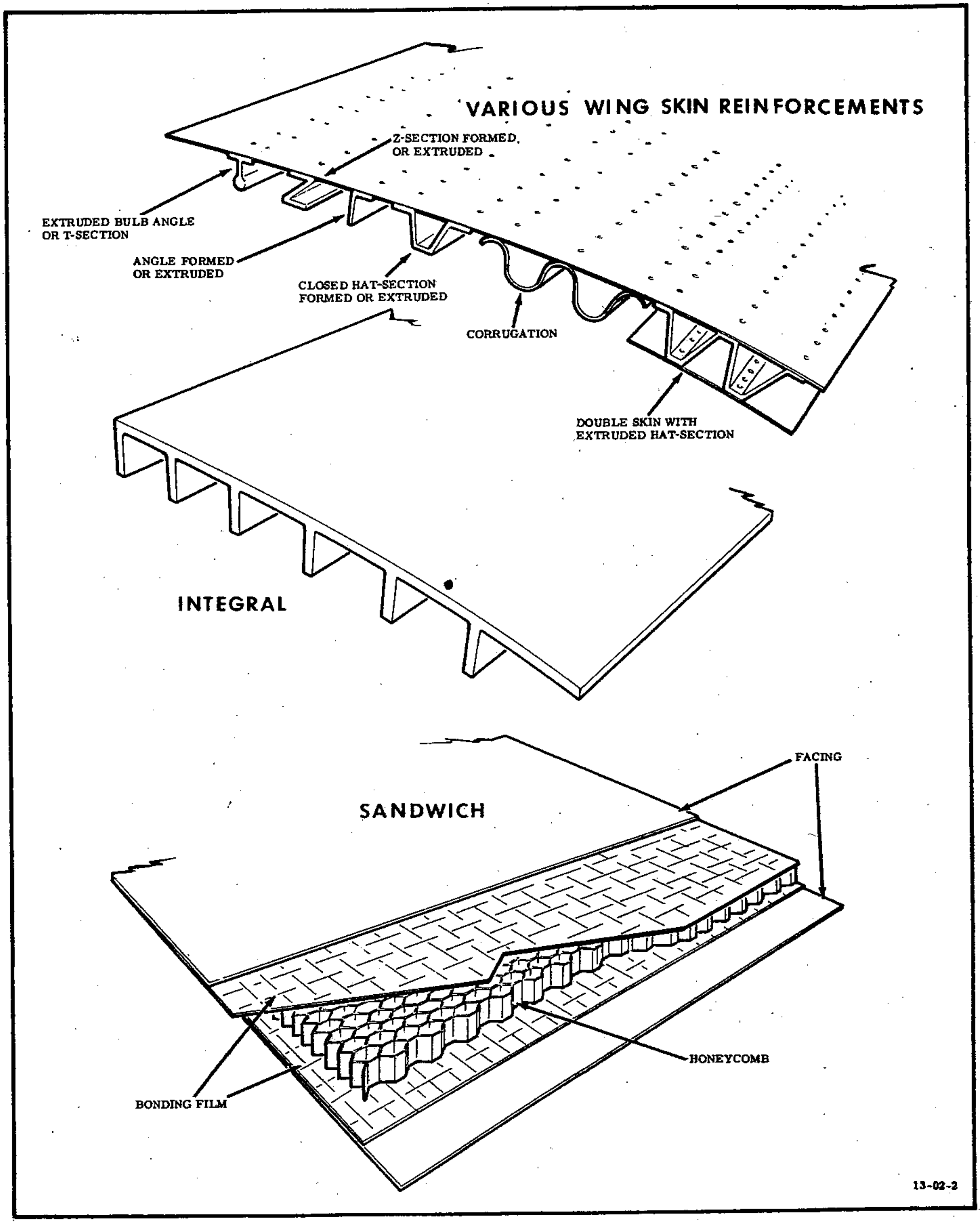

Figure 2-1 Typical Wing Skin Reinforcements

10 Another development, used in various parts of the aircraft, is the sandwich construction. The original sandwich arrangement used in the deHavilland Mosquito consisted of a balsa core and a birch plywood facing. Arrangements on some recent aircraft consist of aluminum alloy facings bonded to a balsa core, aluminum alloy facings bonded to aluminum honeycomb core, and various other combinations of aluminum alloy and glass fibre, both facings and cores. The purpose is to achieve a skin of high strength to weight ratio, capable of resisting loads without local deflection. For examples of various types of skin stiffeners see Figure 2-1.

Engine Mounting

11 A piston engine is mounted on an engine mount of steel tubing, which in turn is attached at a firewall. On multi-engine aircraft, the firewall is usually fastened directly or indirectly to the front spar and the wing is reinforced with additional bracing between the front and rear spars. This is accomplished by employing heavy ribs, a tubular structure, a stressed skin nacelle or a combination of these. On single engine aircraft, the firewall similarly attaches to the longeron terminals, at which point the fuselage is reinforced by a heavy frame.

12 Jet engines are mounted in trunnions that project from castings, forgings or built-up sections. These trunnion supports are usually suspended between two heavy frames in the fuselage or nacelle. Single jet engine aircraft have split fuselages, the split usually being located just aft of the trunnion support. The longerons at this point terminate in pick-up fittings and are braced by heavy frames. The aft end of the fuselage is usually of steel, to withstand the elevated temperatures.

Empennage

13 The structure of the vertical stabilizer or fin, and of the horizontal stabilizer or tailplane, is usually similar to that of the wing. The control surfaces are frequently of monospar construction with ribs and stringers or intercostals. Covering on control surfaces

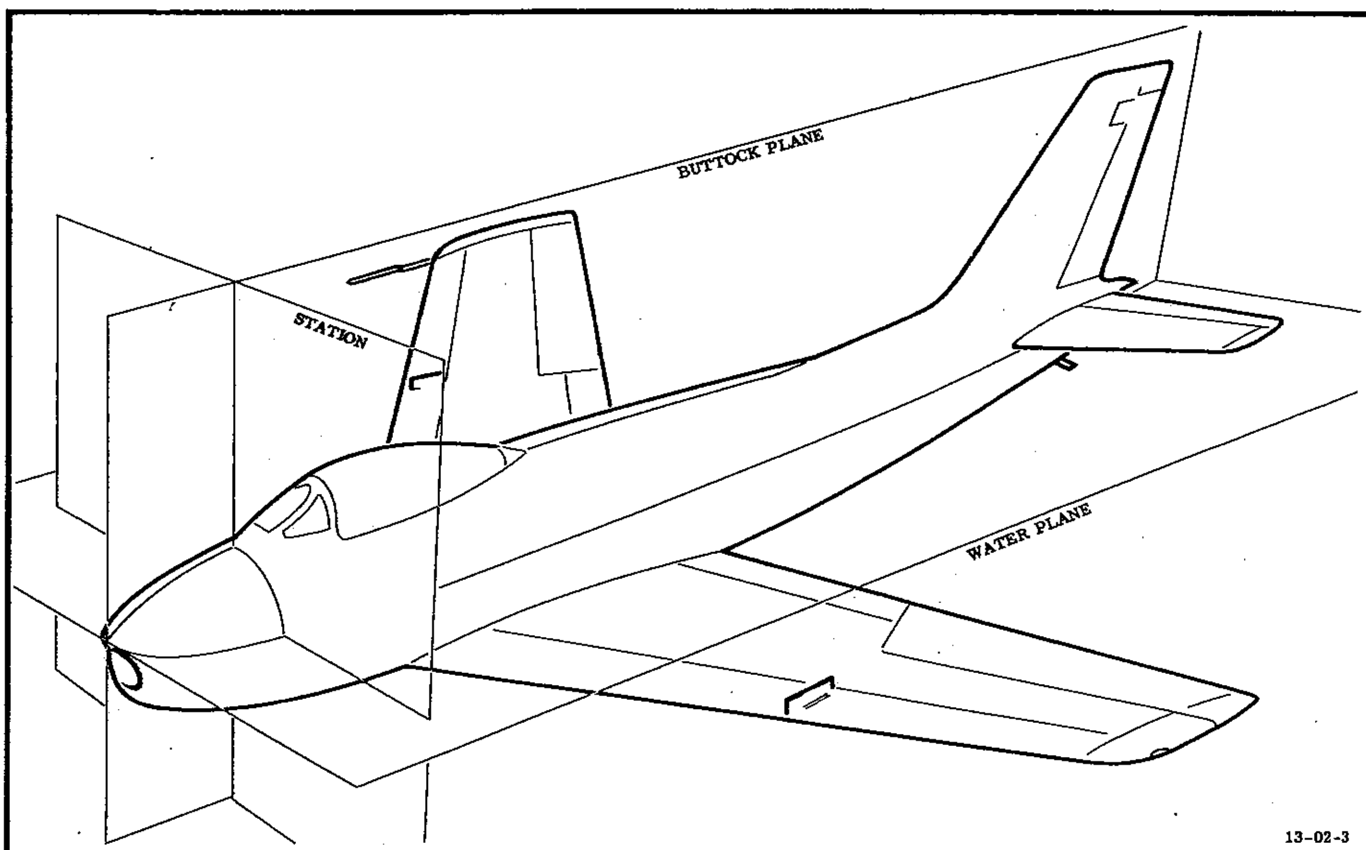

Figure 2-2 Aircraft Reference Planes

is fabric or light gauge alloy. Trailing edges on later aircraft are frequently extrusions of arrowhead section.

Undercarriage

14 The undercarriage consists mainly of shock struts, axles and wheels. The shock struts (oleo legs) and axles are usually steel forgings; the wheel castings of magnesium or aluminum alloys.

AIRCRAFT REFERENCE PLANES

General

15 The aircraft notation system of stations, buttock planes and water planes is derived from naval architecture. See Figure 2-2.

16 Stations are vertical planes normal (at right angles) to the fuselage fore and aft reference line. Thus, a firewall would lie in a station plane. Buttock planes are vertical planes parallel to the fuselage reference line. A cockpit wall would lie in a buttock plane. Water planes are horizontal planes parallel to the fuselage reference line. The cockpit floor would lie in a water plane. Buttock lines and water lines may be regarded as edge views of their respective planes.

17 Zero station is frequently at the nose of an aircraft, or at the firewall in a single engine aircraft. The location varies with different designs, sometimes being placed about midway along the fuselage reference line. Buttock plane 0 and water plane 0 usually occur at the fuselage reference line, so that the line of intersection of these two planes coincides with the fuselage reference line. Specific locations are named by their distances in inches and decimals of an inch from the 0 plane. Buttock planes and lines are marked left and right, and water planes and lines located below the 0 plane are usually indicated by the minus sign.

PART 3

METAL IDENTIFICATION

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METAL IDENTIFICATION

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METAL IDENTIFICATION

METAL RECOGNITION

General

1 Several simple tests have been designed for the identification of metals. These are the colour code, appearance, chip test, spark test, and gas-welding torch test. Other tests may be made to determine the various properties of the metal such as hardness, brittleness, elasticity, malleability and strength. The tests for these properties include hardness tests, tensile tests, compression tests, shear tests, bend tests and fatigue tests. When using data derived from such tests, it must be remembered that there is considerable variation in the mechanical characteristics of various samples of the same alloys, and that many alloys have similar characteristics. The identification methods following are those for which equipment required is available to the maintenance personnel.

Characteristic Colours

2 For the characteristic colours of common aircraft materials, see Figure 3-1.

Surface Appearance

3 Examining the outside unfinished surface of a metal is not always sufficient evidence to classify it, but does make it possible to classify the metal into a group, thereby limiting the additional tests needed for classification. The colour of the metal will put it into a class. This classification is further broken down by examining the surface. The outer surface of aluminum may show evidence of having been rolled or moulded. If it shows forging marks or the evidence of a mould, it is probably low-carbon or cast steel. If the outer surface shows rolling or forging marks, the metal may be high-carbon steel. Stainless steel in the unfinished state is only slightly rough. Wrought iron, copper, brass or bronze, monel metal, and nickel all have smooth outer unfinished surfaces. If colour and appearance are insufficient for identification, use further applicable tests.

Chip Test

4 Make the chip test by removing a small amount of material from the sample with a sharp cold chisel. The material removed will vary from small broken fragments to a continuous strip. The chip may have smooth sharp edges. It may be coarse-grained or fine grained. It may have sawlike edges where it has been cut.

5 The size of the chip and the ease of chipping is important in the identification of the sample, but this method is largely a result of practice. If possible, compare results with a known sample. The following information will aid in recognition of the more common materials:

(a) Aluminum and aluminum alloys: Chips are smooth, have saw edges, and can be continuous if desired.

(b) Monel metal: Chips have smooth edges, and can be continuous if desired. Chips easily.

(c) Nickel: The chips have smooth edges and can be continuous if desired. Chips easily.

(d) High-carbon steel: Chips show fine-grained fracture and can be continuous if desired. Chip edges are lighter in colour than those of low-carbon steel. The metal is hard but can be chipped.

(e) Low-carbon and cast steel: Chips have smooth edges and can be continuous if desired. Metal is easily cut or chipped.

(f) Malleable Iron: Chips are 1/4 to 3/8 inch long. Material is tough and hard to chip.

(g) Wrought iron: Chips have a smooth edge and can be continuous if desired. Metal is soft and easily cut or chipped.

(h) Copper: Chips are smooth, have saw edges where cut, and can be continuous where desired. Metal is easily cut.

(j) Brass and bronze: Chips are smooth and have saw edges. It is difficult to obtain a continuous chip. Brass and bronze are easily cut but more brittle than copper.

Spark Test

6 Make the spark test by holding a sample of the material against a power grinder. The sparks given off, or the lack of sparks, assist in identifying the metal. The length of the spark stream, colour and the type of sparks are the identification features.

7 There are four fundamental spark forms produced by holding a sample of metal against a power grinder, (see Figure 3-2). Shafts, bud, break and arrow are shown in Detail A. The arrow or spearhead is characteristic of steel alloyed with molybdenum. The swelling or buds in the spark line indicate nickel with molybdenum. Shafts and sprigs or sparklers, which indicate a high carbon content are shown in Detail B. Shafts, forks, and sprigs, which indicate a medium carbon content are shown in Detail C. Shafts and forks, which indicate a low carbon content are shown in Detail D.

8 To make the spark test, hold the piece of metal on the wheel in such a manner as to throw the spark stream about 12 inches in front of the viewer. Make several tests to obtain proper results. Do not press too hard, as the pressure will increase the temperature of the spark stream and the burst and will also give the appearance of a higher carbon content than that of the metal actually being tested. If possible, compare results with sparks obtained from a known sample.

Metals	Outside Appearance	Newly Fractured Surface	Freshly Filed Surface
Aluminum	Light grey	Fine crystalline	White
Monel metal	Dark grey	Light grey	Light grey
Nickel	Dark grey	Off white	Bright silvery white
High-carbon steel	Dark grey	Light grey	Bright silvery grey
Low-carbon and cast steel	Dark grey	Bright grey	Bright silvery grey
Malleable iron	Dull grey	Fine crystalline	Light silvery grey
Wrought iron	Light grey	Bright grey	Light silvery grey
Stainless steel	Dark grey	Medium grey	Bright silvery grey
Copper	Reddish brown	Bright red	Bright copper grey
Brass and bronze	Reddish yellow, yellow green, brown	Red to yellow	Reddish yellow to yellow white

Figure 3-1 Colour Code for Identification of Metals

Spark Test for Steels

9 Figure 3-3 shows sparks obtained from low-carbon and cast steel. Figure 3-4 shows sparks from high carbon steel. The spark stream is long (about 70 inches normally) and the volume is moderately large in low-carbon steel, while in high-carbon steel the stream is shorter (about 55 inches) and large in volume. The few sparklers which may occur at any place in low-carbon steel are forked, while in high-carbon steel the sparklers are small and repeating and some of the shafts may be forked. Both will produce a white spark stream.

10 Stainless steel, (see Figure 3-5), produces a spark stream approximately 50 inches in length, of moderate volume with few sparklers. The sparklers are forked. The stream next to the wheel is straw-coloured while at the end it is white.

Spark Test for Iron

11 Sparks produced from malleable iron are about 30 inches long, (see Figure 3-6), of moderate volume, with many small repeating

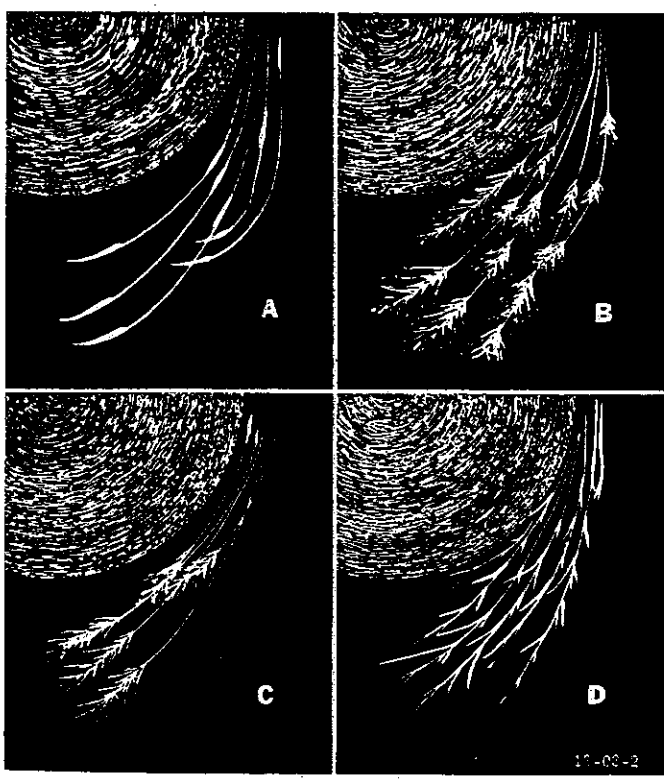


Figure 3-2 Fundamental Spark Forms

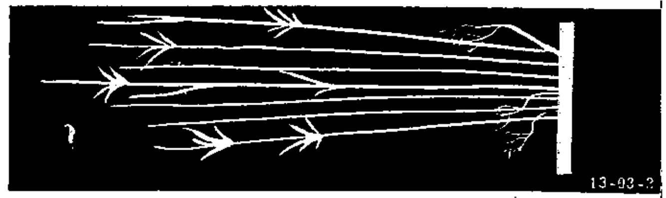


Figure 3-3
Sparks from Low-carbon and Cast Steel

Figure 3-4 Sparks from High-carbon Steel

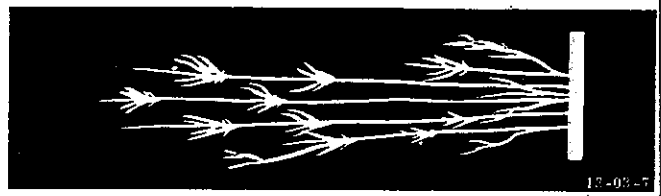


Figure 3-5 Sparks from Stainless Steel

Figure 3-6 Sparks from Malleable Iron

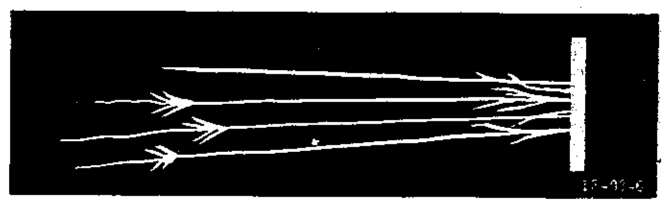


Figure 3-7 Sparks from Wrought Iron

Figure 3-8 Sparks from Nickel

sparklers toward the end of the stream. The entire stream is straw-coloured.

12 The wrought iron spark, (see Figure 3-7), produces a stream about 65 inches in length. The stream is of large volume with few sparklers, which show up toward the end of the stream and are forked. The stream next to the grinding wheel is straw-coloured, while the outer end of the stream is a bright red.

Spark Test for Non-ferrous Metals

13 Nickel, (see Figure 3-8), produces a spark stream only about 10 inches in length. It is small in volume and orange in colour. The sparks form wavy streaks with no sparklers.

14 Monel metal forms a spark stream almost identical to that of nickel and must be identified by other means.

15 Aluminum and its alloys, copper, brass, bronze, and lead form no sparks on the grinding wheel but are identifiable by other means such as colour, surface appearance and chip tests.

Welding Torch Test

16 The acetylene welding torch is used as an aid toward identification of metals by the rate of melting, the appearance of the molten metal and slag, as well as any colour changes which occur during heating. Experience with the torch is required for consistent results. Watch for the following indications:

(a) Aluminum and its alloys melt faster than steel, with no apparent change in colour. The stiff black scum which forms is usually quiet. The molten puddle is the same colour as the unheated metal and is fluid. The black scum forming on the surface tends to mix with the metal and is difficult to remove.

(b) Monel melts more slowly than steel and becomes red before melting. It flows clearly without any sparklers. The slag forms a grey scum in considerable amounts, is quiet and is hard to break up. The molten puddle is fluid under the slag and is quiet. A heavy black scale is formed on cooling.

(c) Nickel melts more slowly than steel and becomes red before melting. The slag, in the form of grey scum, is quiet and is hard to break up. The molten puddle is fluid under the slag.

(d) Stainless steel: The action under the flame varies with the alloy.

(e) High-carbon steel: The molten metal is brighter than in the case of low-carbon steel and the melting surface has a cellular appearance. It sparks more freely than mild steel and the sparks are whiter. It melts quickly under the torch and becomes bright red before melting. The slag is similar to the molten metal.

(f) Low-carbon and cast steel give off sparks when melted and solidify quickly (almost instantly). They melt quickly under the torch and become bright red before melting. The slag is similar to the molten metal. The molten puddle is liquid, straw-coloured, and gives off sparks.

(g) Malleable iron melts at a moderate rate under the torch and becomes red before melting. A medium film of slag develops which is tough but can be broken up. The molten puddle is fluid, watery and straw-coloured. It boils and leaves blowholes. The outside bright steel-like band gives off sparks, but not the centre.

(h) Wrought iron melts rapidly under the torch without sparking and becomes a bright red before melting. It has a peculiar slag coating, oily or greasy in appearance, with white lines. The molten puddle is liquid but not viscous, is straw-coloured and is usually quiet, although it may have a tendency to spark.

(j) Copper melts slowly under the flame and may turn black then red. The copper colour may become intense before melting. There is little slag. The molten puddle has a mirror-like surface directly under the flame and a tendency to bubble. On account of good heat-conducting properties, a larger flame is required to produce fusion of copper than would be needed for steel of the same size. Copper containing small amounts of other metal melts more easily and solidifies more slowly than pure copper.

(k) Brass and bronze melt quite rapidly under the flame and become noticeably red before melting. True brasses contain zinc, which gives off white fumes when the brass is melted. Bronze contains tin. Even a slight amount of tin makes the alloy flow freely like water. Because of a small amount of zinc which is usually present, bronze may fume slightly, but not as much as brass.

Residual Magnetism Test

17 Residual magnetism may be used as a guide to the type of material in question. When in the heat treated condition, low-carbon steels and alloys containing nickel or cobalt, will hold magnetism. High-carbon steel will not hold magnetism easily. Compare the strength of the magnetic pull, using a small compass or field indicator, with a known material. This method is also helpful in distinguishing between austenite stainless steel (300 series, non-magnetic) and martensite stainless steel, (400 series, magnetic).

File Hardness Test

18 The file test is a simple test for hardness of metals and is carried out as follows:

(a) Use a 10 inch bastard file. Hold the piece to be tested in a vise and file the surface of the piece to be tested slowly but firmly. As soon as the file cuts into the metal, remove it.

(b) If the material is cut by the file with extreme ease and tends to clog the surface of the file, it is very soft.

(c) If the material offers some resistance to the file and tends to clog the teeth, it is soft.

(d) If the material offers considerable resistance to the file, but can be filed with repeated effort, it is hard. This material may or may not have been heat treated.

(e) If the material can be removed by extreme effort, in small quantities, by the file, it is very hard and probably has been heat treated.

(f) If the file slides over the material and the file teeth are dulled, it is extremely hard and has been heat treated.

Other Hardness Tests

19 For information regarding other methods of hardness testing, refer to Part 4, following.

Tensile Test

20 Tensile tests are performed in the laboratory, using special equipment, to determine the strength of the metal in resisting forces which tend to pull it apart.

Bend Test

21 A simple bend test may be performed, using a known sample as a guide to determine elasticity. If the metal is bent back and forth until it breaks, the breaking is the result of fatigue or overload and may be used as an indication of identity.

Shear Test

22 Shear strength may be compared to that of a known sample by the ease with which the material may be cut with a pair of shears.

Distinguishing between 75S and 26S (14S) or 24S.

23 To differentiate between 75S and 26S (14S) or 24S aluminum alloy sheet, coil and extrusion, use the following procedure:

(a) Clean a small area, approximately 1 inch square, of the aluminum alloy to be tested.

(b) Abrade the cleaned area with new fine sandpaper or emery cloth.

(c) Place one drop of the cadium sulphate test solution, refer to Paragraph 24, following, on the abraded area and allow to stand for two minutes.

(d) A dark deposit indicates that the test material is 75S aluminum alloy. If the test solution remains colourless, the test material is not 75S aluminum alloy.

(e) Wipe off the test solution and any deposit thoroughly with a clean, dry cloth.

(f) Apply a few drops of 10% chromic acid solution to the tested area, and allow to react for a few minutes. Wipe off thoroughly with a clean, damp cloth.

(g) Test known samples of 26S (14S) and

24S and 75S aluminum alloy and compare with the results produced

NOTE

The cadmium sulphate test solution is extremely corrosive and any of the solution spilled on aircraft materials must be wiped off immediately.

24 Cadmium sulphate test solution is made up, when required, as follows:

Cadmium sulphate	5 gm.
Concentrated hydrochloric acid	5 ml.
Sodium chloride	3 gm.
Distilled water to make	100 ml.

Test for Heat-treatable and Non Heat-treatable Aluminum Alloys

25 All aluminum-base sheets are marked with the specification number or code marking

Steels	SAE No.	Background
Carbon	1000 series	Colours vary depending on carbon content.
	1300 series	Colours vary depending on carbon content.
Chrome nickel	3100 series	White.
	3200 series	Orange.
	3300 series	Black.
	3400 series	Brown.
Chromium	5100 series	Yellow.
	5200 series	Yellow.
Chromium vanadium	6100 series	Dark blue.
Molybdenum	4100 series	Green.
	4600 series	Green.
Nickel	2300 series	Natural and red.
	2500 series	Lead.
Screw stock	1100 series	Colours vary depending on carbon content.
Silico-manganese	9200 series	Light blue.
Staybolt		Brown.
Tungsten	7100 series	Tan.
	7200 series	Tan.

Figure 3-9 Table of Raw Material Background Colours

on approximately every square foot of material. If, for any reason, this identification is not on the material, it is possible to separate the heat-treatable alloys from the non heat-treatable alloys by immersing a sample of the material in a 10% solution of caustic soda (sodium hydroxide). The heat-treatable alloys will turn black due to the copper content, whereas the others will remain bright. This test applies to the alloys containing copper. In the case of Alclad, the surface will remain bright but there will be a dark area in the middle when viewed from the edge.

Strength Characteristics

26 For strength characteristics of various alloys, refer to Part 5, following.

Magnesium Recognition Tests

27 To differentiate between aluminum and magnesium alloys, use the following tests:

(a) Chip test: Magnesium may be chipped easily but the chips are crystalline in shape, not a continuous chip. Aluminum chips are usually continuous.

(b) Flash test: Magnesium filings will burn with an explosive flame at low temperature. Aluminum filings will not ignite.

(c) Appearance: Magnesium alloys are porous. Remove primer and paint coats, if necessary, to compare with a known material.

Carbon content	Colour
0.10-0.20	Red
0.15-0.25	Blue
0.20-0.30	Green
0.25-0.35	Lead
0.30-0.40	Orange
0.35-0.45	White
0.40-0.50	Brown
0.45-0.55	Black
0.45 and over	Yellow
Note: No stripes are used in 1000 and 1100 series.	

Figure 3-10
Table of Raw Material Stripe Colours

Titanium Recognition Tests

28 Titanium has a dull silver grey colour similar to that of stainless steel. Some titanium parts now in use are identified by an etched part number and the word TITANIUM on the part. The following tests may be made to determine if a material is made of titanium:

(a) Spark test: Titanium gives off white traces ending in brilliant white bursts.

(b) Water test: Titanium leaves grey-white marks when moistened with water and rubbed on glass.

Colour Markings

29 Colour markings on raw material provide an accurate means of identification. Background colour and colour of stripes used to denote the various steel alloys are shown in Figures 3-9 and 3-10. Width of stripe used is determined by the area available for colour marking. For sizes under 3/4 inch a small tag bearing the colour code for the material is attached. The colour code in the tables is the system adopted by the National Committee on Iron and Steel for the National Association of Purchasing Agents. This system has not been adopted by all suppliers and is given here for interest only.

DESIGNATION

General

30 Various societies and metal producers have devised codes for the determination of the material using numbers and letters. The most widely used are the SAE system for steels, and the Aluminum Company of America (ALCOA) for aluminum alloys.

STEEL

General

31 A numerical index system devised by the Society of Automotive Engineers (SAE) ident-

ifies the composition of SAE steels. Each SAE number consists of a group of digits. The first digit represents the type of steel. The second digit represents the percentage of the principal alloying element. The last two or three digits indicate the percentage in hundredths of one percent of carbon in the alloy.

SAE Code for Steels

32 The common SAE symbols used in the identification of steels are shown in Figure 3-11.

33 Examples of the application of SAE numbers are as follows:

(a) The SAE number 4150 indicates a molybdenum steel containing 1% molybdenum and 0.50% carbon.

(b) The SAE number 1010 denotes a carbon steel containing 0.10% carbon. The first 0 indicates the lack of a principal alloying element, and hence a plain carbon steel.

(c) The percentages indicated in the SAE number are average. For example, the carbon content of SAE 1050 steel may vary from 0.45% to 0.55% and is indicated as 0.50%.

Type of Steel	Classification
Carbon	1000 series
Nickel	2000 series
Nickel - chromium	3000 series
Molybdenum	4000 series
Chromium	5000 series
Chromium - vanadium	6000 series
Tungsten	7000 series
Silicon - manganese	9000 series

Figure 3-11 SAE Code for Steels

ALUMINUM ALLOYS

General

34 The aluminum alloys fall into several groups, each group being distinguished by one main alloying constituent. The wrought alloys are designated by numbers followed by the letter S (e.g. 17S) while the cast alloys are designated only by a number. Sometimes, when an alloy has been developed by modifying the composition of an existing alloy, it may be designated by the same number preceded by a letter, such as A17S or B195. Symbols are used following the alloy designation to describe the various tempers resulting from cold working, heat-treating or a combination or both.

Wrought Alloys

35 The symbols used for the various groups of wrought alloys are shown in Figure 3-12.

Heat-treatable Alloys

36 The heat-treatable alloys are those in which the mechanical properties may be im-

Alloy	Aluminum Co. of Canada	Aluminum Co. of America
99.5% - 99.69% Pure Aluminum Group	1S	1075
99.0% - 99.49% Commercial Pure Aluminum Group	2S	1100
Manganese Group	3S-9S	3000
Copper Group	10S-29S	2000
Silicon Group	30S-49S	4000
Magnesium and Magnesium Silicide Group	50S-69S	5000 &6000
Zinc Group	70S-79S	7000

Figure 3-12
Aluminum Company Code for Alloy Groups

proved by heat treatment. In contrast to the non heat-treatable alloys, the increased strength is obtained with little sacrifice of ductility. Heat-treatable alloys have the further advantage that they can be heat treated again after annealing to restore their original properties.

Non Heat-treatable Alloys

37 The non heat-treatable alloys contain elements that remain substantially in solid solution or form constituents that are insoluble. This group includes the high-purity alloys and the alloys 2S, 3S, 52S and 56S.

38 The five tempers, with symbols to describe them, used by Canadian mills are shown in Figure 3-13.

Canadian Temper Designations

39 There are eight tempers in which the heat-treatable alloys are supplied by the Canadian mills, but each alloy or product is not always supplied in all tempers. The symbols following the alloy numbers that are used to describe these tempers are shown in Figure 3-14.

American Temper Designations

40 For heat-treated materials supplied by American mills, the temper designations consist of the letter T followed by a number of from one to three digits. The basic designations are shown in Figure 3-15.

41 The first numeral following the letter T shows the type of treatment. The actual conditions will usually be different for different

Symbols	Description
O	Fully annealed
1/2H	One-half hard
3/4H	Three-quarters hard
H	Fully hard
F	As fabricated

Figure 3-13 Alcan Hardness Code

Symbols	Description
O	Fully annealed
W	Solution heat-treated
T	Solution heat-treated and aged
RW	Solution heat-treated and cold-worked
RT	Solution heat-treated, aged and cold-worked
F	As fabricated
Q	Quenched
A33	Quenched and aged

Figure 3-14 Canadian Temper Designations

Designations	Description
T2	Annealed-castings only
T3	Solution heat-treated and then cold-worked
T4	Solution heat-treated
T5	Artificially aged only
T6	Solution heat-treated and then artificially aged
T7	Solution heat-treated and then stabilized
T8	Solution heat-treated, cold-worked and then artificially aged
T9	Solution heat-treated, artificially aged and then cold-worked
T10	Artificially aged and then cold-worked

Figure 3-15 American Temper Designations

alloys and may be varied for a single alloy to produce certain desired results. In this case the tempers, other than the one usually considered standard or the first one used, are designated by a second numeral following the one which shows the type of heat-treatment. Here also there is no attempt to have this numeral indicate any specific set of conditions. Just as the actual temperatures and times required to produce 61S-T6 are different from those required for 18S-T6 or 19S-T6, so are those used for 61S-T61 different from those required for 18S-T61. The numeral 1 following the 6 merely designates properties different from those developed by the standard T-6 treatment for the respective alloys because there has been some modifications of the conditions but not of the type of treatment. The comparative designations for American and Canadian products, are shown in Figure 3-16.

Alcan Alloy	Type	Alcoa Alloy	
		Obsolete	Current
1S	Sheet, Tubing, Wire, Bar and Rod		
2S	Sheet, Wire, Bar and Rod	2S	1100
3S	Sheet	3S	3003
16S	Wire, Bar and Rod	A17S	2117
17S	Wire, Bar and Rod	17S	2017
18S	Wire, Bar and Rod	18S	2017
24S	Sheet, Extrusion, Tubing, Wire, Bar and Rod	24S	2024
24S Alclad	Sheet	24S Alclad	2024
26S	Extrusion, Wire, Rod, Bar and Forging	14S	2014
28S	Wire, Rod and Bar	11S	2011
50S	Extrusion, Tubing, Wire, Bar and Rod	63S	6063
55S	Wire, Rod and Bar	53S	6053
56S	Wire, Rod and Bar	56S	5056
57S	Sheet, Tubing, Wire, Bar and Rod	52S	5052
61S	Forgings	A51S	6151
65S	Sheet, Extrusion, Tubing, Wire, Bar and Rod	61S	6061
75S	Sheet, Extrusion, Wire, Bar, Rod and Forging	75S	7075
75S Alclad	Sheet	75S Alclad	7075
78S	Sheet	78S	7178
79S	Sheet	79S	7079

Figure 3-16 (Sheet 1 of 2) Aluminum Company Codes for Alloys

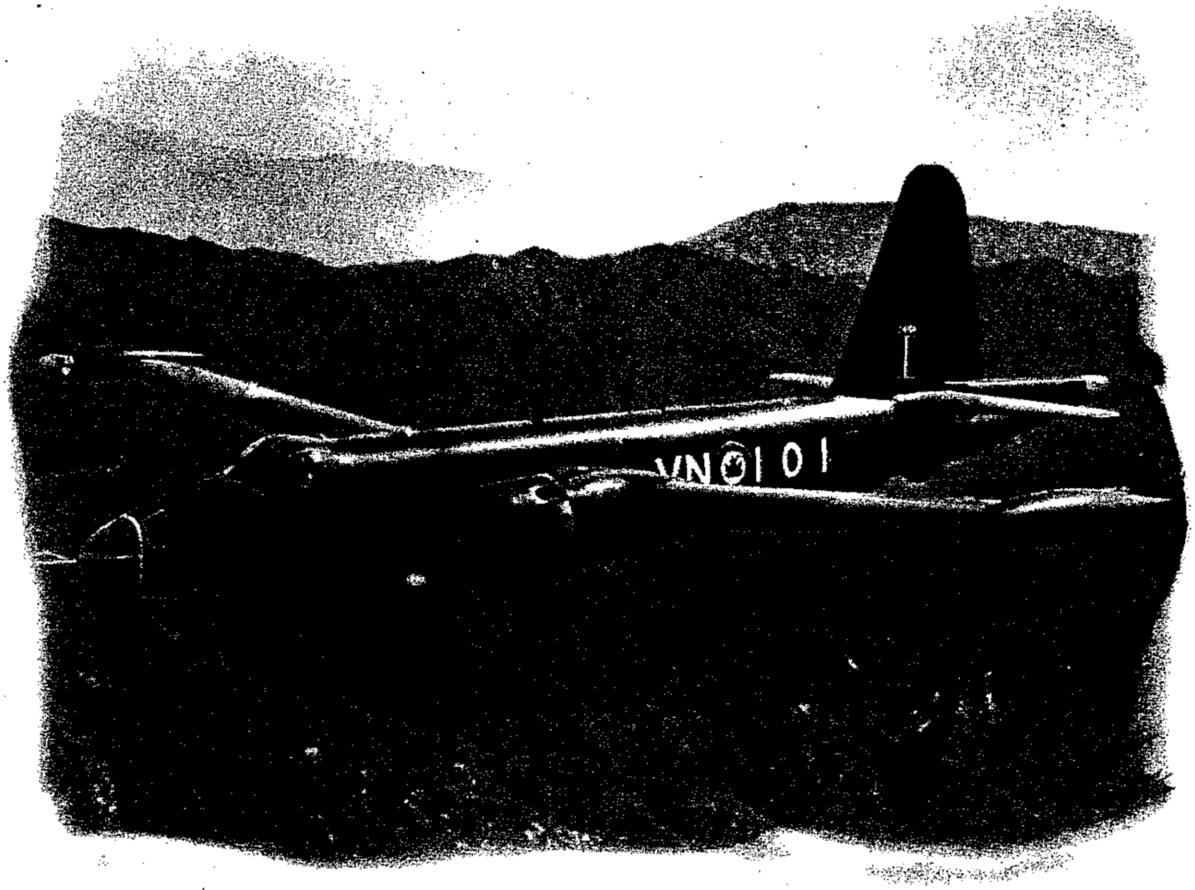
Alcan Alloy	Type	Alcoa Alloy	
		Obsolete	Current
A111	Casting Sand		
117	Casting Sand		
123	Casting Sand	43	
125	Casting Sand	355	
135	Casting Sand	356	
225	Casting Sand	195	
236	Casting Sand		
250	Casting Sand	122	
A320	Casting Sand		
350	Casting Sand	220	
117	Casting Permanent Mould		
123	Casting Permanent Mould		
125	Casting Permanent Mould	355	
135	Casting Permanent Mould	356	
162	Casting Permanent Mould	A132	
236	Casting Permanent Mould		
250	Casting Permanent Mould	122	
160X	Casting Die		
340	Casting Die		

The specifications listed above have similar chemical compositions; the mechanical property requirements may differ. For interchangeability and substitution listings reference is to be made to EO 105-1-3C.

Figure 3-16 (Sheet 2 of 2) Aluminum Company Codes for Alloys

PART 4

HEAT TREATMENT



PART 4

HEAT TREATMENT

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LIST OF ILLUSTRATIONS

PART 4

HEAT TREATMENT

HEAT TREATMENT

General

1 Heat treatment is a series of operations, involving the heating and cooling of a metal or alloy in the solid state, for the purpose of obtaining certain desirable characteristics. The rate of heating and cooling determines the crystalline structure of the material. Almost all metals have a critical temperature at which the grain structure changes. Successful heat treatment depends largely on a knowledge of these temperatures as well as the time required to produce the desired change.

2 Heat treatment involves a cycle of events which may be described as follows:

(a) Heating: Heating a metal to a temperature within or above its critical temperature under carefully controlled conditions.

(b) Soaking or Holding: Keeping a metal at an elevated temperature for a definite time, in order that it may become thoroughly saturated with heat and permit the necessary changes in grain structure to take place.

(c) Cooling: Returning a metal to room temperature by quenching in brine, water, oil or air, or by cooling slowly at controlled rates as in a furnace.

HEAT TREATMENT OF STEEL

General

3 The most common forms of heat treatment for ferrous metals are hardening, tempering, annealing, normalizing and case hardening. These are described in the following paragraphs.

Hardening

4 Heat treatment considerably transforms the grain structure of steel and it is while passing through a critical temperature range that steel acquires hardening power. In order to obtain a condition of maximum hardness, it is necessary to raise the temperature of the steel sufficiently high to allow the change of state to complete itself. This temperature is known as the upper critical point. Steel that has been heated to its upper critical point will harden completely if rapidly quenched but in practice it is necessary to exceed this temperature by approximately 50° to 100°F to ensure thorough heating of the inside of the piece. If the upper critical temperature is exceeded too much, an unsatisfactory grain size will be developed in the hardened steel.

5 Successful hardening of steel will largely depend upon the following factors:

(a) Control over the rate of heating, specifically to prevent cracking of thick and irregular sections.

(b) Thorough and uniform heating through of sections to the correct hardening temperature.

(c) Control of furnace atmosphere, in the case of certain steel parts, to prevent scaling and decarburization.

(d) Correct heat capacity, viscosity and temperature of quenching media to harden adequately and to avoid cracks.

Tempering

6 Steel that has been hardened by rapid cooling from a point slightly above its critical range is often harder than necessary and is generally too brittle for most purposes. In addition, it is under severe internal strain. In order to relieve the strains and reduce the brittleness, the metal is usually tempered. This is accomplished in the same types of furnaces as are use for hardening and annealing. However, less refined methods are sometimes used for tempering small tools.

7 As in hardening, tempering temperatures may be approximately determined by colour. These colours appear only on the surface and are due to a thin film of oxide which forms on the metal after the temperature reaches 450°F. In order to see the tempering colours, the surface must be brightened by buffing. When tempering by the colour method, an open flame or heated iron plate is ordinarily used as the heating medium. Although the colour method is convenient, it should not be used unless adequate facilities for determining temperature are unobtainable. Tempering temperatures and corresponding oxide colours are shown in Figure 4-1.

ANNEALING AND NORMALIZING

General

8 When steel is heated to a point above its critical range, a condition referred to as austenite is produced. If slowly cooled from above its critical temperature, the austenite is broken down and a succession of other conditions are produced, each being normal for a particular range of temperatures. Starting with austenite, these successive conditions are martensite, troostite, sorbite and finally pearlite.

Annealing

9 The most important step in annealing is to raise the temperature of the metal to the critical point, as any hardness that may have existed will then be completely removed. Strains which may have been set up through heat treatment will be eliminated when the steel is heated to the critical point and then restored to its lowest hardness by slow cooling. In annealing, the steel must never be heated more than approximately 50° to 75° F above the critical point, and when large articles are annealed, sufficient time must be allowed for the heat to penetrate the metal.

10 Steel is usually subjected to the annealing process for the following purposes.

(a) To increase its ductility by reducing hardness and brittleness.

(b) To refine the crystalline structure and remove stresses. Steel which has been cold worked is usually annealed to increase its ductility. However, a large amount of cold-drawn wire is used in its cold-worked state when very high yield point and tensile strength are desired and relatively low ductility is permissible, as in spring wires, piano wires, wires for ropes and cables. Heating to low temperatures, as in soldering, will destroy these properties unless done quickly.

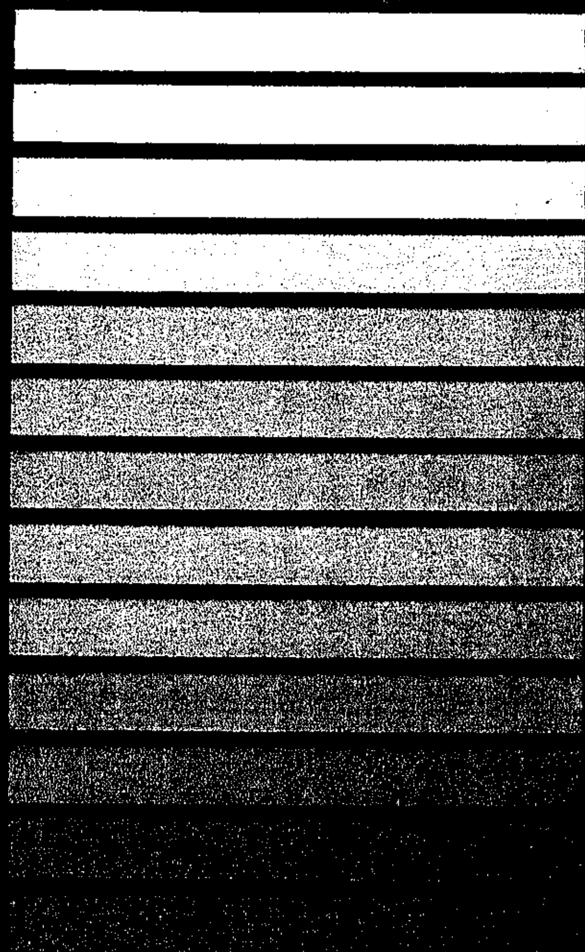
11 Assuming that the part to be annealed is heated to the proper temperature, the required slow cooling may be accomplished in several ways, depending on the metal and the degree of softness required. The common methods are packing and furnace cooling. Packing requires that the part be buried in some substance that does not conduct heat readily. For this purpose, a metal box containing slaked lime, ashes or powdered charcoal (Item 2) is satisfactory. Care must be taken to keep the material perfectly dry. In furnace cooling, the part is merely left to cool down with the furnace.

Normalizing

12 Normalizing, although involving a slightly different heat treatment, may be classed as a form of annealing. This process removes all strains due to machining, forging, bending and welding. Normalizing can only be accomplished with a furnace where the temperatures and the atmosphere may be closely regulated and held constant throughout the entire operation. A reducing atmosphere will normalize the metal with a minimum amount of oxide scale, while an oxidizing atmosphere will leave the metal heavily coated with scale, thus preventing proper development of hardness in any subsequent hardening operation. The articles are placed in the furnace and heated to a point above the critical temperature of the steel. After the parts have been held at this temperature for a sufficient time to allow the heat to penetrate to the centre of the section, they must be removed from the furnace and cooled in still air. Draughts will result in uneven cooling, which will again set up strains in the metal. Prolonged soaking of the metal at high temperatures must be avoided as this practice will cause the grain structure to enlarge. The length of time required for the soaking temperature will depend upon the mass of metal being treated.

Figure 4-1 Colour Chart

HEAT COLORS

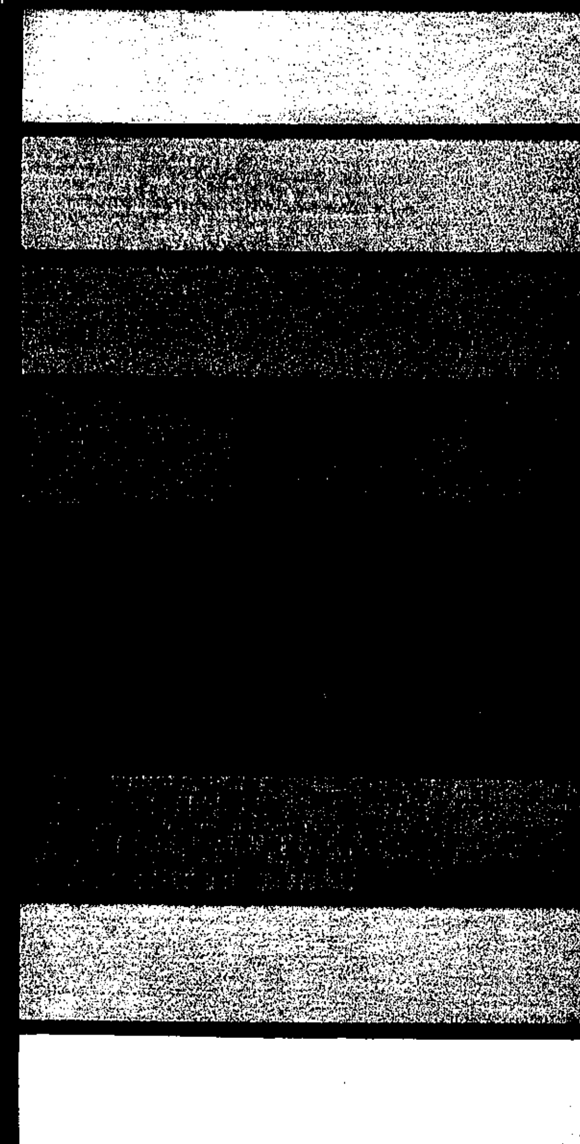


Degrees Fahrenheit	Degrees Centigrade
2500	1371
2400	1316
2300	1260
2200	1204
2100	1149
2000	1093
1900	1038
1800	982
1700	927
1600	871
1500	816
1400	760
1300	704
1200	649
1100	593
1000	538

The above heat colors are reproductions of colors observed on pieces of 31-40 steel as seen through peep holes in enclosed furnaces and during average daylight conditions.

BETHLEHEM STEEL COMPANY

TEMPER COLORS



Degrees Fahrenheit	Degrees Centigrade
700	371
660	349
620	327
580	304
540	282
500	260
460	238
420	216
380	193

The above temper colors were observed on tempering 0.95 per cent carbon steel at the temperatures indicated.

(1) Normalizing describes a metallurgical process and not a set mechanical of properties.

(2) Draw at 1150° F for tensile strength of 70,000 psi.

(3) Tempering temperature:- The temperature to be used for the tempering of steel depends upon the chemical composition, the as-quenched hardness, the prior process and the method of tempering. The exact temperature should be determined by hardness or tensile tests of individual pieces. The tempering temperatures given are based on the tempering of 1 inch round specimens. For parts with greater or smaller cross-sectional areas, the tempering temperature should be adjusted accordingly.

(4) In general, for spring temper, draw at 700° to 800° F Rockwell hardness C40-45.

(5) Bars or forgings may be quenched in water from 1500° to 1600° F.

(6) The following optional annealing treatment for 52100 steel may be used:

Heat to 1430° F, hold for 20 minutes, and cool at controlled rates as follows:

1430° to 1370° F at a rate not to exceed 20° F per hour.
1370° to 1320° F at a rate not to exceed 10° F per hour.
1320° to 1250° F at a rate not to exceed 20° F per hour.

(7) Draw at 350° to 450°F to remove quenching strains. Rockwell hardness C60-65.

(8) In general, for spring temper draw at 725° to 900° F. Rockwell hardness C43-47.

(9) Thin gauge material or parts may be air-cooled if the corrosion resistance is not decreased thereby.

(10) Hardened by cold work only.

(11) When annealing or solution heat treatment is specified, heat type 321 at 1700° to 1950° F and heat type 347 at 1800° to 2050° F to produce maximum softness, corrosion-resistance, and stabilization. Thin sections may be air-cooled while other sections should be water-quenched.

(12) When stress relieving is specified, heat at 1600° to 1700° F for minimum of 1/2 hour to remove residual stresses due to welding or cold work and to stabilize material.

(13) Lower side of range for sheet 0.06 inch and under. Middle of range for sheet and wire up to 0.125 inch. Upper side of range for forgings.

(14) Not recommended for intermediate tensile strengths because of low impact.

(15) 16 Cr-2Ni corrosion-resisting steel shall not be tempered between 700° and 1100° F. To obtain a tensile strength in the range of 115,000 to 145,000 psi, the steel shall be oil-quenched from a temperature of 1800° to 1850° F after a soaking period of 1/2 hour at temperature and shall be tempered at not less than 1100° F. To obtain a tensile strength in the range of 175,000 to 200,000 psi, the steel shall be oil-quenched from a temperature of 1850° to 1900° F after a soaking period of 1/2 hour at the specified temperature and shall be tempered at not more than 700° F. This material does not respond to full annealing by slow cooling from above the critical temperature. To obtain maximum softening, the material should be process-annealed from 4 to 8 hours at 1150° to 1225° F and cooled in air or oil.

(16) Draw at approximately 800° F and cool in air for Rockwell hardness of C50.

Figure 4-2 (Sheet 1 of 3) Heat Treatment Procedure

SAE or AISI No. Carbon and Low Alloy Steels	Temperatures, °F, and Cooling Requirements: Normalizing Air Cool (1)	Annealing: Heating	Annealing: Furnace Cool Below Approx. Temp. Shown	Hardening Cycle: Heat to	Hardening Cycle: Quench in	Recommended Sub-Critical Anneal °F	Approximate Tempering Temperature, °F, for Tensile Strength, psi, 100000	125000	150000	180000	200000	Minimum Tempering Temperature °F
1025	1600-1700	1575-1650	900	1575-1650	Water	1250	(2)					700
1035	1600-1700	1575-1625	900	1525-1600	Water	1250	900					700
1045	1600-1700	1550-1600	900	1500-1575	(Oil	1250	1100					700
1095	1500-1600	1450-1525	900	1450-1525	(or	1250	(4)		1050	850	750	
2330	1600-1700	1425-1500	800	1450-1500	(water	1200	1150	950	800	750		700
3140	1600-1700	1450-1525	900	1475-1525	(Oil	1250	1250	1100	1000	025	700	700
4037	1600-1700	1525-1575	900	1525-1575	Oil or Water (5)	1200	1200	1100	925			700
4130	1600-1700	1550-1600	900	1550-1625	Oil or Water (5)	1250	1250	1100	925	800		700
4135	1600-1700	1525-1575	900	1550-1625	Oil	1250		1100	1050	850	750	700
4140	1600-1700	1525-1575	900	1525-1600	Oil	1250	1300	1200	1100	900	800	700
4150	1575-1650	1500-1550	900	1500-1575	Oil	1250		1200	1100	900	850	700
4340	1600-1700	1525-1575	600	1475-1550	Oil	1250		1150	1050	900	800	700
4640	1600-1700	1525-1575	750	1500-1550	Oil	1200	1200	1100	1000	900	750	700
52100	1600-1700	1400-1450	700(6)	1500-1550	Oil	1200	(7)					
6150	1600-1700	1525-1575	900	1550-1625	Oil	1250	(8)	1200	1000	900	800	700
6195	1600-1700	1500-1550	700	1525-1575	Oil	1200	(7)					
8630	1600-1700	1525-1575	900	1550-1625	Oil or Water (5)	1250	1200	1075	1000	750		700
8735	1600-1700	1525-1575	900	1525-1600	Oil	1250		1025	925	750	700	700
8740	1600-1700	1500-1575	900	1525-1600	Oil	1250		1100	1000	800	750	700

See Notes in Sheet 1 of 3

Figure 4-2 (Sheet 2 of 3) Heat Treatment Procedure

SAE or AISI No. Corrosion Resistant Steels	Temperatures, °F, and Cooling Requirements					Recommended Sub-Critical Anneal °F	Approximate Tempering Temperature, °F, for Tensile Strength, psi, (3)					Minimum Tempering Temperature °F
	Normalizing Air Cool (1)	Annealing		Hardening Cycle								
		Heating	Cooling Media	Heat to	Quench in		100000	125000	150000	180000	200000	
302		1900-2100	Water(9)	(10)								
303		1900-2100	Water(9)	(10)								
304		1900-2100	Water(9)	(10)								
308		1900-2100	Water(9)	(10)								
309		1900-2100	Water(9)	(10)								
310		2000-2150	Water(9)	(10)								
316		1900-2100	Water(9)	(10)								
321		1700-1950	(11) and (12)	(10)								
347		1800-2050	(11) and (12)	(10)								
410	1525-1575	1500-1600	Furnace cool	1750-1850 (13)	Oil	1450	1400	1050	(14)	800	750	
416	1525-1575	1400-1500	Air cool	1750-1850 (13)	Oil	1450	1250	1050	(14)	750		
420		1550-1650	Furnace cool	1800-1900	Air or Oil	1450	1425	1125	1050	1000	075	
15/431 Si-Cr				1850-1950	Oil	1225			(14)			(15)
For Springs				1700-1725	Oil		(see note (16))					
See Notes in Sheet 1 of 3												

Figure 4-2 (Sheet 3 of 3) Heat Treatment Procedure

13 The heat and temper colours of steel are shown in Figure 4-1. Figure 4-2 lists the critical temperatures for hardening, annealing and normalizing, and the quenching media or cooling procedure for obtaining the tensile strength shown.

Case Hardening

14 In many instances it is desirable to produce a hard, wear-resistant surface or case over a strong, tough core. This is known as case hardening and may be accomplished in several ways, the principal ways being carburizing, cyaniding and nitriding.

Carburizing

15 By heating steel while in contact with a carbonaceous substance, carbon released by this material will penetrate the steel to an amount proportional to the time and temperature. For example, if mild or soft steel is heated to 1350° F in an atmosphere of carbonic gases, it will absorb carbon until approximately 0.80% of carbon content has been attained at the surface, this being the saturation point of the steel for the particular temperature. By increasing the heat to 1650°F, the same steel will absorb carbon until a 1.50% carbon content has been attained. This is the normal saturation point for the increased temperature. The lower the carbon content in the steel or alloy, the more readily it will combine with carbon during the carburizing process. Solid, liquid and gas carburizing methods are employed.

16 The simplest method of carburizing consists of soaking the parts at an elevated temperature while in contact with solid carbonaceous material such as wood charcoal (Item 3), bone charcoal and charred leather.

17 Liquid carburizing consists of immersing the parts in a liquid salt bath, heated to the proper temperature, to which amorphous carbon has been added. The carbon pentrates the pores of the steel as in the solid method, producing the desired case hardening.

18 Gas carburizing consists of heating the parts in a retort and subjecting them to a carbonaceous gas such as carbon monoxide (Item 4) or the common fuel gases. This process is particularly adaptable to certain engine parts.

19 When pack carburizing, the parts are packed with the carburizing material in a sealed steel container to prevent the solid carburizing compound from burning and to retain the carbon monoxide and dioxide gases. Nichrome boxes, capped pipes of mild steel or welded mild steel boxes may be used. The container should be so placed as to allow the heat to circulate entirely around it. The furnace must be brought to the carburizing temperature as quickly as possible and held at this heat from 1 to 16 hours, depending upon the depth of case desired and the size of the work. After carburizing, the container should be removed and allowed to cool in air or the parts removed from the carburizing compound and quenched in oil or water. Air cooling, although slow, reduces warpage and is advisable in many cases.

20 Carburized steel parts are rarely used without subsequent heat treatment. This consists of several steps to obtain optimum hardness in the case, and optimum strength and ductility in the core. Grain size of the core and case is refined.

(a) Refining the core is accomplished by reheating the parts to a point just above the critical temperature of the steel. After soaking for a sufficient time to ensure uniform heating, the parts are quenched in oil (Item 1). The temperatures required are given in Figure 4-2.

(b) The hardening temperature for the high carbon case is well below that of the core. It is, therefore, necessary to again heat the parts to the critical temperature of the case and quench them in oil to produce the required hardness. A soaking period of 10 minutes is generally sufficient. The temperatures required for this treatment are listed in Figure 4-4.

(c) A final tempering operation is necessary to relieve the hardening strains produced by the previous treatments. This is accomplished by heating to the temperatures specified in Figure 4-4, soaking until uniformly heated, and cooling in still air. When extreme hardness is desired, the temperature should be carefully held to the lower limit of the range.

Cyaniding

21 Steel parts may be surface hardened by heating while in contact with a cyanide salt, followed by quenching. Only a thin case is obtained by this method and it is seldom used in connection with aircraft con-

struction or repair. Cyaniding is however, a rapid and economical method of case hardening and may be used in some instances for relatively unimportant parts. The work to be hardened is immersed in a bath of molten sodium or potassium cyanide from 30 to 60 minutes. The cyanide bath should be maintained at a temperature of 1400° to 1650° F. Immediately after removal from the bath, the parts are quenched in water. The case obtained in this manner is due principally to the formation of carbides on the surface of the steel. The use of a closed pot is required for cyaniding, as cyanide vapours are extremely poisonous.

Nitriding

22 This method or case hardening is advantageous due to the fact that a harder case is obtained than by carburizing. Many engine parts, such as cylinder barrels and gears, may be treated in this way. Nitriding can only be applied to certain special steel alloys, one of the essential consituents of which is aluminum. The process involves the soaking of the parts in the presence of anhydrous ammonia at a temperature below the critical point of the steel. During the soaking period, the aluminum and iron combine with the nitrogen of the ammonia to produce iron nitrides in the surface of the metal. Warpage of work during nitriding can be reduced by stress relief annealing previously, and by exposure to nitrogen at temperatures no higher than 1000° F. Growth of the work is similarly prevented but cannot be entirely eliminated and some parts may require special allowance in some dimensions to take care of growth. Nitralloy is a typical nitriding steel.

23 The temperature required for nitriding is 950° F, and the soaking period is from 48 to 72 hours. An airtight container must be used and should be provided with a fan to produce good circulation and even temperature throughout. No quenching is required and the parts may be allowed to cool in air.

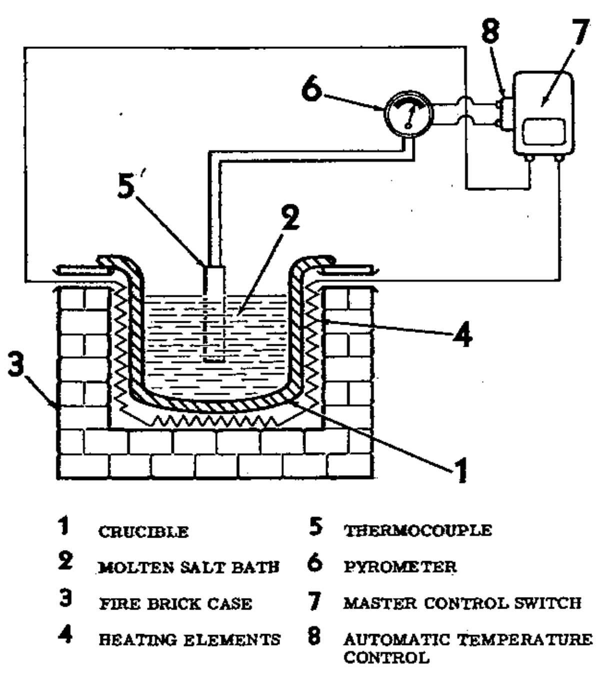


Figure 4-3 Salt Bath Type Furnace

HEAT TREATING PROCEDURE

General

24 Equipment necessary for heat treating consists of a suitable means for bringing the metal to the required temperature, a temperature measuring device and a quenching medium. Heat may, in some instances, be supplied by means of a forge or welding torch. For the treatment required in aircraft work, a furnace is necessary.

Furnaces

25 Heat-treating furnaces are of many designs and no one size or type perfectly fills every heat treating requirement. The size and quantity of metal to be treated, and the various treatments required, determine the size and type of furnace most suitable for each individual case. The general construction of the furnaces is very similar. Furnaces may be heated by means of oil, gas or electricity.

26 A salt bath is often used for small parts that have been finish-machined and for rivets requiring heat treatment. In the salt bath, the parts are heated by submersion in molten salt, which is kept at the required temperatures by means of electrical resistors. Figure 4-3 is a schematic drawing of a furnace used for this purpose which is simply a large crucible surrounded by fire brick. Parts heated in the salt bath are free from scaling, although extreme care must be used to remove all traces of the salt after treatment.

27 In any heat-treating furnace, the temperature at any point in the working zone, with a normal charge, must not vary more than ±25° F from the desired temperature. However, where a tolerance is given, as in Figure 4-2, keep the temperature within that tolerance. The furnace should be equipped with automatic controlling and recording instruments, preferably of the pyrometer type. These should be accurate within 1% of readings taken on a master calibrator.

Quenching

28 The tendency of steel to warp and crack during the quenching process is due to the fact that certain parts of the article cool more rapidly than others and is difficult to overcome. Whenever the change in temperature is not uniform, internal strains are set up in the metal which result in warpage or cracking, depending on the severity of the strains.

Quenching Tanks

29 Quenching tanks must meet the following requirements:

(a) Locate oil and water quenching tanks so that the time involved in transferring material from the furnace or salt bath to the tanks is kept to a minimum.

(b) Tanks must be deep enough to permit vertical quenching of long parts which distort excessively if quenched in any other position.

(c) Tanks must be equipped with agitators to ensure thorough circulation of oil or water. Compressed air agitation is prohibited.

(d) The temperature of the quenching oil (Item 1) must be maintained within the range of 65° to 140° F at the beginning of the quenching operation. The volume of oil in the tank must be such that, after quenching is completed, the temperature of the oil does not exceed 190° F.

(e) The temperature of the quenching water must not be higher than 100° F at the beginning of the quenching operation and must not exceed 190° F at the end of the quenching operation.

Warpage

30 To reduce warpage after heat treatment, observe the following precautions:

(a) Never throw the part into the bath. By permitting it to lie on the bottom of the bath it is apt to cool faster on the top side than on the bottom side, thus causing it to warp or crack.

(b) Agitate the part slightly in the bath to destroy the coating of vapour which prevents it from cooling rapidly.

(c) Quench the part in such a manner that all parts will be cooled uniformly and with the least possible distortion. For example, a gear wheel or shaft should be quenched in a vertical position.

(d) Immerse irregularly shaped sections so that the largest parts of the section enter the bath first.

Straightening of Parts Warped in Quenching

31 Warped parts must be straightened by heating first, and then by applying pressure. This pressure should be gradual and must continue until the piece is cooled. If the article is not too large in cross section, it may be placed between the centres of a lathe, then heated by some means until lard oil, applied to the surface, begins to smoke. At this point, pressure should be applied to the convex side by means of a tool shank held in the tool post. The pressure should be sufficient to spring the part slightly in the opposite direction from that in which it is bent. Local heating must be avoided. The best method is furnace heating, at 675° (± 25°) F. Straightening should be confined to parts for which heat-treatment does not exceed the 180,000 to 200,000 psi range.

Carburizing Procedure

32 Use externally heated baths or pots of an approved type. For liquid carburizing by the perlitonizing method, Perliton 60 (Item 5) is an approved salt and must be used as follows:

(a) Make up the bath or pot initially using Perliton 60 and add this salt as required, to maintain the working level.

(b) When the freshly made up bath becomes molten, add sufficient Perliton carbon (Item 6) to form a complete crust on the top of the salt.

(c) When the bath is at operating temperature, the surface of the salt must not become exposed. If bare patches appear, add more carbon (Item 6) to maintain the coverage.

(d) For solid carburization in furnaces, Perlite S (Item 9) is an approved medium. Metal boxes are required to contain the pack.

Preparation of Material for Carburizing

33 All material must be reasonably clean and free from grease, oil, paint and scale prior to carburizing. Where necessary, clean in accordance with instructions in Part 20, following and include pickling or light grit-blasting as a final operation. Material which is to be carburized or otherwise heat treated in a salt bath must be dried thoroughly as moisture will cause dangerous spattering of the salt.

Loading of Material

34 Material must be so located that all surfaces to be carburized are in direct contact with the carburizing medium. Surfaces must not come into contact with each other, with the sides of the furnace or bath, or with any other interferences.

Carburizing Sequence

35 Use the sequence of operations for the complete heat treatment cycle as shown in Figure 4-4. For soaking time, see Figure 4-5. In cases where the required minimum case depth, as determined on a test piece, is not obtained on the first carburizing cycle, repeat the cycle. Areas which are not to be carburized must be copper plated to a thickness of 0.003 inch minimum prior to carburizing. After

Steel Type	Carburizing		Hardening		Tempering
	Soaking Temp. °F	Quench	Soaking Temp. °F	Quench	Soaking Temp. °F
SAE. 1015	1650	Oil (See Note 1)	1450	Oil or Water (See Note 3)	375
SAE. 1020	1650	Oil (See Note 1)	1450	Oil or Water (See Note 3)	375
SAE. 1025	1650	Oil (See Note 1)	1450	Oil or Water (See Note 3)	375
SAE. 4615	1650	Oil (See Note 1)	1500	Oil	350
SAE. 4620	1650	Oil (See Note 1)	1500	Oil	350
SAE. 4815	1650	Cool In Medium (See Note 2)	1475	Oil	350
SAE. 4820	1650	Cool In Medium (See Note 2)	1475	Oil	350
NE. 8620	1650	Oil (See Note 1)	1525	Oil	350

(1) Oil quench from carburizing. Cooling in the box or pack may be used when pack (solid) carburizing.

(2) Cool in the carburizing medium (in the furnace with carburizing atmosphere, in the salt bath or in the pack) from carburizing.

(3) Where oil or water quenching is specified, use water quenching only when oil quenching will not produce the desired properties, and then only on parts not readily subject to distortion and cracking.

Figure 4-4 Carburizing and Subsequent Heat Treating Operations carburizing strip the copper plating by immersing in a solution of 4.8 pounds of chromic acid (Item 7) and 8.4 ounces of sulphuric acid (Item 8) per Imperial gallon of water at room temperature, for a time sufficient to remove the plating.

Hardening and Tempering after Carburizing

36 Harden after carburizing by one of the following methods:

(a) In a furnace with neutral atmosphere.

(b) In a salt bath with neutral hardening salt.

(c) In a furnace used for gas carburizing with the same atmosphere conditions as employed for carburizing.

(d) In all cases, material must be quenched or cooled from carburizing as shown in Figure 4-4 before subsequent hardening.

Required Depth Of Case (+25% - 10%)	Approximate Soaking Time	
	Liquid Carburizing Medium (Hrs)	Solid Carburizing Medium (Hrs)
0.005	1-1/4	5/6
0.010	2	1-1/3
0.015	3	2
0.020	4-1/2	3
0.025	6-1/4	4
0.030	8	5-1/4
0.035	10-1/2	6-3/4
0.040	14	8-3/4

Soaking time is defined as starting when the furnace or salt bath, after insertion of a load, reaches the required soaking temperature. Soaking time finishes when the load is removed from the furnace or salt bath, or in the case of cooling in the heating medium, when this cooling is started.

Figure 4-5 Carburizing Soaking Times

Removal of Salt after Carburizing or Heat Treatment

37 Where any adhering salt remains on material which has been carburized, hardened or tempered in salt baths, remove the salt by rinsing and scrubbing in water immediately after quenching or cooling from the heat treating operation.

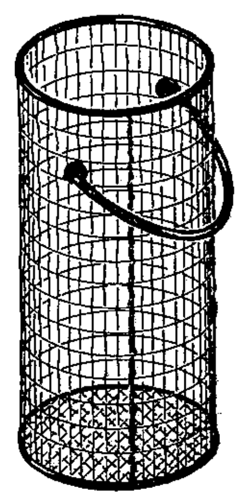
HEAT TREATMENT OF ALUMINUM ALLOY

General

38 For information on the heat treatment, forming and machining of aluminum and its alloys, refer to EO 105-10-1.

Heat Treatment of Rivets

39 Rivets requiring heat treatment are usually heated in small screen wire baskets, (see Figure 4-6), which allow free and rapid



NOTES:

1 FABRICATE CONTAINER FROM STAINLESS STEEL WIRE MESH, OR MILD STEEL WIRE MESH METALLIZED WITH STAINLESS STEEL.

2 MAKE MESH AS LARGE AS POSSIBLE WITHOUT ALLOWING RIVETS TO PASS THROUGH.

3 WELD ALL SEAMS.

4 SIZE: 3-1/2 IN. DIAMETER

5 LENGTH: OPTIONAL.

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Figure 4-6 Air Furnace Rivet Container

circulation of water during the quenching process. The time required for the rivets to reach the proper temperature will depend upon the relationship between the volume of the charge and the heating medium.

40 When heat treating in salt baths, the quantity of rivets in the inner containers must be such that, when lowered into the outer shell in the salt bath, the top layer of rivets is at least four to six inches below the level of the salt, (see Figure 4-7). The covers of the outer shells must be in place during heat treatment.

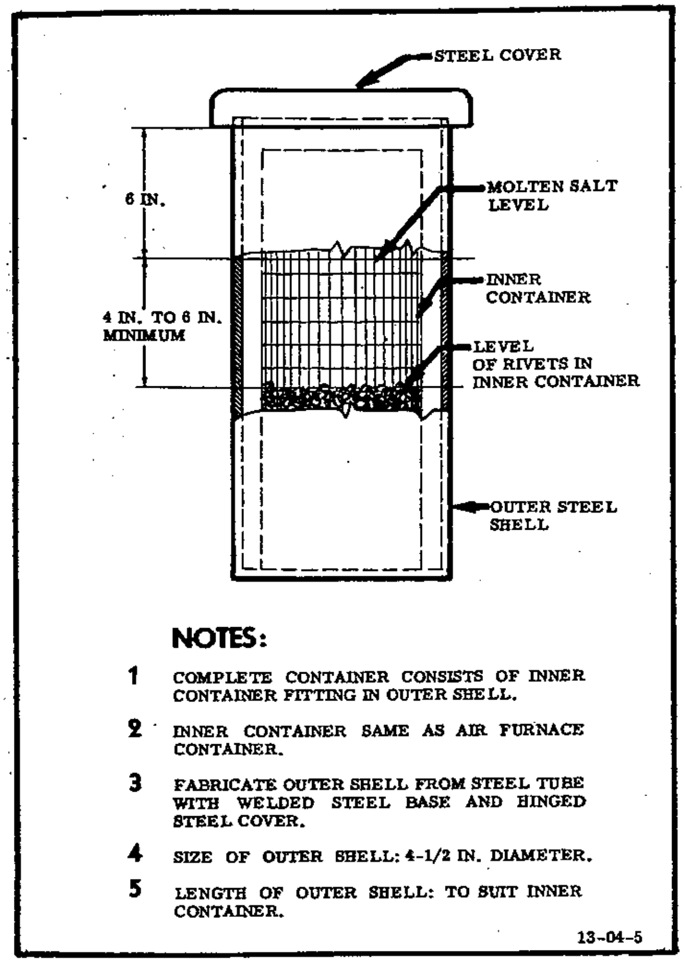


Figure 4-7 Salt Bath Rivet Container

41 Anodized rivets may be heat treated in air furnaces or salt baths. In the latter case, the rivets must not be allowed in direct contact with the molten salt.

Solution Heat Treatment

42 Soaking time for solution heat treatment is a minimum of 1 hour 15 minutes in air furnaces and 1 hour 20 minutes in salt baths. The start of the soaking time is defined as the time at which, after insertion of a load, the furnace or salt bath reaches the specified soaking temperature required for the alloy.

Quenching

43 When quenching rivets after solution heat treatment, place a large wire mesh basket in an almost totally immersed position in the cold water of the quench tank, as shown in Figure 4-8, and dump the rivets from their containers into the basket. After quenching, dry rivets in warm air (not exceeding 150° F) or in alcohol, followed as soon as possible by anodizing.

44 Rivets removed from the cold water and held at room temperature should be driven within one hour after quenching, but may be held for much longer periods without hardening if stored under refrigeration. Rivets will harden completely at room temperature in about 24 hours due to the effects of aging. Rivets driven in the fully hardened or partially hardened condition show a much greater tendency to crack than those driven within one hour after quenching. Rivets made from 17S and 24S alloy must be heat treated before use, whereas, 2S, A17S-T, 53S, 53S-W and 53S-T rivets may be driven in the condition in which they are received.

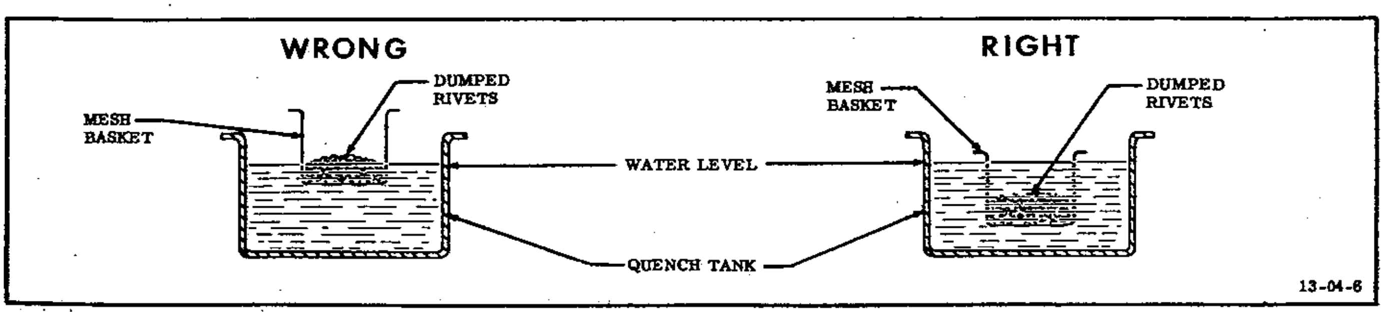


Figure 4-8 Location of Basket in Quench Tank

HARDNESS TESTING

General

45 Hardness testing is important in the determination of the results of heat treatment as well as the condition of the metal before heat treatment. The Tables in Part 25, following, represent a close approximation of the relation between the tensile strength and hardness of wrought carbon and low alloy steels only. These figures are for inspection of these materials but should not be used for other metals except in a very general manner. The methods of hardness testing in general use are: Brinell, Rockwell, Vickers (British), and Shore Scleroscope. The hardness values obtained from Alclad sheet cannot be converted into tensile strength due to the coating on the alloy, but this coating may be removed from areas to be tested in order that the hardness and corresponding strength of the base material can be determined.

Brinell Hardness Test

46 This test consists of pressing a hardened steel ball into a flat surface of the metal being tested by the application of a known pressure. The impression made by the ball is measured by means of a microscope with a micrometer eyepiece, and the Brinell number is obtained by dividing the load in kilograms by the area of the spherical impression made by the ball, measured in square millimeters. The thickness of all samples used for testing must be sufficient to prevent bulging on the underside. The Brinell tester, (see Figure 4-9), consists of the following major parts:

(a) An elevating screw and anvil for bringing the sample into contact with the ball.

(b) A manually-operated hydraulic pump for applying pressure to the hardened steel ball which is mounted on its actuating member.

(c) A pressure gauge for determining the applied pressure.

(d) A release mechanism to relieve the hydraulic pressure after the test has been made.

(e) A microscope with micrometer eyepiece for calculating the area of the impression.

47 The test is performed as follows:

(a) Prepare the sample by filing, grinding and polishing to remove all scratches and variations that may affect the reading.

(b) Place the sample on the anvil of the machine and elevate until the hardened ball contacts the surface to be tested.

(c) Apply the load by pumping the handle.

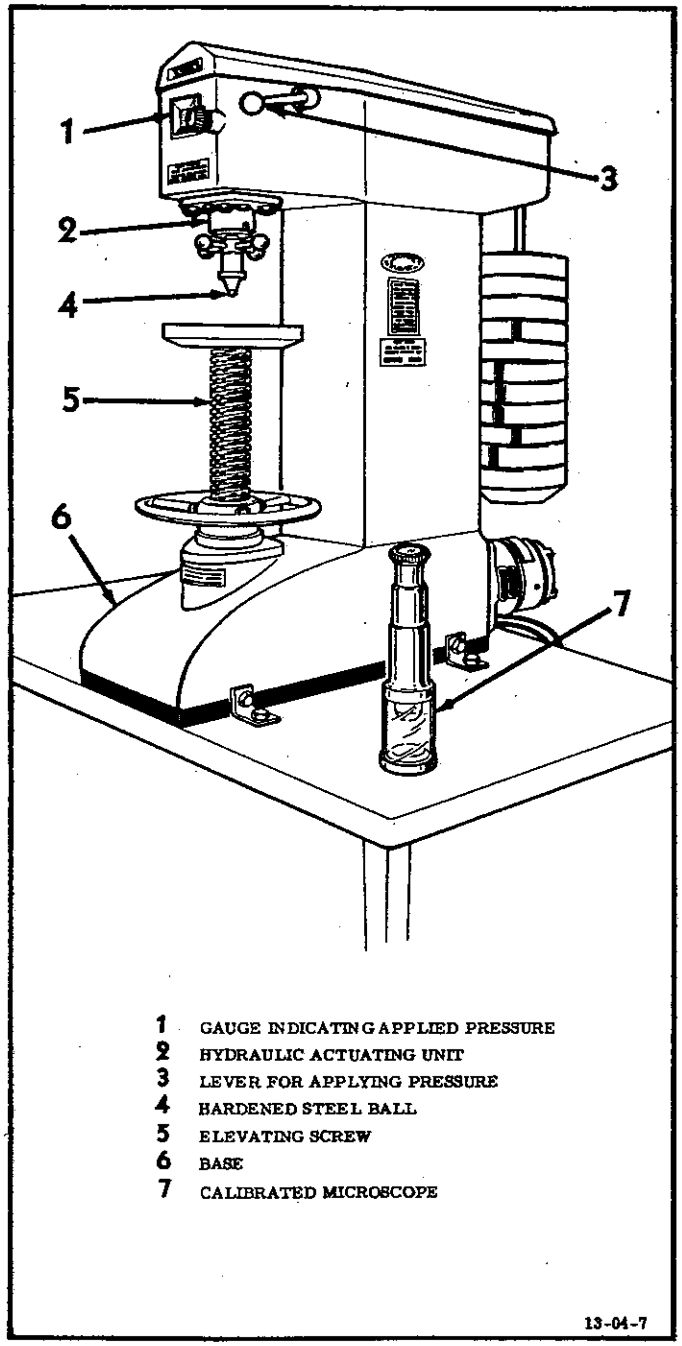


Figure 4-9 Brinell Hardness Tester

(1) A load of 3000 kilograms is required for steel, while 500 kilograms is used when testing softer metals, such as aluminum alloy, brass and bronze.

(2) Normally, the load should be applied for 30 seconds, although this period may be increased to 1 minute for extremely hard steels, in order to produce equilibrium.

(d) Release the pressure and measure area of impression with calibrated microscope.

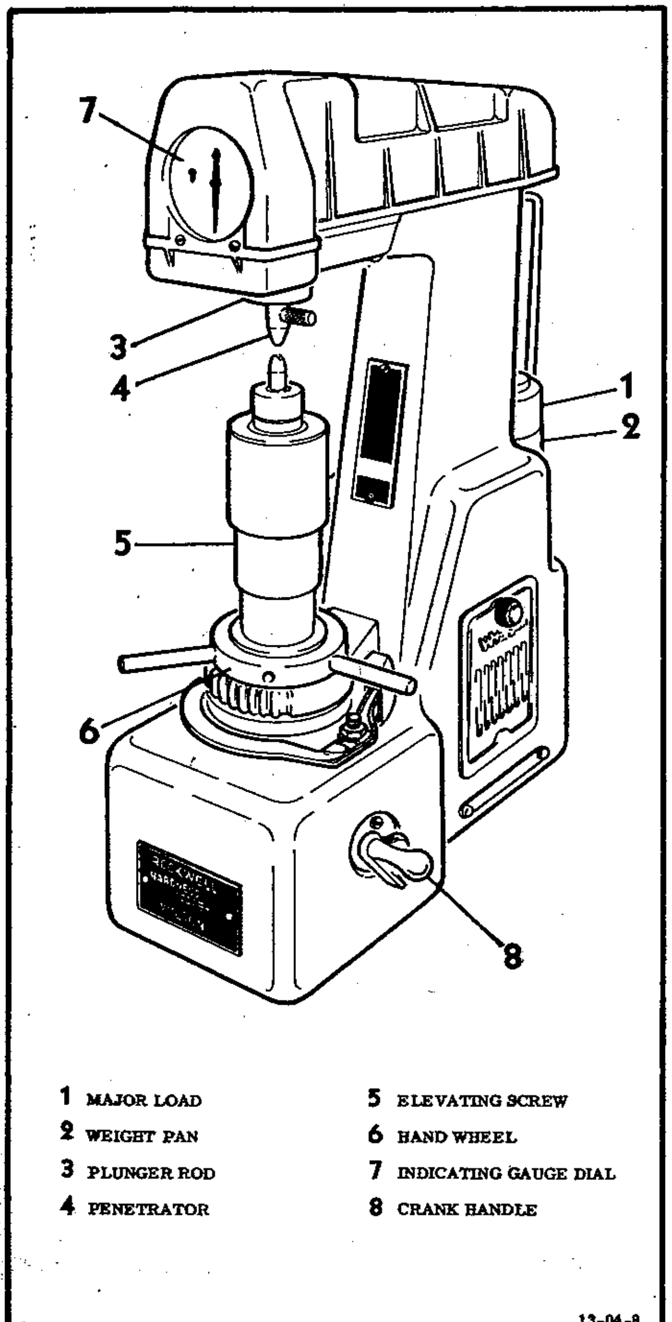


Figure 4-10 Rockwell Hardness Tester

(e) Calculate the Brinell number, completing the test.

$$\text{Brinell No.} = \frac{\text{Load on indenting tool (kg.)}}{\text{Area of impression (mm.}^2\text{)}}$$

(f) After obtaining a Brinell number for a metal, its corresponding tensile strength may be determined by referring to Part 25, following.

(g) Reference may also be made to Part 25 to identify the metal and determine its heat treatment.

Rockwell Hardness Test

48 The Rockwell hardness tester, (see Figure 4-10), consists of a base or stand, elevating screw, anvil, penetrator, a device for applying the load, and a dial indicator. The test consists of the measurement of the difference between a minor and major load applied to a diamond penetrator or hardened steel ball. In all tests, a minor load of 10 kilograms is first applied, in order to seat the penetrator in the surface of the specimen. The actual penetration is then produced by applying a major load. When using the diamond cone penetrator, this major load is 150 kilograms, but when a 1/16 inch steel ball is used, the load is reduced to 100 kilograms. An indication of the application of the major load may be observed by watching the dial indicator. After the pointer comes to rest, this major load is released, leaving the minor load still applied.

49 As Rockwell hardness numbers are based on the difference between the depths of penetration at major and minor load, it will be evident that the greater this difference, the less the hardness number and the softer the material. This difference is automatically registered when the major load is released by a reversed scale on the indicator dial, which thus reads directly the Rockwell hardness number.

50 There are two types of Rockwell hardness testers, the standard and the superficial. The standard tester has a load range from 60 to 150 kilograms and is used for general testing of aircraft materials and parts, finished or unfinished. The superficial tester has a load range of 15 to 45 kilograms and is used mostly for surface hardened and thin materials.

Rockwell Hardness Scales

51 The various Rockwell scales and their

applications are shown in Figure 4-11. The type of penetrator and load used with each will depend on the type of material being tested.

52 The dial indicator on the tester is provided with two scales; the black or C scale and the red or B scale. The C scale is used when testing with the diamond cone and 150 kilogram load, while the B scale is used in connection with the steel ball penetrator and 100 kilogram load. Readings, when recorded, must be prefixed by the letter B or C to show which scale has been used. When the readings fall below the table value, C-20 (B-98), (refer to Part 25, following), the material is considered too soft for the diamond cone and a 1/16 inch hardened ball should be used. The diamond cone must be used for all hard materials (those above 100 on the B scale), as the steel ball mav be deformed by the test.

Scale	Testing Application
A	For tungsten carbide and other extremely hard materials. Also for thin, hard sheets.
B	For materials of medium hardness, such as low and medium carbon steels in the annealed condition or aluminum.
C	For materials harder than Rockwell B-100.
D	Where somewhat lighter load is desired than on C scale, as on case-hardened pieces.
E	For very soft materials such as bearing materials.
F	Same as E scale but using 1/16-inch ball.
G	For metals harder than tested on B scale.
H & K	For softer metals.
15-N, 30-N, 45-N	Where shallow impression or small area is desired. For hardened steel and hard alloys.
15-T, 30-T, 45-T	Where shallow impression or small area is desired for materials softer than hardened steel.

Figure 4-11 Rockwell Scales

53 Several anvils are included as regular equipment with each machine, and their selection depends upon the shape of the section to be tested.

54 The procedure for making the Rockwell test is as follows:

(a) Prepare the sample as described for the Brinell test. The surface finish must be proportional to the load used. For the higher load, the surface should be polished with No. 1 abrasive paper. The lower load requires a very smooth finish. Use No. 00 abrasive paper.

(b) Select the proper penetrator and place the corresponding weight on the weight pan.

(c) Place sample on the anvil and, by turning hand wheel, raise slowly until contact is made with the penetrator. Continue turning until the pointer of the indicator has made three revolutions and is within five divisions (plus or minus) of the upright position. This applies the 10 kilogram or minor load on the sample.

(d) Apply the major load by means of the handle shown in Figure 4-10.

(e) Release the major load by returning the handle to its original position, and read the hardness number directly on the indicator scale.

(f) The tensile strength corresponding to the hardness number, identification of material and condition of temper may be determined by reference to tables in Part 25, following.

Vickers Diamond Pyramid Tester

55 The Vickers hardness tester is similar to the Brinell machine, using a diamond shaped point. The diagonal of the impression is measured and calculation made to obtain the hardness number.

Shore Scleroscope Hardness Test

56 Testing hardness with the scleroscope consists of dropping a diamond-tipped hammer upon the test specimen from a definite height and measuring the rebound produced. In one type of tester, the height of the rebound must be measured directly on the scale of the machine, while on another the amount is indicated on a dial.

57 The tester, (see Figure 4-12), consists of the following major parts:

(a) A base, provided with levelling screws and a clamping arrangement to hold the sample to be tested.

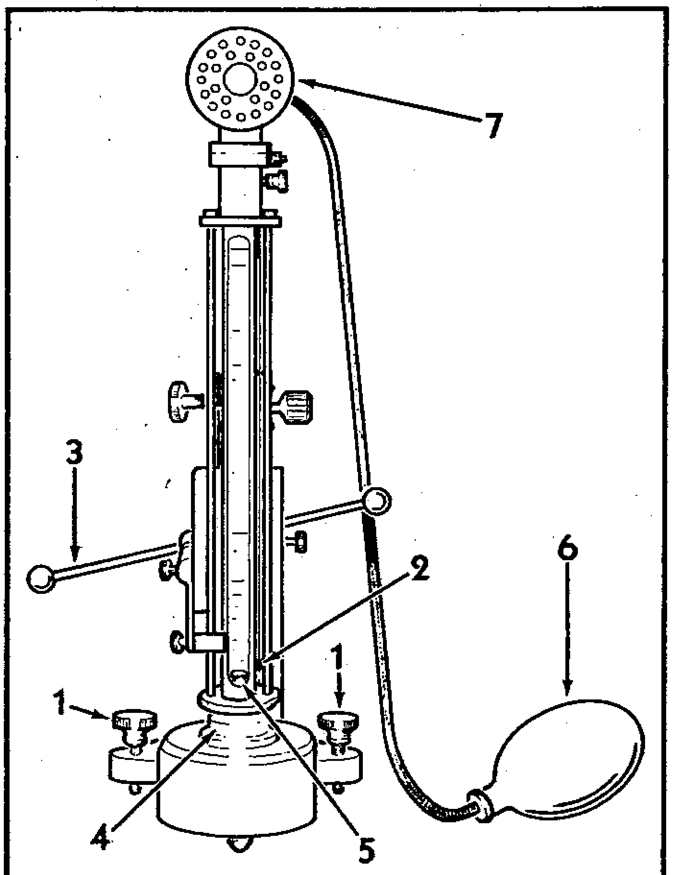


Figure 4-12 Shore Scleroscope

(b) A vertical glass tube mounted on the base and containing the cylindrical diamond-point hammer.

(c) A suction head and bulb for lifting and releasing the hammer.

(d) A scale, visible through the glass tube, for determining the height of the rebound.

(e) A magnifier hammer with a larger contact area is supplied for use with extremely soft metals.

58 The test is made as follows:

(a) Level the instrument by means of the adjusting screws. The level position is determined by means of the plumb rod shown at (2), (see Figure 4-12).

(b) Prepare test specimen as described for the Brinell and Rockwell tests and clamp it on the base. This is done by raising lever (3), inserting the sample, and exerting pressure on the clamping shoe (4).

(c) Raise the hammer (5) by squeezing and releasing the bulb (6).

(d) Release the hammer by again squeezing the bulb and observe its rebound.

(e) Several tests should be made at different points of a specimen, and an average reading taken to reduce visual error.

(f) The results obtained from the test may then be checked against the values given in Part 25, following.

Shore Durometer Test

59 For the shore durometer test, refer to Part 15, following.

Material Specifications

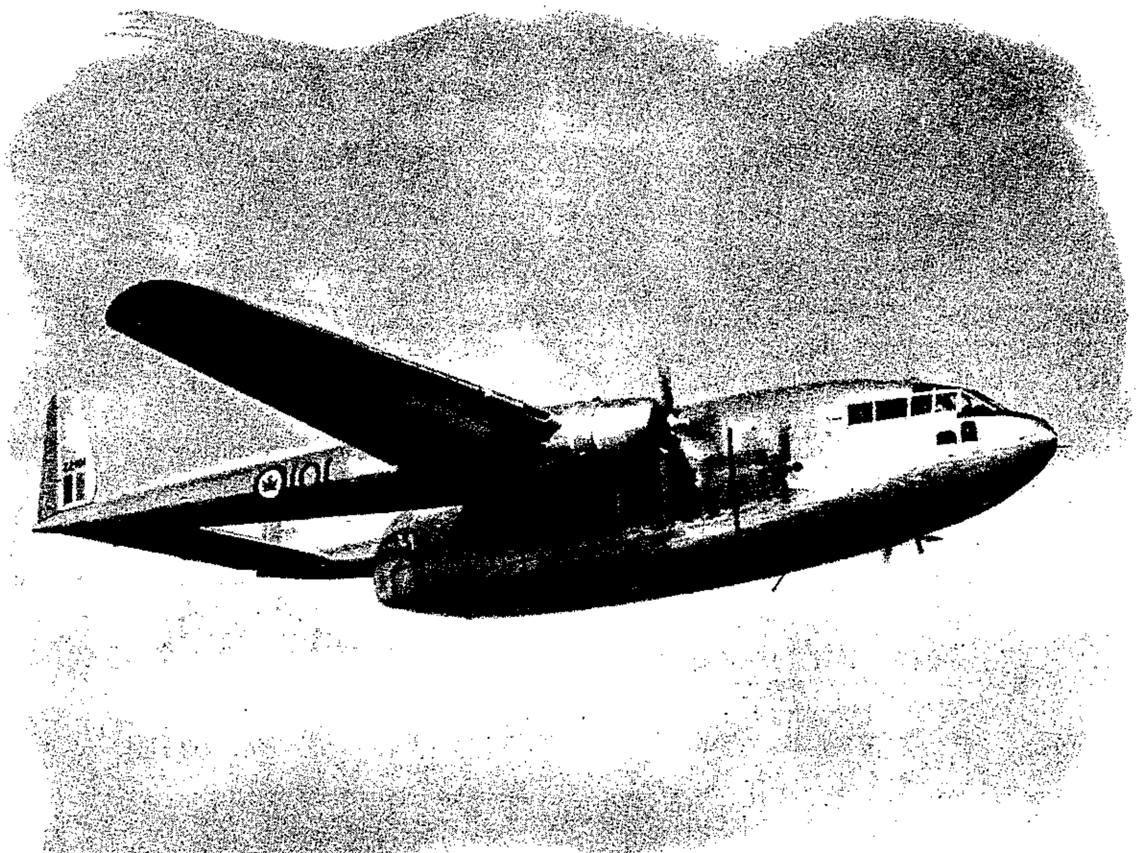
60 For table showing item numbers, materials, specifications and manufacturers, see Figure 4-13.

Item No	Material	RCAF Ref	Specification	Manufacturer
1	Oil, General Purpose, Low temperature, Anti-corrosive	34A/124	3-GP-335	
2	Charcoal, Powdered			Commercial Grade
3	Charcoal, Wood			Commercial Grade
4	Carbon Monoxide, for Gas Carbonizing			Commercial Grade
5	Salt, Perliton 60			E F Houghton & Co of Canada 100 Symes Rd. Toronto 9
6	Carbon, Perliton			E F Houghton & Co of Canada 100 Symes Rd. Toronto 9
7	Acid, Chromic	33C/494	O-C-303	
8	Acid, Sulphuric	33C/4	15-GP-8	
9	Perlite S			E F Houghton & Co of Canada 100 Symes Rd. Toronto 9

Figure 4-13 Table of Material Specifications

PART 5

RIVETS



PART 5

RIVETS

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(Continued)

LIST OF ILLUSTRATIONS

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PART 5

RIVETS

RIVETS

General

1 Aircraft rivets are divided into two main groups; the common solid shank rivets, and the special rivets, such as Hi-Shear, hollow and blind. The common solid shank aluminum alloy rivets, which comprise 90% of all aircraft rivetting, are again divided into two groups; those requiring heat treatment and possible refrigeration before driving, and those driven in the as received condition. The first group includes 17S-T and 24S-T, the second group includes 2S, 56S, and A17S-T. 17S-T rivets are sometimes driven as received. (Refer to Paragraph 47, following.)

Heat Treatment

2 For heat treatment of rivets, refer to Part 4, following.

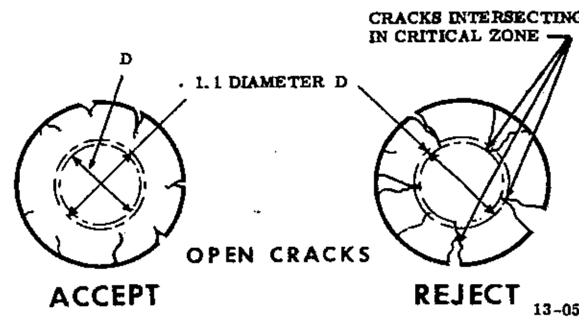
Rivet Heads and Tool Shapes

3 The heads of aluminum alloy solid shank rivets have been standardized to two types; 100° flush head (AN426) (Item 2) and universal head, (AN470) (Item 2), (see Figure 5-1). The correct tool shape for these rivets, both rivet set and bucking bar, is flat. With AN470 rivets the minimum protrusion above the sheet is the same for the manufactured heads as for the bucked head, (see Figure 5-2). The obsolete AN442 (flat head, aluminum alloy) is also driven with flat tools. The obsolete AN430 (round head, aluminum alloy) and AN456 (brazier head, aluminum alloy) and the current AN435 (round head, steel, monel and copper) are to be driven only with sets formed to fit the rivet head.

Inspection of Rivetting

4 The following limitations govern the acceptability of rivet heads:

(a) To be acceptable, the rivet head must have a minimum crack-free surface diameter equal to 1.1 times the rivet shank diameter.



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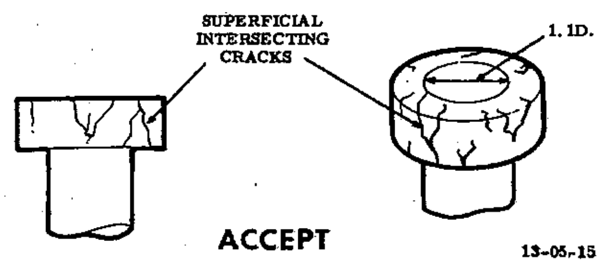
(b) Superficial intersecting cracks on the side of the head or outside the critical surface diameter of 1.1 shank diameter are acceptable. A superficial crack is defined as one having a shallow penetration not extending into the critical areas (1.1D) of the driven head of a rivet.



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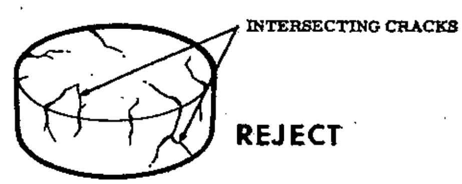
(c) Rivets are not acceptable if cracks (other than superficial) intersect in the head, producing a potential cause for a portion of the head to chip off.



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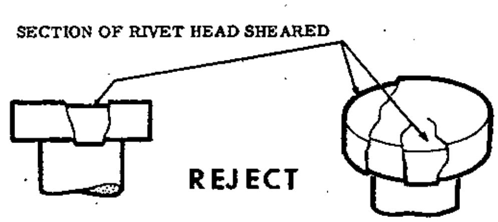
(d) Rivets are not acceptable if a section of the rivet head is sheared.



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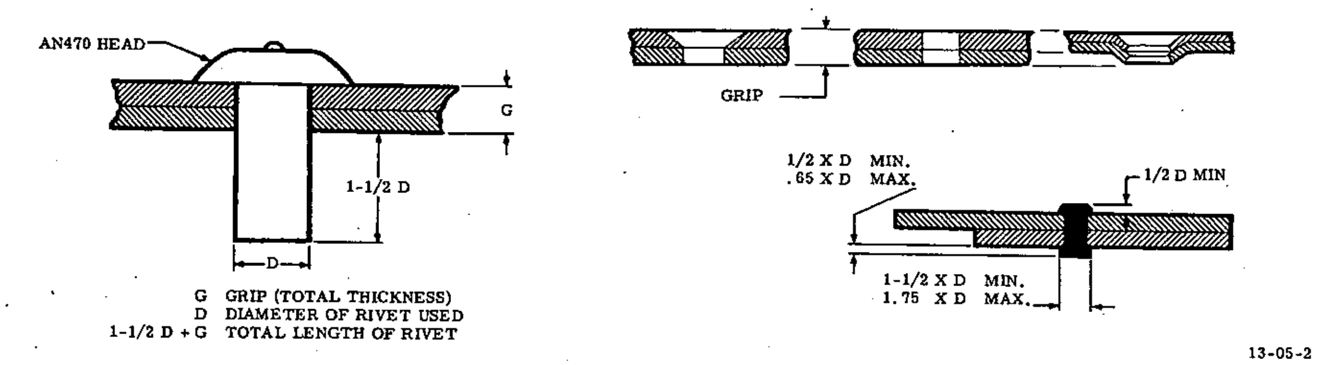


Diameter in Inches		Rivet Lengths for Raised Head Rivets					Rivet Lengths for Countersunk Rivets				
		3/32	1/8	5/32	3/16	1/4	3/32	1/8	5/32	3/16	1/4
Length of Rivet in Inches	Dash No. for Rivet	Max. Grip	Max. Grip	Max. Grip	Max. Grip	Max. Grip	Max. Grip	Max. Grip	Max. Grip	Max. Grip	Max. Grip
1/8	2	0	0	0	0	0	0	0	0	0	0
3/16	3	.070	.031	0	0	0	.039	0	0	0	0
1/4	4	.133	.094	.055	.016	0	.102	.063	.024	0	0
5/16	5	.195	.156	.117	.078	0	.164	.125	.086	.047	0
3/8	6	.253	.219	.180	.141	.062	.222	.188	.149	.110	.031
7/16	7	.305	.281	.242	.203	.125	.274	.250	.211	.172	.094
1/2	8	.353	.344	.305	.266	.188	.322	.313	.274	.235	.157
9/16	9	.398	.406	.367	.328	.250	.367	.375	.336	.297	.219
5/8	10	.443	.464	.430	.391	.312	.412	.433	.399	.360	.281
11/16	11	.490	.516	.492	.453	.375	.459	.485	.461	.422	.344
3/4	12	.542	.564	.550	.516	.438	.511	.533	.519	.485	.407
13/16	13	.604	.606	.602	.578	.500	.573	.575	.571	.547	.469
7/8	14	.665	.644	.650	.641	.562	.634	.613	.619	.610	.531
15/16	15	.725	.685	.692	.698	.625	.694	.654	.661	.667	.594
1	16	.788	.731	.730	.746	.688	.757	.700	.699	.715	.657

When the grip length falls between those given in the tables, select the longer rivet. Grip= total material thickness. If rivet of proper length is not available, cut off longer rivet to exact length, not grip, required.

Figure 5-1 Rivet Dimensions

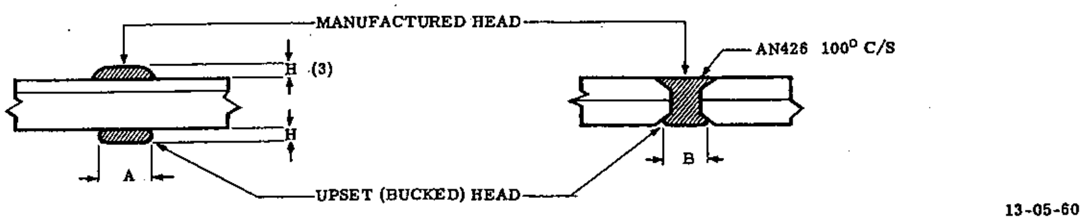
Selection of Rivet

5 Wherever possible, the rivets used in repair are to be of the same type as those used in the original construction. The determination of the length of a rivet is an important part of any repair. The length used depends on the grip or combined thicknesses of material to be rivetted plus a minimum allowance of 1.5 diameters for upsetting the shank. For convenience in selecting the proper lengths, Figure 5-1 lists the grip lengths for rivets of common sizes. The nearest standard rivet length greater than the calculated sum is always used.

6 A rivet shank will expand up to 15%. (Refer to Part 24, following, for dimensions.) If the original rivet hole is enlarged beyond this, replacement with the next larger size of rivet (1/32 inch greater diameter) is necessary to obtain the required tightness. If this is not done, and the same size rivet is replaced in an elongated hole, the ability of the rivet to carry its share of the shear load is impaired, with consequent joint weakness. Generally speaking, the slight decrease in sheet area created by increasing the rivet diameter will not be critical.

Laying Out Rivet Pattern

7 Wherever possible, rivet edge distance, rivet spacing and distance between rows should be the same as that of the original installation.



Rivet Size	A Diameter		B Diameter	H Height	
	Min	Max	Min	Min	Max
3/32	0.140	0.157	0.154	0.031	0.063
1/8	0.187	0.208	0.206	0.042	0.083
5/32	0.234	0.260	0.257	0.052	0.104
3/16	0.281	0.312	0.309	0.062	0.125
7/32	0.328	0.365	0.361	0.073	0.146
1/4	0.375	0.417	0.413	0.083	0.167

NOTE

Where rivets join plastic parts and the minimum acceptable upset will prevent cracking, dimensions approaching A min. and H max. values are recommended.

Maximum values represent desirable upper limits and are for reference only.

These values also apply to the minimum acceptable height of the manufactured head of AN442 and AN470 rivets driven with a flat set.

Figure 5-2 Upset Head Dimensions

Where this is not possible, follow the detailed instructions in Part 24, following. For protruding head rivets, minimum for edge distance is twice hole diameter, minimum spacing of rivets is four times hole diameter. Twice the diameter is satisfactory for standard edge distance for spacing and edge distance of flush rivets.

8 When rivetting external seams, especially in the thinner gauge materials, exercise care to maintain the above mentioned distances. Values larger than standard may result in the formation of water traps caused by the tendency of the sheet to lift along its edge when rivetted. When this occurs, serious corrosion inevitably follows. This is especially true of seaplanes which are in contact with salt water. For edge distances, see Figure 5-3.

9 Provide a minimum of 1/32 inch between the edge of non-flush rivet heads and bend radius tangent points. Otherwise maintain the normal edge distances, (see Figure 5-4).

10 If watertight, fuel tight or flotation tight joints are required see Figure 5-5 as a guide for maximum spacing of rivets.

Drilling

11 Drill holes with either a light power drill or a hand drill. The standard straight shank twist drill is most commonly used.

12 To transfer holes from one drilled part to another, place the second part over the first, use the established holes to guide the drill, and drill through. For very thin material, scribe the hole location from the drilled part onto the part to be drilled, spot the holes with a centre punch on the bench and drill. In areas involving complete new sections, either drill from the skin inward into the stringer or drill from the stringer outward. In either method, first drill .098 inch pilot holes in the member nearest the operation. Locate and attach the second member to the first by C clamps or spring fasteners (Cleco) through the holes, size drill through both members, separate sheets and burr holes.

13 Flimsy members, such as light stringers, requiring drilling from skin surfaces are often marked along their length with a rivet line in pencil. Place the skin, predrilled with pilot holes, over the stringer and flex the latter to bring the pencil line onto the skin holes centre line. Use an occasional Cleco fastener (Item 1) to hold the stringer in position. Drilling the skin from the stringer may often prove more convenient, but, because of the flexibility of the customary stringer, the resulting rivet line in the skin may prove somewhat irregular.

Drill Sizes

14 The size hole to drill for the application of the various sizes of rivets is specified in Figure 5-6.

Drilling Practices

15 Observe the following practices in drilling for rivets:

(a) Centre punch all rivet locations. The centre punch mark must be large enough to prevent the drill from slipping out of position, yet it must not dent the surface of the material. Placing a bucking bar behind the metal during punching will help to prevent denting.

(b) Make sure drill is of the correct size and that it is sharp, with the drill points ground according to standard practice, (included angle of 118°, clearance angle of 12° to 15°).

(c) Place the drill in the centre punch mark. When using a power drill, give the chuck a few turns before starting the motor.

(d) While drilling, always hold the drill at right angles to the work.

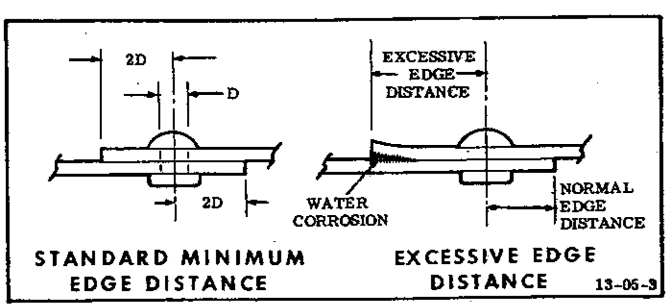


Figure 5-3 Edge Distance

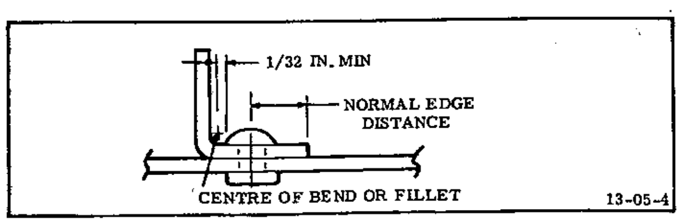


Figure 5-4 Bend Line Edge Distance

(e) Avoid excessive pressure. Let the drill bit do the cutting.

(f) Never push the drill through the stock.

(g) Remove all burrs with a burring tool.

(h) Clean away all drill swarf.

Spotfacing

16 The work surface nearest to the original manufactured head of the rivet must be flat and

Gauge of Thinnest Material	Watertight 2 Rows				Fueltight 2 Rows				Flotation Single Row			
	Rivet Diameters				Rivet Diameters				Rivet Diameters			
	1/8	5/32	3/16	1/4	1/8	5/32	3/16	1/4	3/32	1/8	5/32	3/16
.0159	1/2				7/16				9/16	5/8	11/16	3/4
.020	1/2				7/16				9/16	5/8	11/16	3/4
.025	1/2	5/8			7/16	9/16			9/16	11/16	3/4	13/16
.028	1/2	5/8			7/61	9/16			5/8	11/16	3/4	13/16
.032	1/2	5/8			7/16	9/16			5/8	11/16	3/4	7/8
.036	1/2	5/8			7/16	9/16			5/8	3/4	13/16	7/8
.040	1/2	5/8	3/4		7/16	9/16			11/16	3/4	13/16	15/16
.045		5/8	3/4			9/16	11/16			3/4	7/8	15/16
.051		5/8	3/4			9/16	11/16			13/16	15/16	1
.057		5/8	3/4			9/16	11/16			13/16	15/16	1-1/16
.064		5/8	3/4	1		9/16	11/16			7/8	1	1-1/8
.072			3/4	1			11/16				1-1/16	1-3/16
.080			3/4	1			11/16				1-1/8	1-1/4
.090			3/4	1			11/16				1-3/16	1-3/8
.102			3/4	1			11/16					1-7/16
.114			3/4	1			11/16					1-1/2
.128			3/4	1			11/16	15/16				1-9/16
.144			3/4	1			11/16	15/16				
.162				1				15/16				
.182				1				15/16				
.250				1				15/16				

Figure 5-5 Rivet Spacing for Fluid Tight Joints

normal to the rivet hole. Machining is not required upon this surface except for removing fillets or for angularity in excess of 8°. Where spotfacing is required to remove excessive angularity, the spotface diameters shown in Figure 5-7 must be used.

Balancing Shear and Bearing Strengths

17 The diameter and number of the rivets used in a joint should be such that the total shear strength of the rivets is approximately equal to the bearing, or crushing, strength of the material being rivetted. The shear strength of a rivet is found by multiplying its cross-sectional area in square inches by the shear value in pounds per square inch of the rivet material. The bearing strength of the material equals the rivet diameter times the allowable bearing stress in pounds per square inch of the material multiplied by the thickness of the material. Thus the shear strength of a rivet varies directly with the square of its diameter and may be increased rapidly by increasing the size of rivets, whereas the bearing strength of the material, if its thickness is unchanged, varies directly with the rivet diameter and may be increased rapidly by using a greater number of rivets. This would usually be accomplished by additional rows of rivets rather than additional rivets in the same row, in order not to reduce bearing strength of the sheet.

Rivet Diameter	Drill Size	Drill Diameter
1/16	No. 51	.0670
3/32	No. 40	.0980
1/8	No. 30	.1285
5/32	No. 21	.1590
3/16	No. 11	.1910
7/32	No. 1	.2280
1/4	F	.2570
5/16	P	.3230
3/8	W	.3860

Figure 5-6 Rivet Drill Sizes

18 Therefore, by varying the diameter and number of rivets, the shear strength of the rivets may be made approximately equal to the bearing strength of the material. In calculating the shear strength of a rivet, the number of planes on which a rivets tends to shear must be considered, because the shear strength increases directly in relation to the number of planes or thicknesses.

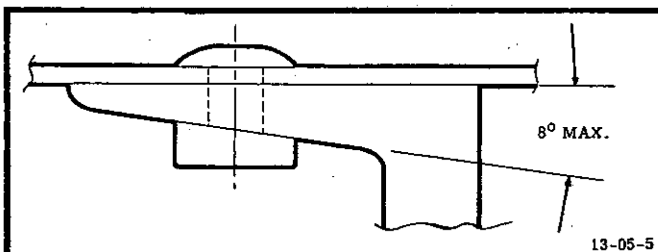
RIVET FAILURE

General

19 Rivetted joints are designed on the assumption that the total joint strength is simply the summation of the individual rivet strength. When any one rivet fails, its load must be immediately carried by the others, and, if they are unable to do so, progressive joint failure will take place. Stress concentrations usually cause one rivet to fail first, and visual detection of such a rivet in a joint indicates that it has been highly loaded, with the possibility that other rivets have partially failed.

Shear

20 Shear failure is a breakdown of the rivet shank by forces acting in the plane of two adjacent sheets, causing a slipping action which may be severe enough to break the rivet shank in two. If the shank has been loaded over the



Rivet Dia.	Spotface Diameter	Fillet Radius
3/32	3/8	.031
1/8	7/16	.031
5/32	1/2	.031
3/16	9/16	.062
1/4	11/16	.062

Figure 5-7 Spotfacing Dimensions

yield point of the material, a permanent deformation occurs and the shank of the rivet is joggled. Sheet displacement occurs and the rivet holes are no longer aligned.

Bearing

21 Bearing failure can occur in the sheet at the edge of the rivet hole if the rivet is excessively strong in shear. Large rivets in thin sheets cause such failures. The sheet is locally crushed, having been loaded beyond its yield point, and the resulting permanent distortion destroys the mechanical rigidity of the joint. If the hole elongation is slight, replacement is made by the next size larger rivet. However, if failure occurs at the edge of the sheet, causing appreciable distortion out to the sheet edge, or if a complete tear-out has occurred, replacement of the sheet must be effected.

Head Failure

22 Certain more complex loadings may be placed on a joint, causing tensions to be applied to the rivet head. Since rivets are not designed to withstand appreciable tension loads, the head may fail by shearing through the area corresponding to the rivet shank, or may fail through a prying action which causes failure of the head itself. Any visible head distortion is cause for replacement. This latter type of failure usually occurs with blind rivets (mechanically expanding and explosive) wherein the formed head is distorted by tension forces, allowing a cocking of the rivet which continues until a rivet tension failure occurs. This is especially true of single shear lap joints in the thicker sheet gauges.

Detecting Rivet Failures

23 Examine rivets for tipped heads and/or looseness, and for the presence of cracked paint around rivet heads. Chipped or cracked paint on or around the heads of the rivets may be indicative of slipped or loose rivets. Remove paint, if necessary, to determine accurately the true condition of the rivets. If the heads are tipped or rivets are loose due to excessive load, they will show up in groups of several consecutive rivets. The heads will be tipped in the same direction if bona fide tipping has occurred. If the heads which appear to be tipped are not in groups and are not tipped in the same direction, tipping may have occurred during installation.

24 Rivets which are known to have been critically loaded, but which show no visible distortion, may be inspected by drilling off the head and carefully punching out the shank. If the shank is joggled and the holes in the sheets misaligned, the rivet has obviously failed in shear. Flush rivets which show head slippage, within the dimple or countersink, indicate either sheet bearing failure or rivet shear failure and must be removed for inspection and replacement.

25 If suspected failed rivets cannot be detected by visual inspection, the joint may be checked by drilling and punching out several rivets. If the rivet shanks are joggled, showing partial shear failure, the rivets should be replaced with the next size larger rivets. If the rivet holes show elongation, the sheet has failed locally in bearing and again the next size rivet must be used in replacement. Any deformation of the sheet surrounding the rivet head indicates a probable partial rivet failure. Sheet failures, such as tear-outs and cracks between rivets, usually indicate damaged rivets, and the complete repair of the joint may require replacement by next size larger rivets.

Removal of Rivets

26 The following procedure is to be followed when removing rivets:

(a) Centre punch rivet head.

(b) For drilling the rivet head, use a relatively long-pointed drill with a diameter slightly less than that of the rivet.

(c) Carefully centre the drill and drill slowly with a light pressure.

(d) Discontinue drilling before the full diameter of the drill reaches the rivetted skin. The rivet head will usually be twisted off by the drill.

(e) If the head does not shear off, knock the head off by tapping lightly with a sharp-edged tool. Support the rivet during this operation.

FLUSH RIVETTING

General

27 Flush rivetting is achieved by radius dimpling, coin dimpling, countersinking, or

by a combination of either coin or radius dimpling with countersinking. Radius dimpling is accomplished by stationary or portable squeezers using suitable size dies, or by using the rivet to be driven as the male die. Coin dimpling, (see Figure 5-8), is done on portable or stationary squeezers, using dies subject to high ram pressures. These dies form the dimple and then swage the metal into a nearly perfect seat for the rivet. Unlike the radius dimple, the included angles of nesting coin dimples do not vary. Coin dimpling is the preferred method. On harder types of metal, heat is used on the dies to form the metal without cracking. This is called hot coin dimpling. Dimpling of metal to metal bonded parts and of extruded material to any alloy temper or thickness is prohibited.

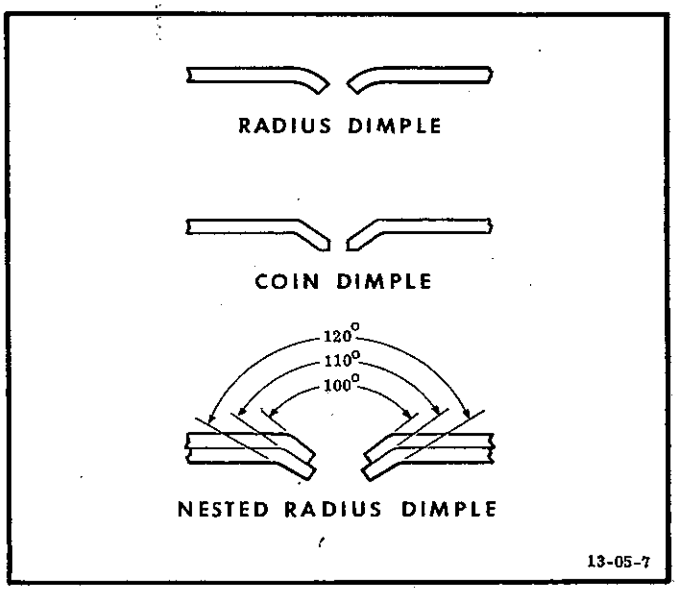


Figure 5-8 Dimples

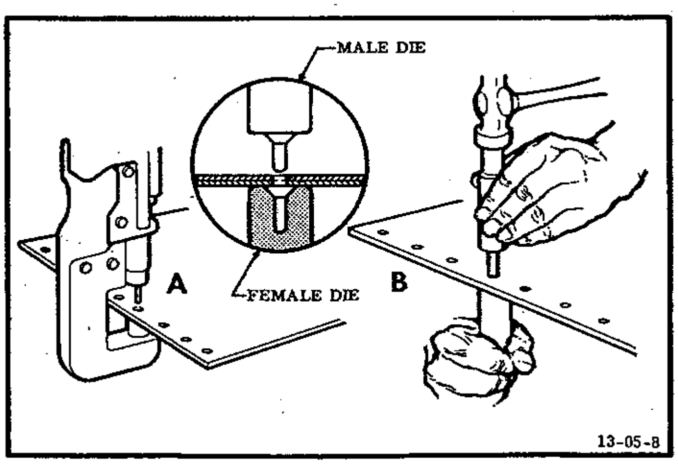


Figure 5-9 Radius Dimpling

Radius Dimpling

28 Dimpling dies for light work may be set up in portable pneumatic or hand squeezers, as shown at (A) on Figure 5-9. For repair work, the dies can be held by hand as in (B). If dies are used with a squeezer, they must be adjusted accurately to the thickness of the sheet being dimpled. For sheet thickness for predimpling, see Figure 5-10.

Radius Dimpling with Rivet (Draw Dimpling)

29 Dimpling with the rivet is a method of flush rivetting in which the rivet is drawn into the materials, thereby forming its own countersink. The rivet may be drawn by squeezing, using a flat dolly in one member of the squeezer and a dimpling die, or a draw-set, having an angle of 115° in the other member. The flat dollies are then used to upset the rivet.

30 Where squeezers cannot be used because of inaccessibility, the dimpling and rivetting may be done with pneumatic hammers, a draw set, and suitable bucking bars. For dimensions of typical bucking bars, see Figure 5-11. To dimple the material, insert the rivet (A), (see Figure 5-12), in the drilled hole and place a swivel draw set (B) over the shank of the rivet on the inside of the structure. Use the draw set in a hammer, usually of 4X size, which is adjusted to give a hard blow. Hold a bucking bar (C) against the head of the rivet, and, with

Diameter of Rivet	Thickness of Outer Sheet		*Max. Thickness of Middle Sheet	Thickness of Inner Sheet	
	Min.	Max.		Min.	Max.
3/32	.020	.064	.064	.016	.064
1/8	.020	.081	.081	.020	.081
5/32	.020	.081	.081	.025	.081
3/16	.020	.081	.081	.032	.081
1/4	.020	.093	.093	.051	.093

*Dimension omitted when only two sheets are used.

Figure 5-10
Sheet Thicknesses for Predimpling

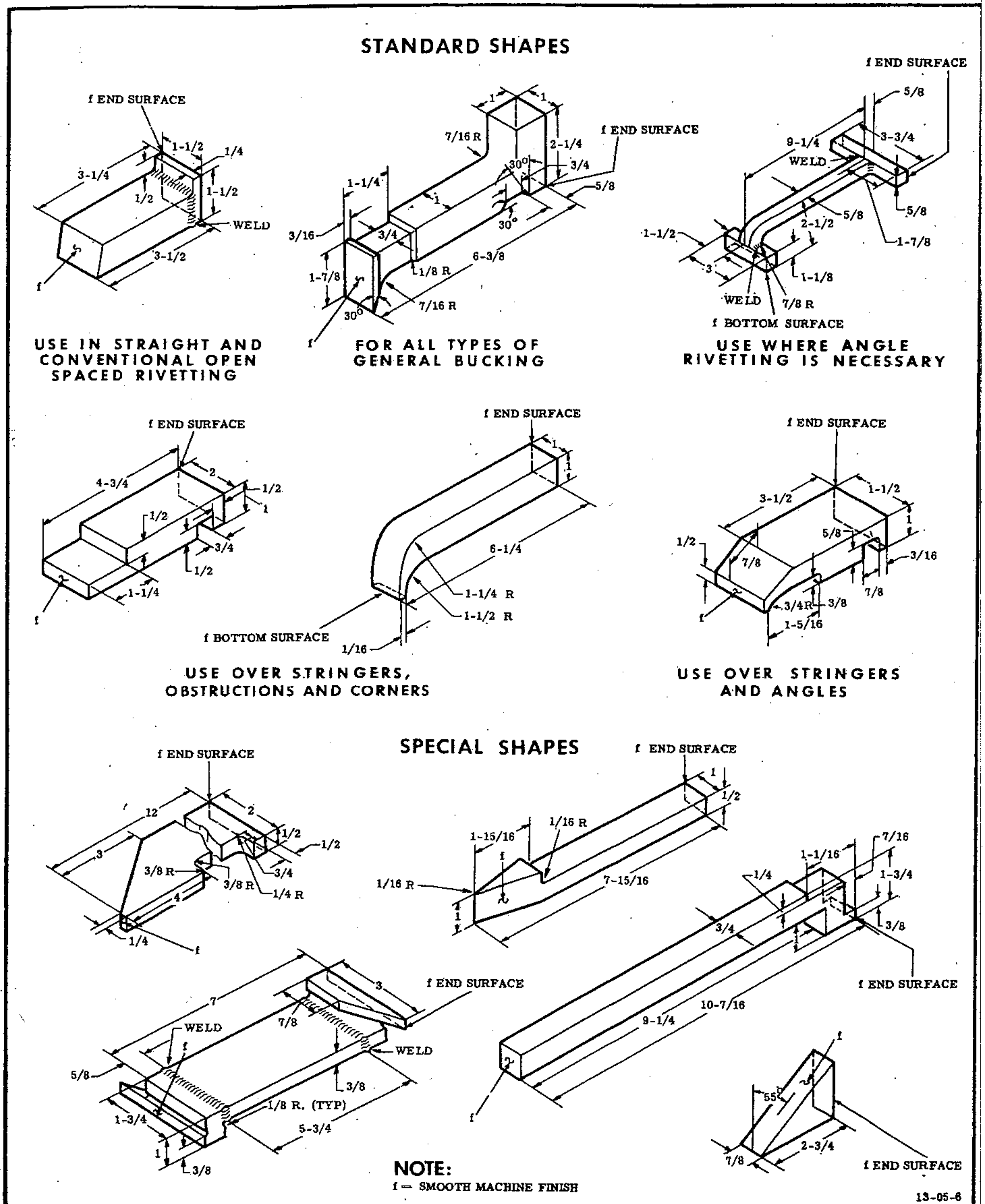


Figure 5-11 Bucking Bars

a short burst, draw the rivet flush with the skin as shown in view (B). The adjustment of the hammer should be carefully made, since too light a blow will not draw the rivet flush with the skin and too hard a blow will damage the skin by dimpling it too deeply. Ensure that blows are properly timed. If the burst is timed too short or too long, it has the same effect as either too light or too heavy a blow.

31 A number of rivets may be inserted and the dimpling done before they are upset. Since the draw set is countersunk at 115°, the metal is forced in toward the shank of the rivet and holds it in place. The rivets are then upset in the usual manner by bucking from the inside and hammering from the outside. Alternating the hammering action from inside to outside in the dimpling and rivetting operations prevents buckling and keeps the outer skin smooth and taut.

Limitations of Dimpling with Rivets

32 Limits for dimpling with the rivet, are given for the total thickness of the sheets, the thickness of the outer skin, and the thickness of the inner sheet, (see Figure 5-13). If three parts are being rivetted together, the thickness of the middle sheet is governed by the thickness of the outer and inner sheets.

Coin Dimpling

33 For operation of dimpling machines, refer to EO 70-50-5A/1. For spacing, gauge limits and tool operating temperatures, see Figures 5-14 and 5-15.

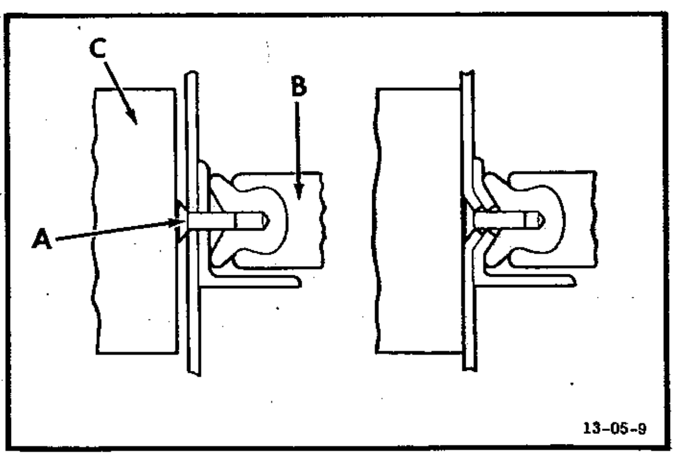


Figure 5-12 Radius Dimpling Completed

Testing Dimples

34 Prior to dimpling, make a test specimen, (see Figure 5-16), as follows:

(a) The specimen should be of the same material, heat-treat and thickness as the skin to be dimpled. A suitable size is 1 inch by 8 inches.

(b) Drill at least six holes along the centre line. Dimple the holes.

(c) Bend the specimen across the dimples as shown and inspect for acceptability. (See Figure 5-17.)

35 Drive flush rivets by the same methods and in the same manner as rivets with universal heads. To avoid cracking the dimple of the inner sheet, align the dimpled rivet holes before the rivet is driven and draw the sheets tightly together. Do not upset rivet shank too flat, (see Figure 5-1, Detail A). If rivet holes are out of alignment, the rivets will be clinched and will crack the dimple of the inner sheet, especially if the material is thin. To ensure that the sheets are drawn tightly together so that the rivet cannot upset between the sheets and so crack the inner dimple, use a draw buck as shown in Figure 5-18. Place the draw buck (A) over the shank of the rivet (B) and, with a few blows of the hammer and rivet set (C), draw the sheets tightly together.

Cut Countersinking

36 For cut countersinking, predrill the rivet holes to rivet size and then countersink. The

Diameter of Rivet	Total Thickness of Sheet	Max. Thickness of Outer Sheet	Thickness of Inner Sheet	
			Min.	Max.
3/32	.073	.036	.025	.036
1/8	.093	.051	.032	.051
5/32	.101	.064	.040	.064

Note: Total thickness of outer and inner sheets must not exceed values given in the second column.

Figure 5-13
Sheet Thicknesses for Dimpling with Rivet

countersink pilot size must correspond to the drilled hole size. Keep the cutter sharp to avoid chatter and vibration which would result in improper seating of the rivet head. Countersinks must be capable of .001 inch adjustments.

Rivet Milling

37 Rivet heads must be flush within the tolerances shown in Figure 5-19. This can be accomplished with a micro-shaver which will mill a rivet head on a flat or convex surface but not on a concave surface. Place the tool directly over the rivet head and apply pressure evenly on a flat surface. When used on a convex surface, place the tool on the chordline of the curve and rock in order to mill the rivet to the rounded contour. Take care not to touch the sheet with the cutter.

NOTE

When rivet heads are shaved, the head

Rivet Dia.	Min. Edge Distance For Dimpled Joints	Spacing for Dimpled Joints		Min. Thickness For Machine C'Sink	Min. Thickness For Machine C'Sink
		Minimum	Maximum		
3/32	1/4	7/16	1-1/2	.040	.050
1/8	5/16	9/16	1-1/2	.050	.063
5/32	3/8	23/32	1-1/2	.063	.071
3/16	7/16	27/32	1-1/2	.071	.080
7/32	1/2	1	1-1/2	.080	.090
1/4	9/16	1-1/8	1-1/2	.100	.112

NOTE

Minimum edge distance for joints other than dimpled joints is 2 x hole diameter.

Minimum spacing for joints other than dimpled joints is 4 x hole diameter.

Rivet Diam.	Thickness For Dimpling											
	Minimum				Maximum							
			Titanium			Stationary Squeezer				Portable Squeezer		
						Titanium		C.R. Steel			C.R. Steel	
	Al. Alloy	Milled Al. Alloy Clad On Top	Pure AMS 4900 4901	Alloy AMS 4908	Al. Alloy	Pure AMS 4900 4901	Alloy AMS 4908	Anld	1/2H	Al. Alloy	Anld	1/2H
3/32	.020	.020	.016	.025	.051	.063	.056	.050	.050	.051	.050	.050
1/8	.020	.025	.016	.025	.064	.063	.063	.063	.063	.064	.063	.050
5/32	.025	.032	.016	.025	.072	.100	.063	.080	.063	.064	.063	.036
3/16	.032	.040	.016	.025	.091	.100	.100	.080	.063	.051	.050	.032
7/32	.032	.040	.016	.025	.091	.100	.100	.080	.063	.051	.050	.032
1/4	.040		.025	.025	.102	.063	.063	.063	.050	.102	.063	.050

Figure 5-14 Spacing and Gauge Limits

diameter must not be reduced by more than 5%.

Flushness Tolerance of Countersunk Rivets

38 To determine flushness tolerance of countersunk rivets, see Figure 5-19

SUBSTITUTION

General

39 If a rivet is replaced by a rivet of lower strength material, the substitute rivet must be larger than the original rivet in order to have an equivalent strength in single shear. For a guide for such substitutions, see Figure 5-20. The rivets in any column may be replaced by the rivets shown in the column immediately to the right of it. When making a substitution between materials not shown in adjacent columns to the right, the shear strengths of the rivets, as shown in the table, will have to be compared to find the substitute of correct size.

40 When substitutions are made to the left of any column, use the same diameter rivet, irrespective of shear strength.

41 Allowable single shear strengths of some commonly used British rivets are shown in Figure 5-21.

Rivet Number Code

42 For rivet numbering code, see Figure 5-22.

Material or Group of Materials	Temperature -°F		
	Both Tools Unheated	Hot (1)	
		2 Heated Tools	1 Heated Tool
Aluminum Alloy 14S-T6, 24S-T (all heat treated tempers) and 75S-T6	Prohibited (3)	500°(±25°)	575°(±25°)
Corrosion Resistant Steel (2)	Room Temperature	500°(±25°)	575°(±25°)
Titanium Burr Both Sides Prior to Dimpling	Prohibited	750°(±25°)	
Other Aluminum Alloys	Room Temperature	Not required	Not required

NOTE

(1) When hot dimpling, use the two heated tools method unless the application necessitates the one heated tool method. Allow 30 minutes for the tools to heat up, if not provided with an automatic temperature control.

(2) Dimple corrosion resistant steel at room temperature, if the dimples are found satisfactory. If not, one of the heated tool methods must be used. Dimple characteristics must be the same as that required for aluminum alloys. In some cases it may be necessary to pass a sizing drill through the dimpled hole to eliminate burrs. Burring of holes before dimpling should not be done.

(3) Dimple 24S-T (all heat treated tempers) hot as specified in the table or cold at room temperature.

Figure 5-15 Coin Dimpling Temperatures

Applications of Standard Rivet Types

43 For applications of standard rivet types, see Figure 5-23.

Substitution of Bolts for Rivets

44 Use AN-3 series bolts or AN502, AN525 or NAS220 series screws to replace standard solid shank rivets only when the proper rivets or rivetting equipment is not available. Use bolts or screws of the same size as the replaced rivet, ensuring that a close fit is obtained.

Replacement Precautions

45 In replacing monel rivets, do not use cadium plated bolts where subject to temperatures over 450°F (233°C), or zinc plated bolts where subject to 700°F (371°C) or above.

Colouring of Rivets

46 The practice of colour coding rivets has been abandoned with these exceptions:

(a) DuPont rivets are colour coded for grip length. (Refer to Paragraph 93, following.)

(b) 56S blind rivets (for magnesium) are frequently coloured orange.

(c) 56S solid rivets are sometimes coloured red or orange.

17S-T DH Rivets

47 17S-T rivets, driven hard, (17S-T DH) may be substituted for 24S-T rivets. Since ultimate allowable shear strength of the 17S-T rivets is 35,000 pounds per square inch, this

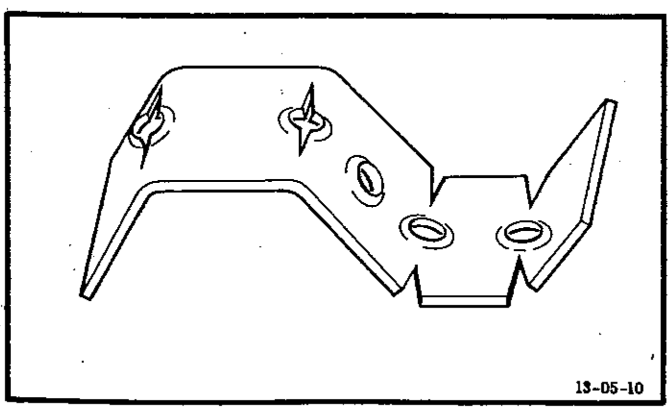


Figure 5-16 Bend Test Specimen

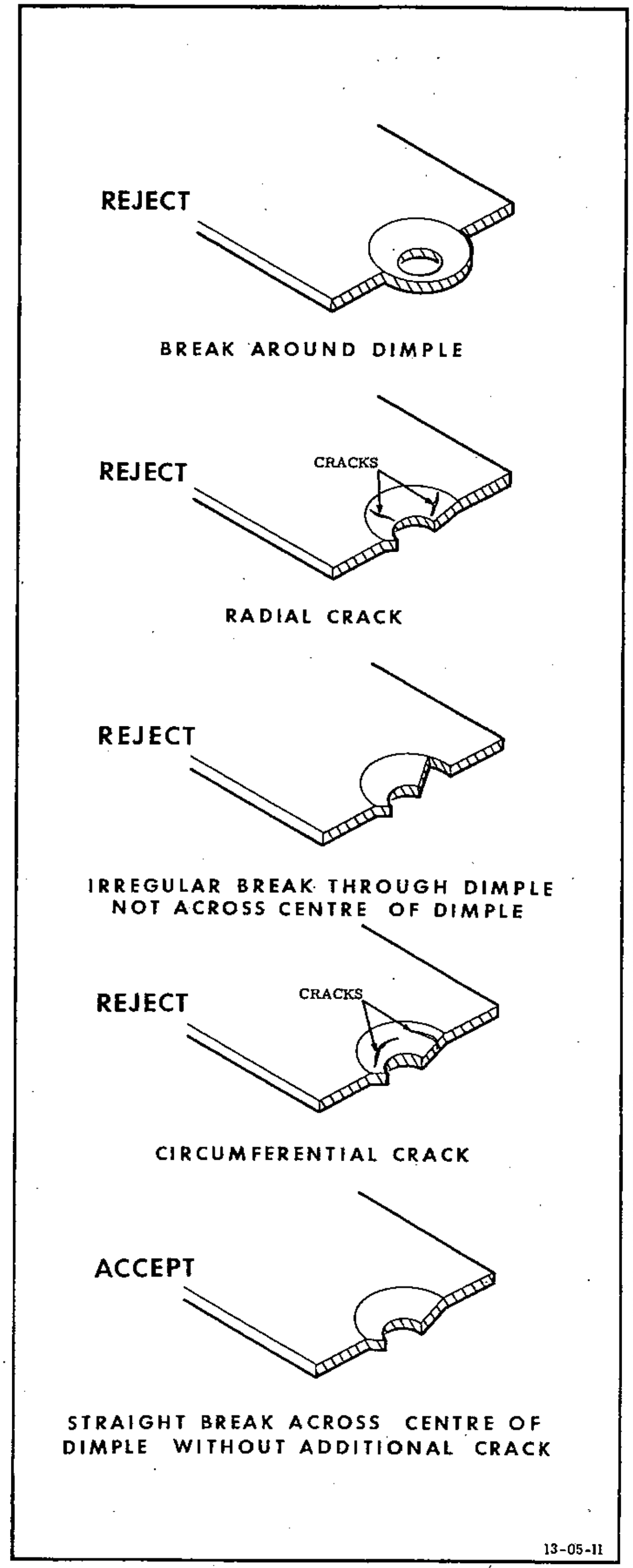


Figure 5-17
Acceptability of Dimples on Bend Test

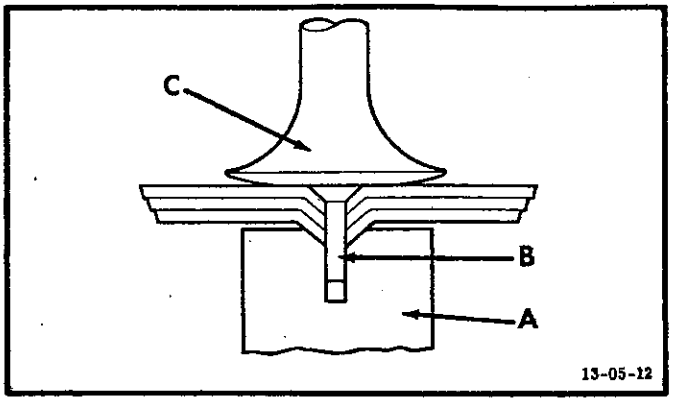
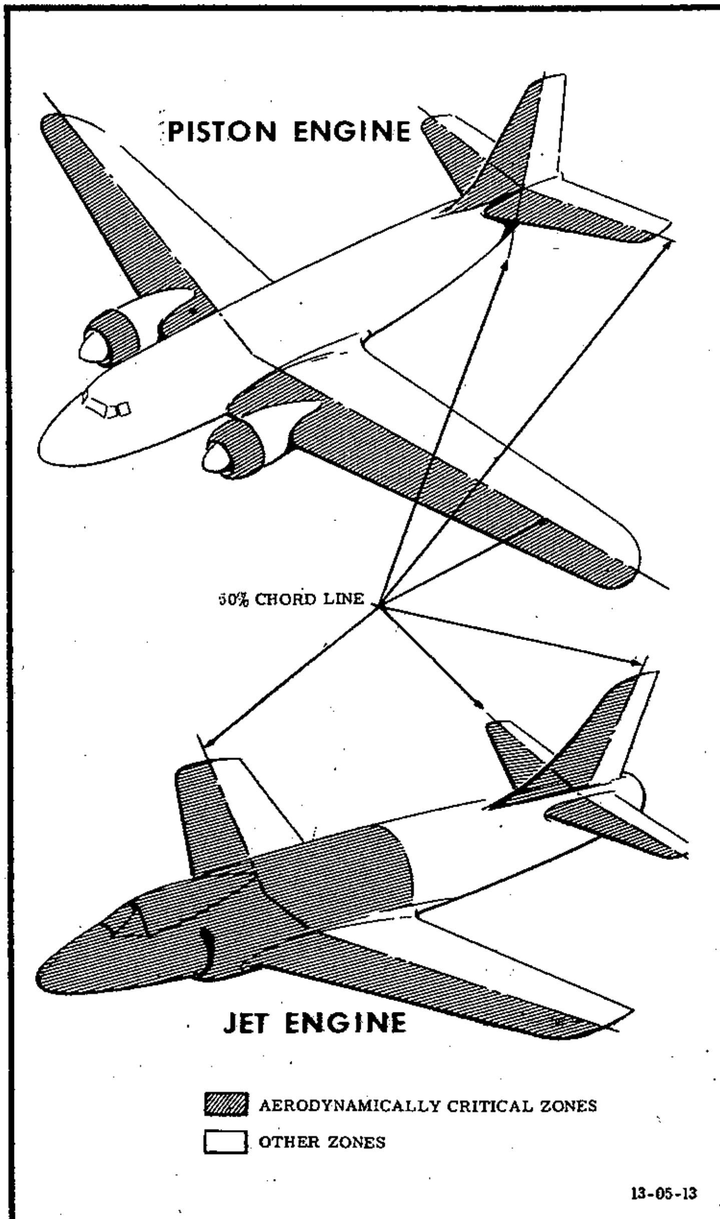


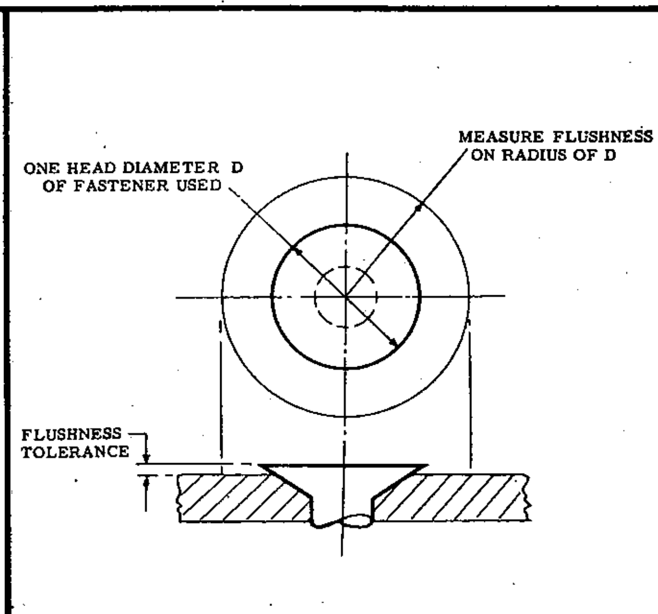
Figure 5-18 Draw Bucking of Rivets

substitution is, therefore, only applicable to odd designs which were based on a shear strength of 35,000 pounds per square inch for 24S-T rivets.

48 Before driving, the rivets are to be aged at room temperature at least four days after quenching. The driven head diameter is to be at least 1.5 times the nominal shank diameter of the rivet.

49 17S-T rivets, driven hard, can be successfully substituted for other rivets in most places, with the possible following exceptions:





Type of Aircraft	Surface	Flushness Tolerances: Critical Zones (1): C'Sunk Joints	Flushness Tolerances: Critical Zones (1): Dimpled Joints	Flushness Tolerances: Non-Critical Zones: C'Sunk Joints	Flushness Tolerances: Non-Critical Zones: Dimpled Joints
Jet Propelled	Contoured	+.002 -.000	+.002 -.004		
Flat		+.002 -.000	+.002 -.002	+.010 -.000	+.010 -.004
Propeller Driven	Flat & Contoured	+.005 -.000	+.005 -.004		

Figure 5-19 Flushness Tolerance Application

24S-T		17S-T HD		17S-T		A17S-T		56S	
Dia.	Shear Pound	Dia.	Shear Pound	Dia.	Shear Pound	Dia.	Shear Pound	Dia.	Shear Pound
						1/16	92	3/32	187
				1/16	104	3/32	207	1/8	331
		1/16	116	3/32	235	1/8	367	5/32	517
1/16	126	3/32	262	1/8	416	5/32	574	3/16	746
3/32	283	1/8	466	5/32	651	3/16	828	1/4	1325
1/8	503	5/32	730	3/16	940	1/4	1470	5/16	2070
5/32	786	3/16	1050	1/4	1670	5/16	2300	3/8	2980
3/16	1134	1/4	1870	5/16	2610	3/8	3310		
1/4	2020	5/16	2920	3/8	3760				
5/16	3146	3/8	4200						

Figure 5-20 Permissible Rivet Substitutions and Single Shear Strengths

Rivet Diameter	3/32	1/8	5/32	3/16	7/32	1/4	5/16	3/8
LS 37 Snap and Countersunk	260	450	730	990	1380	1730	2750	3900
LS 57 Snap and Countersunk	225	425	620	880	1110	1570		

Figure 5-21 Allowable Single Shear Strengths of British Rivets

Rivet Number Code: AN426AD5-12

AN 426 AD 5 12

- 12 — Lengths in 16ths of an inch
- 5 — Diameter in 32nds of an inch
- AD — Material code as shown (A17S-T)
- 426 — Head style
- AN — Army-Navy Specification

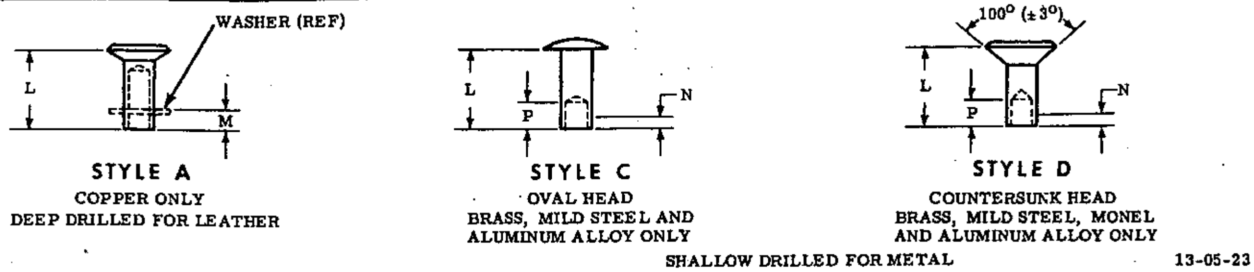
The predominating colour of labels for boxes of AN rivets are as follows: 2S - White, 24S-T - Red, 17S-T - Yellow, A17S-T - Orange, 56S - Blue.

Figure 5-22 Standard Rivet Numbering Code

<table>
<tr><th rowspan="2">Rivet Material</th><th>Dimpled</th><th>Raised Teat</th><th>Raised DoubleDash</th><th>Raised Cross</th><th>Plain</th><th>Triangle</th><th>Plain</th></tr>
<tr><th>Al. Alloy A17S-T4</th><th>Al. Alloy 17S-T4</th><th>Al. Alloy 24S-T4</th><th>Al. Alloy 56S-F</th><th>Al. 2S-F</th><th>Mild Steel Cad-Plated</th><th>Monel</th></tr>
<tr><td>Universal Head</td><td>AN740AD</td><td>AN470D</td><td>AN470DD</td><td>AN470B</td><td>AN470A</td><td></td><td>NAS508M</td></tr>
<tr><td>Round Head</td><td></td><td></td><td></td><td></td><td></td><td>AN435C</td><td>AN435M</td></tr>
<tr><td>Flush Head</td><td>AN426AD</td><td>AN426D</td><td>AN426DD</td><td>AN426B</td><td>AN426A</td><td>AN427C</td><td>AN427M</td></tr>
<tr><td>Max temp for Strength</td><td>200° F</td><td>200° F</td><td>200° F</td><td>200° F</td><td></td><td>550° F</td><td>1000° F</td></tr>
<tr><td>Sizes</td><td>3/32, 1/8 5/32</td><td>3/32, 1/8 5/32</td><td>3/16 Dia & over</td><td>All Sizes</td><td>All Sizes</td><td>5/16 Dia max</td><td>3/16 Dia max</td></tr>
<tr><td>Al. Alloy to Al. Alloy</td><td colspan="3">Preferred</td><td>Prohibited</td><td>(1)</td><td colspan="2">Prohibited</td></tr>
<tr><td>Al. Alloy to Cad-Plated Steel</td><td colspan="3" rowspan="3">(2)</td><td colspan="2" rowspan="6">Prohibited</td><td rowspan="6">Preferred
(3)</td><td rowspan="6">Prohibited</td></tr>
<tr><td>Al. Alloy to Corr-Res Steel</td></tr>
<tr><td>Al. Alloy to Titanium</td></tr>
<tr><td>Cad-Plated Steel to Cad-Plated Steel</td><td colspan="3" rowspan="3">Permissible but Undesirable</td></tr>
<tr><td>Cad-Plated Steel to Corr-Res Steel</td></tr>
<tr><td>Cad-Plated Steel to Titanium</td></tr>
<tr><td>Corr-Res Steel to Corr-Res Steel</td><td colspan="3" rowspan="3">Prohibited</td><td colspan="3" rowspan="3">Prohibited</td><td rowspan="3">Preferred</td></tr>
<tr><td>Corr-Res Steel to Titanium</td></tr>
<tr><td>Titanium to Titanium</td></tr>
<tr><td>Magnesium Alloy to Magnesium Alloy</td><td colspan="3" rowspan="3">Prohibited</td><td rowspan="3">Preferred</td><td colspan="3" rowspan="3">Prohibited</td></tr>
<tr><td>Magnesium Alloy to Cad-Plated Steel</td></tr>
<tr><td>Magnesium Alloy to Al. Alloy</td></tr>
<tr><td>Soft Material</td><td colspan="2">Acceptable</td><td>Prohibited</td><td>Undesirable</td><td>Preferred</td><td colspan="2">Prohibited</td></tr>
</table>

Note: (1) May be used for welding, where extra softness is required, or for plugging holes.
(2) May be used for weight saving or strength.
(3) Not recommended for structural applications.

Figure 5-23 Applications of Standard Rivet Types



	Lengths (L) and Dash Numbers (For Mild Steel)											Dimensions		
Dia.	1/8	5/32	3/16	7/32	1/4	5/16	3/8	7/16	1/2	5/8	3/4	M	N	P
3/32			6-6		6-8	6-10	6-12		6-16	6-20			1/16	1/1
1/8	8-4	8-5	8-6	8-7	8-8	8-10	8-12	8-14	8-16	8-20	8-24		1/16	1/1
9/64	9-4	9-5	9-6	9-7	9-8	9-10	9-12	9-14	9-16	9-20	9-24	3/32	1/16	1/8
3/16	12-4	12-5	12-6	12-7	12-8	12-10	12-12	12-14	12-16	12-20	12-24	1/8	3/32	1/8

Use Washer AN960CU11 on 9/64 Dia. Style A Rivet, AN960CU316 on 3/16 Dia. Style A Rivet.
M and N = Rivetting Allowance.

These Rivets may be used only within the restrictions of the applicable maintenance manual, or with the approval of engineering authority.

Material: Brass, Specification QQ-W-321, Grade B; Monel, Specification QQ-N-281, annealed; 1010 or 1015 Mild Steel; Copper, QQ-W-341, Aluminum Alloy A17S-T.

Finish: Mild Steel Rivets shall be cadmium plated, Specification AN-P-61, or Zinc Plated, Specification AN-P-32.

Sample Callout

AN450 A 12 C 8

- 8 — Length in 32nds
- C — Material*
- 12 — Dia. in 64ths
- A — Rivet Style

* C: for Copper
B: for Brass
M: for Monel
AD: for A17S-T

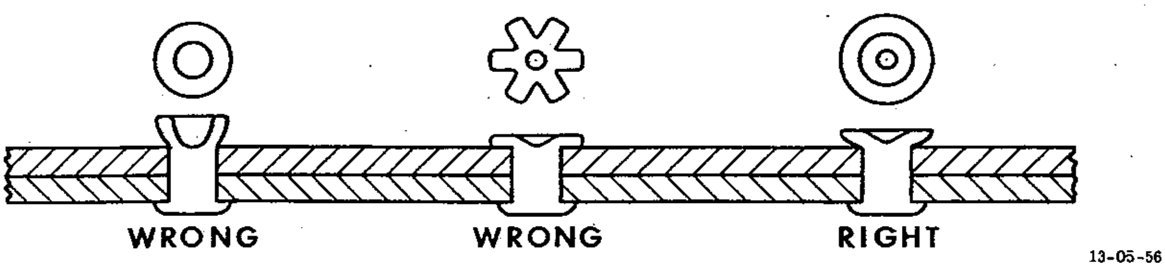


Figure 5-24 AN450 Tubular Rivet

(a) In tight corners and places not easily accessible to the bucker.

(b) On thin skin assemblies, as the skin tends to become dished

(c) In regions where long rivets are employed, as the long rivets tend to buckle.

(d) Where the head is adjacent to soft material (such as aluminum sheet 2SO).

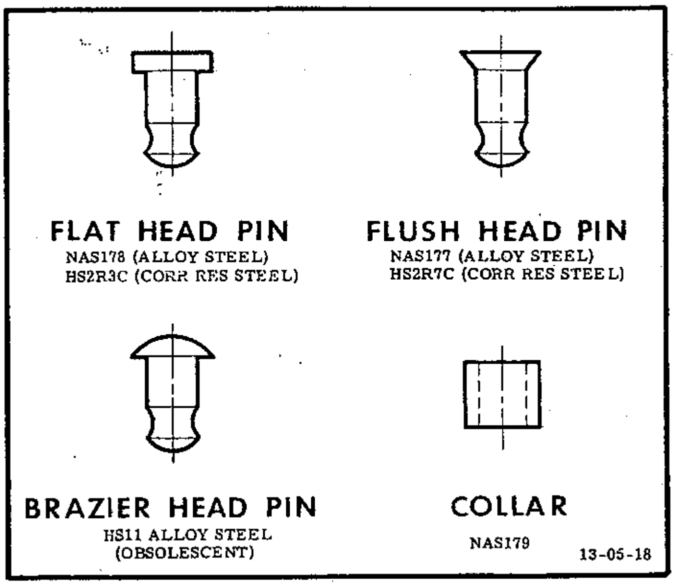


Figure 5-25 Hi-Shear Rivet Types

AN450 TUBULAR RIVETS

General

50 Tubular rivets (Item 3) should be installed with the head against the soft material and projecting through the material from 3/64 to 5/64 inch, then upset by the use of a specially-shaped set which curls the point rather than flattening or splitting it. Hole size for tubular rivets is to be the same as for solid rivets.

Upset of Tubular Rivets

51 The point should be swelled sufficiently to bear against the hole and the rivet must not be loose in the hole. The upset need not curl back against the sheet. For table of tubular rivets, see Figure 5-24.

HI-SHEAR RIVETS

NOTE

Hi-Shear rivets are not at present authorized for field use and should be replaced with similar size AN bolts. Where spotfacing is required, approval must be obtained from the engineering authority. For replacement of flush Hi-Shear rivets, refer to Part 24, following.

Hi-Shear Rivet Size	Standard Rivet		Oversize Rivet
	Pilot Hole	Final Hole	Final Hole
3/16	.172-.176 (No.17)	.189 -.192 (No.12)	.2045-.2085 (No. 5)
1/4	.227-.231 (No.1)	.249 -.254 (1/4)	.265 -.270 (H)
5/16	.280-.285 (9/32)	.3115-.3165 (5/16)	.3281-.3321 (21/64)
3/8		.374 -.379 (3/8)	.3906-.3946 (25/64)
7/16		.4365-.4415 (7/16)	.4531-.4571 (29/64)
1/2		.4995-.504 (1/2)	.5156-.5206 (33/64)
Holes to be dimpled shall be pilot drilled dimpled and be drilled to size.			

Figure 5-26 Hi-Shear Rivet Hole Drill Sizes

General

52 Hi-Shear rivets are used primarily for shear loads and permanent attachment only. The rivets are installed with rivetting equipment, requiring accessibility from both sides, but are unlike ordinary rivets in other respects. The Hi-Shear rivet consists of two parts; a cadmium-plated alloy steel pin, heat-treated to a tensile strength of 125,000 pounds per square inch, with a head on one end, a groove at the other end, and an aluminum alloy retaining collar. Only the collar is upset during installation, being forced into the groove on the pin by axial pressure from a special tool which simultaneously gives the collar its conical shape and trims and ejects the excess collar material. For Hi-Shear rivet types, see Figure 5-25.

53 As the pin does not swell during assembly, continuous support is not needed. Thus, hollow sections which are sufficiently rigid to withstand the axial pressure of the collar-upsetting operation may be successfully rivetted.

54 The alloy steel standard pin is comparable to a standard AN bolt in regard to material, body diameter, heat treatment and finish. (The so-called 3/16 size Hi-Shear rivet is the size of a No. 10 screw.) Hi-Shear rivets are available in sizes 3/16, 1/4, 5/16 and 3/8 inch diameters.

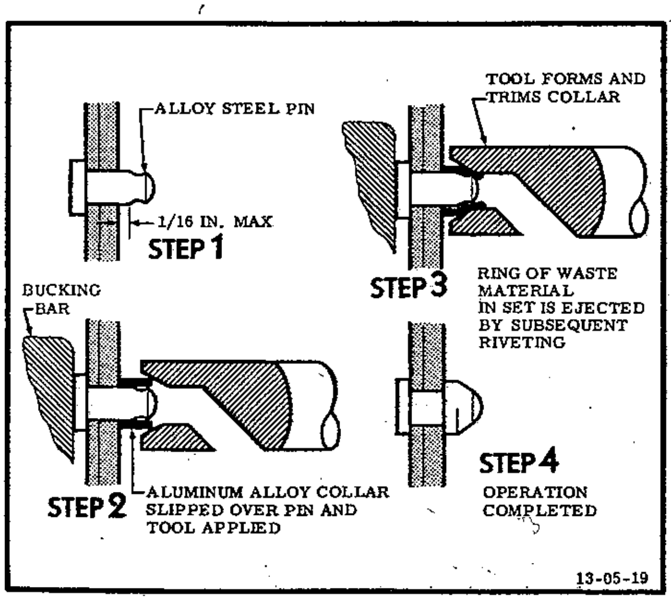


Figure 5-27 Hi-Shear Rivetting

Coding

55 The first dash number indicates nominal diameter in 1/32 inch, the second dash number indicates maximum grip in 1/16 inch. The collar dash number is the nominal inside diameter in 1/32 inch. Collars are one length only for each diameter. Rivet heads are marked with a cross similar to AN bolts. For table for approved drill sizes when drilling for Hi-Shear rivets, see Figure 5-26.

Rivetting

56 For selection and grip length, determine the proper length rivet by the rivet code number or by trial. The last dash number of the rivet code gives the maximum grip length in 1/16 inch. In determining the length by trial, the straight portion of the shank should be flush or extend up to 1/16 inch from the work, (see Figures 5-25 and 5-27). Use a washer only if correct length pin is not available. The length of pin is governed only by the X lengths, (see Figure 5-28).

57 For hole sizes required for dimpling and countersinking, see Figures 5-29, 5-30 and 5-31.

58 Where machining is required, use spot-face dimensions as shown in Figure 5-32.

Tool Clearances

59 Minimum clearances for driving Hi-Shear rivets are shown in Figure 5-33.

Installation

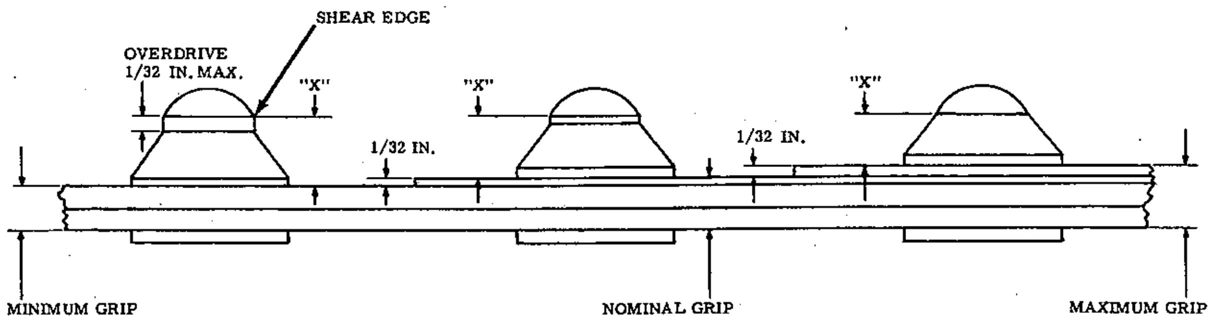
CAUTION

Do not rework the ends or internal surfaces of Hi-Shear rivet sets.

60 Hi-Shear rivet collars in the as received condition automatically supply the internal lubrication to the rivet sets as they are driven. (See Figure 5-27.)

61 Where the retention of pins and collars during installation is difficult, use sealing compound (Item 4) to hold them in place. Take care that the area where the compound is to be applied is free from all chips and dirt.

ACCEPT

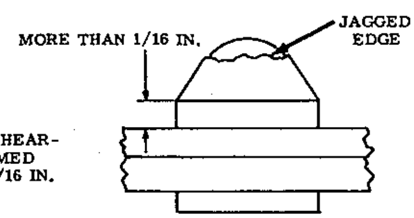


RIVET SIZE "X"

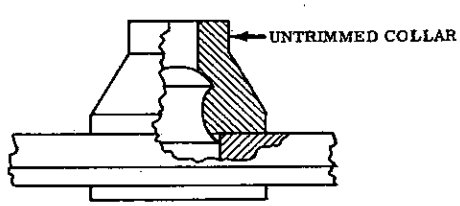
3/16 IN.	0.115 - 0.197
1/4 IN.	0.155 - 0.237
5/16 IN.	0.196 - 0.278
3/8 IN.	0.238 - 0.320
7/16 IN.	0.279 - 0.361
1/2 IN.	0.320 - 0.402

REDRIVE

REDRIVE IF COLLAR BREAKS OFF ABOVE SHEAR-EDGE AND THE THICKNESS OF THE UNFORMED PORTION AT THE COLLAR BASE EXCEEDS 1/16 IN.

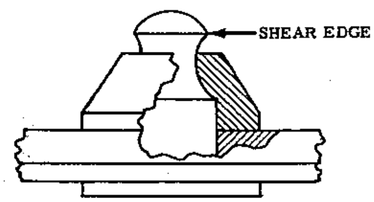


REJECT



PIN TOO SHORT

REPLACE BY ANOTHER PIN ONE DASH NUMBER LONGER, WITH OR WITHOUT A WASHER IF UNABLE TO TRIM COLLAR AND IF THE DRIVING TOOL IS IN DANGER OF MARRING THE WORK.



PIN TOO LONG

REPLACE BY ANOTHER PIN ONE DASH NUMBER SHORTER OR USE THE SAME PIN WITH A WASHER IF A GAP EXISTS BETWEEN SHEAR-EDGE AND TOP OF COLLAR.

13-05-22

Figure 5-28 Hi-Shear Rivet Acceptability Limits

BLIND RIVETS

General

62 Blind rivets are designed to take care of rivetting jobs in inaccessible places or in double surfaced structures where access to both sides of the work is impossible.

Interchangeability of Blind Rivets

63 Blind rivets have been standardized within the RCAF for modification, maintenance and repairs to Cherry and Huck self-plugging rivets. Cherry and Huck pull-through hollow type rivets are to be used where there is not sufficient clearance to allow installation of the self-plugging type rivets.

64 Various American type blind rivets, the material thickness to be rivetted and the reference number of the Cherry self-plugging rivets are shown in Figure 5-34. The rivets listed in Columns 7 to 10 inclusive may be substituted by those shown on the same line in Column 4 or replaced if the hole is within tolerances. Where the hole is beyond tolerances the oversize rivets in Column 6 or the next larger diameter of the nominal size rivets in Column 4 may be used.

65 The explosive rivets shown in Columns 11 and 12, may be substituted by those shown in the same line in Column 6 or replaced if the hole is within tolerances. Where the hole is beyond tolerances the next larger shank diameter of the nominal size rivet in Column 4 may be used.

66 Where the grip length range of the rivets in Columns 11 and 12, covers two grip length dash numbers in Columns 4 and 6, it is recommended that the material thickness be determined before making the rivet selection.

NOTE

For definition of grip length, see Figure 5-1.

67 The type and diameter of the self-plugging Cherry rivets that may be substituted for the Canadian standard and the British type (Chobert and Tucker) rivets are shown on the same line in Figure 5-35. The grip length for the Cherry rivet is to be determined by measurement. The Canadian standard rivet uses the same dash numbers for the diameter and length as the Cherry rivet code.

Rivet Size	Thickness			
	Aluminum Alloy	Milled Al.Alloy Clad on Top	Titanium Pure AMS 4900 4901	Titanium Alloy AMS 4908
3/16	.020	.032	.016	.025
1/4	.025	.040	.016	.025
5/16	.032	.050		

Figure 5-29
Minimum Material Thickness for Dimpling

Fastener Size	Stationary Squeezer					Portable Squeezer		
	Aluminum alloy	Corrosion Resistant Steel		Titanium		Aluminum alloy	Corrosion Resistant Steel	
		Annealed	1/2 Hard	Pure AMS4900 AMS4901	Alloy AMS4908		Annealed	1/2 Hard
3/16	.081	.080	.080	.063	.063	.064	.050	.032
1/4	.091	.063	.050	.063	.063			
5/16	.091	.050	.050					

Figure 5-30 Maximum Material Thickness for Dimpling

68 The protruding head rivets shown in Columns 5 and 6, may be replaced by the Cherry rivet shown on the same line if the hole is within tolerance. Where the hole is beyond tolerance, the next larger size rivet must be used. In replacing the aluminum alloy rivets, the Cherry CR179 oversize rivet may be used.

69 The countersunk head rivets shown in Columns 5 and 6, may be replaced by the next larger size rivet to that shown on the same line after the holes have been recountersunk to 100° included angle.

70 If the hole is within tolerance, A17S-T solid rivets may be replaced by self-plugging Cherry or Huck rivets, substituted size for size. Where the hole is beyond tolerance, the oversize Cherry or the next larger nominal Cherry rivet must be used. 17S-T or 24S-T solid rivets may be substituted by the next larger nominal size self-plugging Cherry or Huck rivets. Where the hole is beyond tolerance, the next larger oversize rivet or the second larger nominal size self-plugging Cherry rivet is to be used.

Rivet Size	Countersink	Sub-Countersink
3/16	.063	.071
1/4	.071	.080
5/16	.080	.090
3/8	.090	
7/16		
1/2		

Figure 5-31 Minimum Material Thickness for Countersinking

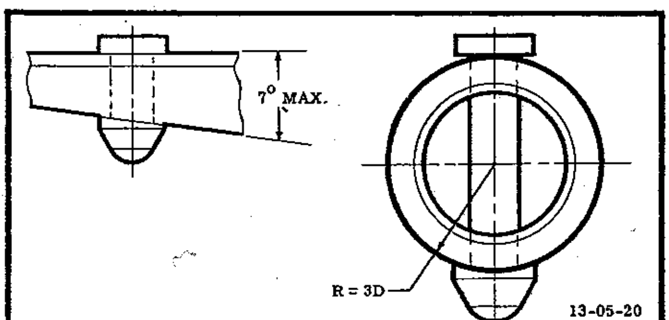


Figure 5-32 Hi-Shear Machining Dimensions.

71 Hole tolerance may be checked with the Cherry rivet hole size gauge and the grip length or thickness determined by the use of the Cherry selector gauge.

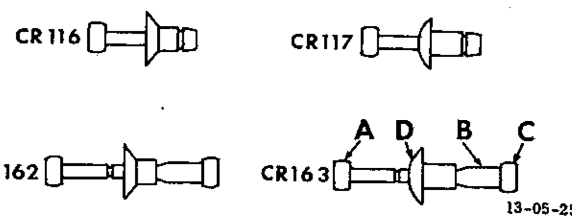
NOTE

Blind rivets should be used to replace solid rivets only when the layout of the repair makes it impossible to buck solid rivets. The close out should always be planned to permit the largest possible proportion of the rivets to be solid.

Cherry Blind Rivets

72 Cherry blind rivets (Item 5) are made in two types, self-plugging and hollow pull-through. For Cherry rivet types, see Figure 5-36.

73 The self-plugging type operates as follows:



(a) The rivet gun, manual or pneumatic, bearing down on the rivet head pulls the stem of the rivet by its head (A).

(b) The plug section (B) on being drawn through the hollow Cherry rivet, expands it.

(c) The upsetting head of the stem (C) enters the blind end of the rivet, thus forming a tulip shape head tight against the inner sheet.

(d) The stem, made of aluminum alloy, then breaks off at the groove (D) leaving the plug section a force fit in the rivet.

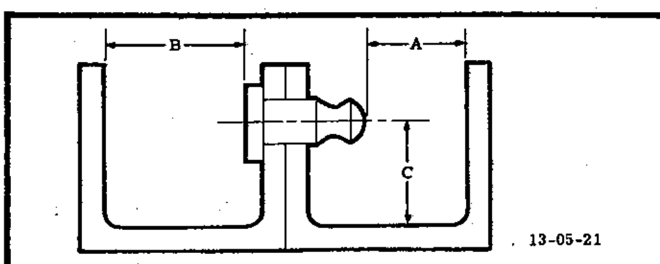


Figure 5-33 Hi-Shear Clearances

Thickness to be rivetted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #30		Drill #29						
			CR162		CR178		1195	LS1126	9SP-100	DR-134	1195
.030	1/8	18363	-4-2	19736	-4-2	462-4-1	-4BC-6	-4-2	-A4-1		-4AC-4
.045	1/8	18363	-4-2	19736	-4-2	462-4-1	-4BC-6	-4-2	-A4-1	-100-6	-4AC-4
.064	1/8	18363	-4-2	19736	-4-2	462-4-1	-4BC-6	-4-2	-A4-1	-100-6	-4AC-6
.065	1/8	18363	-4-2	19736	-4-2	462-4-1	-4BC-6	-4-2	-A4-1	-100-8	-4AC-6
.078	1/8	18363	-4-2	19736	-4-2	462-4-1	-4BC-6	-4-2	-A4-1	-100-8	-4AC-8
.079	1/8	18328	-4-4	18344	-4-4	462-4-7	-4BC-12	-4-4	-A4-1	-100-8	-4AC-8
.084	1/8	18328	-4-4	18344	-4-4	462-4-7	-4BC-12	-4-4	-A4-1	-100-8	-4AC-8
.085	1/8	18328	-4-4	18344	-4-4	462-4-7	-4BC-12	-4-4	-A4-1	-100-10	-4AC-10
.104	1/8	18328	-4-4	18344	-4-4	462-4-7	-4BC-12	-4-4	-A4-1	-100-10	-4AC-10
.105	1/8	18328	-4-4	18344	-4-4	462-4-7	-4BC-12	-4-4	-A4-1	-100-12	-4AC-12
.124	1/8	18328	-4-4	18344	-4-4	462-4-7	-4BC-12	-4-4	-A4-1	-100-12	-4AC-12
.125	1/8	18328	-4-4	18344	-4-4	462-4-7	-4BC-12	-4-4	-A4-1	-100-14	-4AC-14
.140	1/8	18328	-4-4	18344	-4-4	462-4-7	-4BC-12	-4-4	-A4-1	-100-14	-4AC-14
.141	1/8	18329	-4-6	18345	-4-6	462-4-14	-4BC-18	-4-6	-A4-3	-100-14	-4AC-14
.144	1/8	18329	-4-6	18345	-4-6	462-4-14	-4BC-18	-4-6	-A4-3	-100-14	-4AC-14
.145	1/8	18329	-4-6	18345	-4-6	462-4-14	-4BC-18	-4-6	-A4-3	-100-16	-4AC-16
.164	1/8	18329	-4-6	18345	-4-6	462-4-14	-4BC-18	-4-6	-A4-3	-100-16	-4AC-16
.165	1/8	18329	-4-6	18345	-4-6	462-4-14	-4BC-18	-4-6	-A4-3	-100-18	-4AC-18
.184	1/8	18329	-4-6	18345	-4-6	462-4-14	-4BC-18	-4-6	-A4-3	-100-18	-4AC-18
.185	1/8	18329	-4-6	18345	-4-6	462-4-14	-4BC-18	-4-6	-A4-3	-100-20	-4AC-20

Typical callout - column 4 = CR162-4-2   100° Countersunk A17S-T aluminum alloy.

Figure 5-34 (Sheet 1 of 17) Interchangeability of Blind Rivets

Thickness to be rivetted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #30		Drill #29						
			CR162		CR178		1195	LS1126	9SP-100	DR-134	1195
.188	1/8	18329	-4-6	18345	-4-6	462-4-14	-4BC-18	-4-6	-A4-3	-100-20	-4AC-20
.203	1/8	18329	-4-6	18345	-4-6	462-4-14	-4BC-18	-4-6	-A4-3	-100-20	-4AC-20
.204	1/8	18330	-4-8	18346	-4-8	462-4-20	-4BC-25	-4-8	-A4-3	-100-20	-4AC-20
.205	1/8	18330	-4-8	18346	-4-8	462-4-20	-4BC-25	-4-8	-A4-3	-100-22	-4AC-20
.224	1/8	18330	-4-8	18346	-4-8	462-4-20	-4BC-25	-4-8	-A4-3	-100-22	
.225	1/8	18330	-4-8	18346	-4-8	462-4-20	-4BC-25	-4-8	-A4-3	-100-24	
.244	1/8	18330	-4-8	18346	-4-8	462-4-20	-4BC-25	-4-8	-A4-3	-100-24	
.245	1/8	18330	-4-8	18346	-4-8	462-4-20	-4BC-25	-4-8	-A4-3	-100-26	
.250	1/8	18330	-4-8	18346	-4-8	462-4-20	-4BC-25	-4-8	-A4-3	-100-26	
.251	1/8	18330	-4-8	18346	-4-8	462-4-20	-4BC-25	-4-8	-A4-3	-100-26	
.264	1/8	18330	-4-8	18346	-4-8	462-4-20	-4BC-25	-4-8	-A4-3	-100-26	
.265	1/8	19764	-4-10	25315	-4-10	462-4-26		-4-10	-A4-5	-100-28	
.284	1/8	19764	-4-10	25315	-4-10	462-4-26		-4-10	-A4-5	-100-28	
.285	1/8	19764	-4-10	25315	-4-10	462-4-26		-4-10	-A4-5	-100-30	
.304	1/8	19764	-4-10	25315	-4-10	462-4-26		-4-10	-A4-5	-100-30	
.305	1/8	19764	-4-10	25315	-4-10	462-4-26		-4-10	-A4-5	-100-32	
.324	1/8	19764	-4-10	25315	-4-10	462-4-26		-4-10	-A4-5	-100-32	
.325	1/8	19764	-4-10	25315	-4-10	462-4-26		-4-10	-A4-5	-100-34	
.328	1/8	19764	-4-10	25315	-4-10	462-4-26		-4-10	-A4-5		
.329	1/8	19765	-4-12	25316	-4-12	462-4-32		-4-12	-A4-5		

Typical callout - column 6 = CR178-4-6   100° Countersunk A17S-T aluminum alloy

Figure 5-34 (Sheet 2 of 17) Interchangeability of Blind Rivets

Thickness to be riveted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #30		Drill #29						
			CR162		CR178		1195	LS1126	9SP-100	DR-134	1195
.344	1/8	19765	-4-12	25316	-4-12	462-4-32		-4-12	-A4-5	-100-34	
.345	1/8	19765	-4-12	25316	-4-12	462-4-32		-4-12	-A4-5	-100-36	
.364	1/8	19765	-4-12	25316	-4-12	462-4-32		-4-12	-A4-5	-100-36	
.390	1/8	19765	-4-12	25316	-4-12	462-4-32		-4-12	-A4-5		
			Drill #20		Drill #16					DR-173	
.079	5/32	18331	-5-4	18347	-5-4	462-5-7	-5BC12	-5-4	-A5-1	-100-8	-5AC-8
.084	5/32	18331	-5-4	18347	-5-4	462-5-7	-5BC12	-5-4	-A5-1	-100-8	-5AC-8
.085	5/32	18331	-5-4	18347	-5-4	462-5-7	-5BC12	-5-4	-A5-1	-100-10	-5AC-10
.104	5/32	18331	-5-4	18347	-5-4	462-5-7	-5BC12	-5-4	-A5-1	-100-10	-5AC-10
.105	5/32	18331	-5-4	18347	-5-4	462-5-7	-5BC12	-5-4	-A5-1	-100-12	-5AC-12
.124	5/32	18331	-5-4	18347	-5-4	462-5-7	-5BC12	-5-4	-A5-1	-100-12	-5AC-12
.125	5/32	18331	-5-4	18347	-5-4	462-5-7	-5BC12	-5-4	-A5-1	-100-14	-5AC-14
.140	5/32	18331	-5-4	18347	-5-4	462-5-7	-5BC12	-5-4	-A5-1		
.141	5/32	18332	-5-6	18348	-5-6	462-5-14	-5BC18	-5-6	-A5-3		
.144	5/32	18332	-5-6	18348	-5-6	462-5-14	-5BC18	-5-6	-A5-3	-100-14	-5AC-14
.145	5/32	18332	-5-6	18348	-5-6	462-5-14	-5BC18	-5-6	-A5-3	-100-16	-5AC-16
.164	5/32	18332	-5-6	18348	-5-6	462-5-14	-5BC18	-5-6	-A5-3	-100-16	-5AC-16
.165	5/32	18332	-5-6	18348	-5-6	462-5-14	-5BC18	-5-6	-A5-3	-100-18	-5AC-18
.184	5/32	18332	-5-6	18348	-5-6	462-5-14	-5BC18	-5-6	-A5-3	-100-18	-5AC-18
.185	5/32	18332	-5-6	18348	-5-6	462-5-14	-5BC18	-5-6	-A5-3	-100-20	-5AC-20

Typical callout - column 8 = 1195-5BC-12 100° Countersunk A17S-T aluminum alloy

Figure 5-34 (Sheet 3 of 17) Interchangeability of Blind Rivets

Thickness to be riveted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #20		Drill #16						
			CR162		CR178		1195	LS1126	9SP-100	DR-173	1195
.203	5/32	18332	-5-6	18348	-5-6	462-5-14	-5BC-18	-5-6	-A5-3	-100-20	-5AC-20
.204	5/32	18364	-5-8	25273	-5-8	462-5-20	-5BC-25	-5-8	-A5-3	-100-20	-5AC-20
.205	5/32	18364	-5-8	25273	-5-8	462-5-20	-5BC-25	-5-8	-A5-3	-100-22	-5AC-22
.224	5/32	18364	-5-8	25273	-5-8	462-5-20	-5BC-25	-5-8	-A5-3	-100-22	-5AC-22
.225	5/32	18364	-5-8	25273	-5-8	462-5-20	-5BC-25	-5-8	-A5-3	-100-24	-5AC-24
.244	5/32	18364	-5-8	25273	-5-8	462-5-20	-5BC-25	-5-8	-A5-3	-100-24	-5AC-24
.245	5/32	18364	-5-8	25273	-5-8	462-5-20	-5BC-25	-5-8	-A5-3	-100-26	
.264	5/32	18364	-5-8	25273	-5-8	462-5-20	-5BC-25	-5-8	-A5-3	-100-26	
.265	5/32	18364	-5-8	25273	-5-8	462-5-20	-5BC-25	-5-8	-A5-3	-100-28	
.266	5/32	18333	-5-10	20179	-5-10	462-5-26	-5BC-31	-5-10	-A5-5		
.284	5/32	18333	-5-10	20179	-5-10	462-5-26	-5BC-31	-5-10	-A5-5	-100-28	
.285	5/32	18333	-5-10	20179	-5-10	462-5-26	-5BC-31	-5-10	-A5-5	-100-30	
.304	5/32	18333	-5-10	20179	-5-10	462-5-26	-5BC-31	-5-10	-A5-5	-100-30	
.305	5/32	18333	-5-10	20179	-5-10	462-5-26	-5BC-31	-5-10	-A5-5	-100-32	
.324	5/32	18333	-5-10	20179	-5-10	462-5-26	-5BC-31	-5-10	-A5-5	-100-32	
.325	5/32	18333	-5-10	20179	-5-10	462-5-26	-5BC-31	-5-10	-A5-5	-100-34	
.328	5/32	18333	-5-10	20179	-5-10	462-5-26	-5BC-31	-5-10	-A5-5	-100-34	
.329	5/32	19768	-5-12	25317	-5-12	462-5-32	-5BC-38	-5-12	-A5-5	-100-34	
.344	5/32	19768	-5-12	25317	-5-12	462-5-32	-5BC-38	-5-12	-A5-5	-100-34	
.345	5/32	19768	-5-12	25317	-5-12	462-5-32	-5BC-38	-5-12	-A5-5	-100-36	
.364	5/32	19768	-5-12	25317	-5-12	462-5-32	-5BC-38	-5-12	-A5-5	-100-36	

Typical callout - column 9 = LS1126-5-6 100° Countersunk A17S-T aluminum alloy

Figure 5-34 (Sheet 4 of 17) Interchangeability of Blind Rivets

Thickness to be rivetted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #20		Drill #16						
			CR162		CR178		1195	LS1126	9SP-100	DR-173	1195
.365	5/32	19768	-5-12	25317	-5-12	462-5-32	-5BC-38	-5-12	-A5-5	-100-38	
.384	5/32	19768	-5-12	25317	-5-12	462-5-32	-5BC-38	-5-12	-A5-5	-100-38	
.390	5/32	19768	-5-12	25317	-5-12	462-5-32	-5BC-38	-5-12	-A5-5		
.391	5/32	26097	-5-14	25317	-5-14	462-5-39		-5-14	-A5-7		
.453	5/32	26097	-5-14	25317	-5-14	462-5-39		-5-14	-A5-7		
.454	5/32	26097	-5-16	25317	-5-16				-A5-7		
.515	5/32	26097	-5-16	25317	-5-16				-A5-7		
			Drill #10		Drill #5					DR-204	
.079	3/16	18334	-6-4	19738	-6-4	462-6-7	-6BC-12	-6-4	-A6-1		
.084	3/16	18334	-6-4	19738	-6-4	462-6-7	-6BC-12	-6-4	-A6-1		
.085	3/16	18334	-6-4	19738	-6-4	462-6-7	-6BC-12	-6-4	-A6-1	-100-10	-6AC-10
.104	3/16	18334	-6-4	19738	-6-4	462-6-7	-6BC-12	-6-4	-A6-1	-100-10	-6AC-10
.105	3/16	18334	-6-4	19738	-6-4	462-6-7	-6BC-12	-6-4	-A6-1	-100-12	-6AC-12
.124	3/16	18334	-6-4	19738	-6-4	462-6-7	-6BC-12	-6-4	-A6-1	-100-12	-6AC-12
.125	3/16	18334	-6-4	19738	-6-4	462-6-7	-6BC-12	-6-4	-A6-1	-100-14	-6AC-14
.140	3/16	18334	-6-4	19738	-6-4	462-6-7	-6BC-12	-6-4	-A6-1		
.141	3/16	19335	-6-6	19739	-6-6	462-6-14	-6BC-18	-6-6	-A6-3	-100-14	-6AC-14
.144	3/16	19335	-6-6	19739	-6-6	462-6-14	-6BC-18	-6-6	-A6-3	-100-14	-6AC-14
.145	3/16	19335	-6-6	19739	-6-6	462-6-14	-6BC-18	-6-6	-A6-3	-100-16	-6AC-16
.164	3/16	19335	-6-6	19739	-6-6	462-6-14	-6BC-18	-6-6	-A6-3	-100-16	-6AC-16

Typical callout - column 10 = 9SP-100-A5-5 100° Countersunk A17S-T aluminum alloy

Figure 5-34 (Sheet 5 of 17) Interchangeability of Blind Rivets

Thickness to be riveted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #10		Drill #5						
			CR162		CR178		1195	LS1126	9SP-100	DR-204	1195
.165	3/16	19335	-6-6	19739	-6-6	462-6-14	-6BC-18.	-6-6	-A6-3	-100-18	-6AC-18
.184	3/16	19335	-6-6	19739	-6-6	462-6-14	-6BC-18	-6-6	-A6-3	-100-18	-6AC-18
.185	3/16	19335	-6-6	19739	-6-6	462-6-14	-6BC-18	-6-6	-A6-3	-100-20	-6AC-20
.203	3/16	19335	-6-6	19739	-6-6	462-6-14	-6BC-18	-6-6	-A6-3	-100-20	
.204	3/16	18365	-6-8	19740	-6-8	462-6-20	-6BC-25	-6-8	-A6-3	-100-20	-6AC-20
.205	3/16	18365	-6-8	19740	-6-8	462-6-20	-6BC-25	-6-8	-A6-3	-100-22	-6AC-22
.224	3/16	18365	-6-8	19740	-6-8	462-6-20	-6BC-25	-6-8	-A6-3	-100-22	-6AC-22
.225	3/16	18365	-6-8	19740	-6-8	462-6-20	-6BC-25	-6-8	-A6-3	-100-24	-6AC-24
.244	3/16	18365	-6-8	19740	-6-8	462-6-20	-6BC-25	-6-8	-A6-3	-100-24	-6AC-24
.245	3/16	18365	-6-8	19740	-6-8	462-6-20	-6BC-25	-6-8	-A6-3	-100-26	-6AC-26
.250	3/16	18365	-6-8	19740	-6-8	462-6-20	-6BC-25	-6-8	-A6-3	-100-26	
.251	3/16	18365	-6-8	19740	-6-8	462-6-20	-6BC-25	-6-8	-A6-3	-100-26	
.264	3/16	18365	-6-8	19740	-6-8	462-6-20	-6BC-25	-6-8	-A6-3	-100-26	
.265	3/16	18365	-6-8	19740	-6-8	462-6-20	-6BC-25	-6-8	-A6-3	-100-28	
.266	3/16	19731	-6-10	19773	-6-10	462-6-26	-6BC-31	-6-10	-A6-5	-100-28	
.284	3/16	19731	-6-10	19773	-6-10	462-6-26	-6BC-31	-6-10	-A6-5	-100-28	
.285	3/16	19731	-6-10	19773	-6-10	462-6-26	-6BC-31	-6-10	-A6-5	-100-30	
.304	3/16	19731	-6-10	19773	-6-10	462-6-26	-6BC-31	-6-10	-A6-5	-100-30	
.305	3/16	19731	-6-10	19773	-6-10	462-6-26	-6BC-31	-6-10	-A6-5	-100-32	
.312	3/16	19731	-6-10	19773	-6-10	462-6-26	-6BC-31	-6-10	-A6-5	-100-32	

Typical callout - column 11 = DR-204-100-18 100° Countersunk A17S-T aluminum alloy

Figure 5-34 (Sheet 6 of 17) Interchangeability of Blind Rivets

Thickness to be riveted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #10		Drill #5						
			CR162		CR178		1195	LS1126	9SP-100	DR-204	1195
.313	3/16	19731	-6-10	19773	-6-10	462-6-26	-6BC-31	-6-10	-A6-5	-100-32	
.324	3/16	19731	-6-10	19773	-6-10	462-6-26	-6BC-31	-6-10	-A6-5	-100-32	
.325	3/16	19731	-6-10	19773	-6-10	462-6-26	-6BC-31	-6-10	-A6-5	-100-34	
.328	3/16	19731	-6-10	19773	-6-10	462-6-26	-6BC-31	-6-10	-A6-5	-100-34	
.329	3/16	19732	-6-12	19774	-6-12	462-6-32	-6BC-38	-6-12	-A6-5	-100-34	
.344	3/16	19732	-6-12	19774	-6-12	462-6-32	-6BC-38	-6-12	-A6-5	-100-34	
.345	3/16	19732	-6-12	19774	-6-12	462-6-32	-6BC-38	-6-12	-A6-5	-100-36	
.364	3/16	19732	-6-12	19774	-6-12	462-6-32	-6BC-38	-6-12	-A6-5	-100-36	
.365	3/16	19732	-6-12	19774	-6-12	462-6-32	-6BC-38	-6-12	-A6-5	-100-38	
.375	3/16	19732	-6-12	19774	-6-12	462-6-32	-6BC-38	-6-12	-A6-5	-100-38	
.376	3/16	19732	-6-12	19774	-6-12	462-6-32		-6-12	-A6-5		
.384	3/16	19732	-6-12	19774	-6-12	462-6-32		-6-12	-A6-5	-100-38	
.385	3/16	19732	-6-12	19774	-6-12	462-6-32		-6-12	-A6-5	-100-40	
.390	3/16	19732	-6-12	19774	-6-12	462-6-32	-6BC-38	-6-12	-A6-5		
.391	3/16	19732	-6-14	19774	-6-14	462-6-39	-6BC-44	-6-14	-A6-7		
.404	3/16	19732	-6-14	19774	-6-14	462-6-39		-6-14	-A6-7	-100-40	
.405	3/16	19732	-6-14	19774	-6-14	462-6-39		-6-14	-A6-7	-100-42	
.424	3/16	19732	-6-14	19774	-6-14	462-6-39		-6-14	-A6-7	-100-42	
.444	3/16	19732	-6-14	19774	-6-14	462-6-39		-6-14	-A6-7	-100-44	
.445	3/16	19732	-6-14	19774	-6-14	462-6-39		-6-14	-A6-7	-100-46	

Typical callout - column 4 = CR162-6-10 100° Countersunk A17S-T aluminum alloy

Figure 5-34 (Sheet 7 of 17) Interchangeability of Blind Rivets

Thickness to be riveted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #10		Drill #5						
			CR162		CR178		1195	LS1126	9SP-100	DR-204	1195
.453	3/16	19732	-6-14	19774	-6-14	462-6-39	-6BC-44	-6-14	-A6-7	-100-46	
.454	3/16	19732	-6-16	19774	-6-16	462-6-45		-6-16	-A6-7		
.464	3/16	19732	-6-16	19774	-6-16	462-6-45		-6-16	-A6-7	-100-46	
.465	3/16	19732	-6-16	19774	-6-16	462-6-45		-6-16	-A6-7	-100-48	
.484	3/16	19732	-6-16	19774	-6-16	462-6-45		-6-16	-A6-7	-100-48	
.500	3/16	19732	-6-16	19774	-6-16	462-6-45		-6-16	-A6-7		
.515	3/16	19732	-6-16	19774	-6-16	462-6-45		-6-16	-A6-7		
.516	3/16	19732	-6-18	19774	-6-18	462-6-51		-6-18	-A6-7		
.545	3/16	19732	-6-18	19774	-6-18	462-6-51		-6-18	-A6-7		
.578	3/16	19732	-6-18	19774	-6-18	462-6-51		-6-18	-A6-9		
			Drill #F		Drill #I						
.141	1/4	19732	-8-6	19774	462-8-6	462-8-14		-8-6	-A8-3		
.203	1/4	19732	-8-6	19774	-8-6	462-8-14		-8-6	-A8-3		
.204	1/4	19732	-8-8	19774	-8-8	462-8-20		-8-8	-A8-3		
.265	1/4	19732	-8-8	19774	-8-8	462-8-20		-8-8	-A8-3		
.266	1/4	19732	-8-10	19774	-8-10	462-8-26		-8-10	-A8-5		
.328	1/4	19732	-8-10	19774	-8-10	462-8-26		-8-10	-A8-5		
.329	1/4	19732	-8-12	19774	-8-12	462-8-32		-8-12	-A8-5		
.390	1/4	19732	-8-12	19774	-8-12	462-8-32		-8-12	-A8-5		
.391	1/4	19732	-8-14	19774	-8-14	462-8-39		-8-14	-A8-7		

Typical callout - column 6 = CR178-6-14 100° Countersunk A17S-T aluminum alloy

Figure 5-34 (Sheet 8 of 17) Interchangeability of Blind Rivets

Thickness to be riveted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #F		Drill #I						
			CR162		CR178		1195	LS1126	9SP-100	DR-204	1195
.453	1/4	19732	-8-14	19774	-8-14	462-8-39		-8-14			
.454	1/4	19732	-8-16	19774	-8-16	462-8-45		-8-16			
.515	1/4	19732	-8-16	19774	-8-18	462-8-45		-8-16	-A8-7		
.516	1/4	19732	-8-18	19774	-8-18	462-8-51		-8-18	-A8-9		
.578	1/4	19732	-8-18	19774	-8-18	462-8-51		-8-18	-A8-9		
			Drill #L								
.141	9/32	19732	-9-6	19774		462-9-14		-9-6			
.204	9/32	19732	-9-8	19774		462-9-20		-9-8			
.266	9/32	19732	-9-10	19774		462-9-26		-9-10			
.329	9/32	19732	-9-12	19774		462-9-32		-9-12			
.391	9/32	19732	-9-14	19774		462-9-39		-9-14			
.454	9/32	19732	-9-16	19774		462-9-45		-9-16			
.516	9/32	19732	-9-18	19774		462-9-51		-9-18			

Typical callout - column 9 = LS1126-8-14 100° Countersunk A17S-T aluminum alloy

Figure 5-34 (Sheet 9 of 17) Interchangeability of Blind Rivets

Thickness to be rivetted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #30		Drill #29						
			CR163		CR179		1195	LS1127	9SP-B	DR-134A	1195
.030	1/8	19361	-4-2	19737	-4-2	463-4-1	-4B-6	-4-2	-A4-1	-4	-4A-4
.044	1/8	19361	-4-2	19737	-4-2	463-4-1	-4B-6	-4-2	-A4-1	-4	-4A-4
.045	1/8	19361	-4-2	19737	-4-2	463-4-1	-4B-6	-4-2	-A4-1	-6	-4A-6
.064	1/8	19361	-4-2	19737	-4-2	463-4-1	-4B-6	-4-2	-A4-1	-6	-4A-6
.065	1/8	19361	-4-2	19737	-4-2	463-4-1	-4B-6	-4-2	-A4-1	-8	-4A-8
.078	1/8	19361	-4-2	19737	-4-2	463-4-1	-4B-6	-4-2	-A4-1		
.079	1/8	18336	-4-4	18349	-4-4	463-4-7	-4B-12	-4-4	-A4-1		
.084	1/8	18336	-4-4	18349	-4-4	463-4-7	-4B-12	-4-4	-A4-1	-8	-4A-8
.085	1/8	18336	-4-4	18349	-4-4	463-4-7	-4B-12	-4-4	-A4-1	-10	-4A-10
.104	1/8	18336	-4-4	18349	-4-4	463-4-7	-4B-12	-4-4	-A4-1	-10	-4A-10
.105	1/8	18336	-4-4	18349	-4-4	463-4-7	-4B-12	-4-4	-A4-1	-12	-4A-12
.124	1/8	18336	-4-4	18349	-4-4	463-4-7	-4B-12	-4-4	-A4-1	-12	-4A-12
.125	1/8	18336	-4-4	18349	-4-4	463-4-7	-4B-12	-4-4	-A4-1	-14	-4A-14
.140	1/8	18336	-4-4	18349	-4-4	463-4-7	-4B-12	-4-4	-A4-1		
.141	1/8	18337	-4-6	18350	-4-6	463-4-14	-4B-18	-4-6	-A4-3		
.144	1/8	18337	-4-6	18350	-4-6	463-4-14	-4B-18	-4-6	-A4-3	-14	-4A-14
.145	1/8	18337	-4-6	18350	-4-6	463-4-14	-4B-18	-4-6	-A4-3	-16	-4A-16
.164	1/8	18337	-4-6	18350	-4-6	463-4-14	-4B-18	-4-6	-A4-3	-16	-4A-16
.165	1/8	18337	-4-6	18350	-4-6	463-4-14	-4B-18	-4-6	-A4-3	-18	-4A-18
.184	1/8	18337	-4-6	18350	-4-6	463-4-14	-4B-18	-4-6	-A4-3	-18	-4A-18
.185	1/8	18337	-4-6	18350	-4-6	463-4-14	-4B-18	-4-6	-A4-3	-20	-4A-20

Typical callout - column 10 = 9SP-B-A4-1 Protruding head aluminum alloy

Figure 5-34 (Sheet 10 of 17) Interchangeability of Blind Rivets

Typical callout - column 11 = DR-134A-20 Protruding head aluminum alloy

Thickness to be rivetted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #30		Drill #29						
			CR163		CR179		1195	LS1127	9SP-B	DR-134A	1195
.203	1/8	18337	-4-6	18350	-4-6	463-4-14	-4B-18	-4-6	-A4-3	-20	-4A-20
.204	1/8	18338	-4-8	18351	-4-8	463-4-20	-4B-25	-4-8	-A4-3	-20	-4A-20
.205	1/8	18338	-4-8	18351	-4-8	463-4-20	-4B-25	-4-8	-A4-3	-22	
.224	1/8	18338	-4-8	18351	-4-8	463-4-20	-4B-25	-4-8	-A4-3	-22	
.225	1/8	18338	-4-8	18351	-4-8	463-4-20	-4B-25	-4-8	-A4-3	-24	
.244	1/8	18338	-4-8	18351	-4-8	463-4-20	-4B-25	-4-8	-A4-3	-24	
.245	1/8	18338	-4-8	18351	-4-8	463-4-20	-4B-25	-4-8	-A4-3	-26	
.264	1/8	18338	-4-8	18351	-4-8	463-4-20		-4-8	-A4-3	-26	
.265	1/8	19780	-4-10	18351	-4-10	463-4-26		-4-10	-A4-5	-28	
.284	1/8	19780	-4-10	18351	-4-10	463-4-26		-4-10	-A4-5	-28	
.285	1/8	19780	-4-10	18351	-4-10	463-4-26		-4-10	-A4-5	-30	
.304	1/8	19780	-4-10	18351	-4-10	463-4-26		-4-10	-A4-5	-30	
.305	1/8	19780	-4-10	18351	-4-10	463-4-26		-4-10	-A4-5	-32	
.324	1/8	19780	-4-10	18351	-4-10	463-4-26		-4-10	-A4-5	-32	
.325	1/8	19780	-4-10	18351	-4-10	463-4-26		-4-10	-A4-5	-34	
.328	1/8	19780	-4-10	18351	-4-10	463-4-26		-4-10	-A4-5	-34	
.329	1/8	19766	-4-12	18351	-4-12	463-4-32		-4-12	-A4-5	-34	
.344	1/8	19766	-4-12	18351	-4-12	463-4-32		-4-12	-A4-5	-34	
.345	1/8	19766	-4-12	18351	-4-12	463-4-32		-4-12	-A4-5	-36	
.364	1/8	19766	-4-12	18351	-4-12	463-4-32		-4-12	-A4-5	-36	
.390	1/8	19766	-4-12	18351	-4-12	463-4-32		-4-12	-A4-5		

Figure 5-34 (Sheet 11 of 17) Interchangeability of Blind Rivets

Thickness to be riveted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #20		Drill #16						
			CR163		CR179		1195	LS1127	9SP-B	DR-173A	1195
.079	5/32	18339	-5-4	18352	-5-4	463-5-7	-5B-12	-5-4	-A5-1	-8	-5A-8
.084	5/32	18339	-5-4	18352	-5-4	463-5-7	-5B-12	-5-4	-A5-1	-8	-5A-8
.085	5/32	18339	-5-4	18352	-5-4	463-5-7	-5B-12	-5-4	-A5-1	-10	-5A-10
.104	5/32	18339	-5-4	18352	-5-4	463-5-7	-5B-12	-5-4	-A5-1	-10	-5A-10
.105	5/32	18339	-5-4	18352	-5-4	463-5-7	-5B-12	-5-4	-A5-1	-12	-5A-12
.124	5/32	18339	-5-4	18352	-5-4	463-5-7	-5B-12	-5-4	-A5-1	-12	-5A-12
.125	5/32	18339	-5-4	18352	-5-4	463-5-7	-5B-12	-5-4	-A5-1	-14	-5A-14
.140	5/32	18339	-5-4	18352	-5-4	463-5-7	-5B-12	-5-4	-A5-1	-14	-5A-14
.141	5/32	18340	-5-6	18353	-5-6	463-5-14	-5B-18	-5-6	-A5-3	-14	-5A-14
.144	5/32	18340	-5-6	18353	-5-6	463-5-14	-5B-18	-5-6	-A5-3	-14	-5A-14
.145	5/32	18340	-5-6	18353	-5-6	463-5-14	-5B-18	-5-6	-A5-3	-16	-5A-16
.164	5/32	18340	-5-6	18353	-5-6	463-5-14	-5B-18	-5-6	-A5-3	-16	-5A-16
.165	5/32	18340	-5-6	18353	-5-6	463-5-14	-5B-18	-5-6	-A5-3	-18	-5A-18
.184	5/32	18340	-5-6	18353	-5-6	463-5-14	-5B-18	-5-6	-A5-3	-18	-5A-18
.185	5/32	18340	-5-6	18353	-5-6	463-5-14	-5B-18	-5-6	-A5-3	-20	-5A-20
.203	5/32	18340	-5-6	18353	-5-6	463-5-14	-5B-18	-5-6	-A5-3	-20	-5A-20
.204	5/32	18341	-5-8	25274	-5-8	463-5-20	-5B-25	-5-8	-A5-3	-20	-5A-20
.205	5/32	18341	-5-8	25274	-5-8	463-5-20	-5B-25	-5-8	-A5-3	-22	-5A-22
.224	5/32	18341	-5-8	25274	-5-8	463-5-20	-5B-25	-5-8	-A5-3	-22	-5A-22
.225	5/32	18341	-5-8	25274	-5-8	463-5-20	-5B-25	-5-8	-A5-3	-24	-5A-24

Typical callout - column 12 = 1195-5A-8 Protruding head aluminum alloy

Figure 5-34 (Sheet 12 of 17) Interchangeability of Blind Rivets

Thickness to be rivetted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #20		Drill #16						
			CR163		CR179		1195	LS1127	9SP-B	DR-173A	1195
.244	5/32	18341	-5-8	25274	-5-8	463-5-20	-5B-25	-5-8	-A5-3	-24	-5A-24
.245	5/32	18341	-5-8	25274	-5-8	463-5-20	-5B-25	-5-8	-A5-3	-26	
.264	5/32	18341	-5-8	25274	-5-8	463-5-20	-5B-25	-5-8	-A5-3	-26	
.265	5/32	18341	-5-8	25274	-5-8	463-5-20	-5B-25	-5-8	-A5-3	-28	
.266	5/32	19362	-5-10	20178	-5-10	463-5-26	-5B-31	-5-10	-A5-5	-28	
.284	5/32	19362	-5-10	20178	-5-10	463-5-26	-5B-31	-5-10	-A5-5	-28	
.285	5/32	19362	-5-10	20178	-5-10	463-5-26	-5B-31	-5-10	-A5-5	-30	
.304	5/32	19362	-5-10	20178	-5-10	463-5-26	-5B-31	-5-10	-A5-5	-30	
.305	5/32	19362	-5-10	20178	-5-10	463-5-26	-5B-31	-5-10	-A5-5	-32	
.324	5/32	19362	-5-10	20178	-5-10	463-5-26	-5B-31	-5-10	-A5-5	-32	
.325	5/32	19362	-5-10	20178	-5-10	463-5-26	-5B-31	-5-10	-A5-5	-34	
.328	5/32	19362	-5-10	20178	-5-10	463-5-26	-5B-31	-5-10	-A5-5	-34	
.329	5/32	19770	-5-12	20178	-5-12	463-5-32	-5B-38	-5-12	-A5-5	-34	
.344	5/32	19770	-5-12	20178	-5-12	463-5-32	-5B-38	-5-12	-A5-5	-34	
.345	5/32	19770	-5-12	20178	-5-12	463-5-32	-5B-38	-5-12	-A5-5	-36	
.364	5/32	19770	-5-12	20178	-5-12	463-5-32	-5B-38	-5-12	-A5-5	-36	
.365	5/32	19770	-5-12	20178	-5-12	463-5-32	-5B-38	-5-12	-A5-5	-38	
.384	5/32	19770	-5-12	20178	-5-12	463-5-32	-5B-38	-5-12	-A5-5	-38	
.390	5/32	19770	-5-12	20178	-5-12	463-5-32	-5B-38	-5-12	-A5-5		
.391	5/32	26098	-5-14	20178	-5-14	463-5-39		LS1126	-A5-7		

Typical callout - column 4 = CR163-5-8 Protruding head aluminum alloy

Figure 5-34 (Sheet 13 of 17) Interchangeability of Blind Rivets

Thickness to be riveted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #20		Drill #16						
			CR163		CR179	•	1195	LS1126	9SP-B	DR-173A	1195
.453	5/32	26098	-5-14	20178	-5-14	463-5-39		-5-14	-A5-7		
.454	5/32	26098	-5-16	20178	-5-16				-A5-7		
.515	5/32	26098	-5-16	20178	-5-16				-A5-7		
			Drill #10		Drill #5			LS1127		DR-204A	
.030	3/16	19733	-6-2	20178	-6-2	463-6-1	-6B-6	-6-2	-A6-1		
.065	3/16	19733	-6-2	20178	-6-2				-A6-1	-8	-6A-8
.078	3/16	19733	-6-2	20178	-6-2	463-6-1	-6B-6	-6-2	-A6-1	-8	-6A-8
.079	3/16	18342	-6-4	19741	-6-4	463-6-7	-6B-12	-6-4	-A6-1	-8	-6A-8
.084	3/16	18342	-6-4	19741	-6-4	463-6-7	-6B-12	-6-4	-A6-1	-8	-6A-8
.085	3/16	18342	-6-4	19741	-6-4	463-6-7	-6B-12	-6-4	-A6-1	-10	-6A-10
.104	3/16	18342	-6-4	19741	-6-4	463-6-7	-6B-12	-6-4	-A6-1	-10	-6A-10
.105	3/16	18342	-6-4	19741	-6-4	463-6-7	-6B-12	-6-4	-A6-1	-12	-6A-12
.124	3/16	18342	-6-4	19741	-6-4	463-6-7	-6B-12	-6-4	-A6-1	-12	-6A-12
.125	3/16	18342	-6-4	19741	-6-4	463-6-7	-6B-12	-6-4	-A6-1	-14	-6A-14
.140	3/16	18342	-6-4	19741	-6-4	463-6-7	-6B-12	-6-4	-A6-1	-14	-6A-14
.141	3/16	18343	-6-6	19742	-6-6	463-6-14	-6B-18	-6-6	-A6-3	-14	-6A-14
.144	3/16	18343	-6-6	19742	-6-6	463-6-14	-6B-18	-6-6	-A6-3	-14	-6A-14
.145	3/16	18343	-6-6	19742	-6-6	463-6-14	-6B-18	-6-6	-A6-3	-16	-6A-16
.164	3/16	18343	-6-6	19742	-6-6	463-6-14	-6B-18	-6-6	-A6-3	-16	-6A-16
.165	3/16	18343	-6-6	19742	-6-6	463-6-14	-6B-18	-6-6	-A6-3	-18	-6A-18

Typical callout - column 6 = CR179-5-14 Protruding head aluminum alloy

Figure 5-34 (Sheet 14 of 17) Interchangeability of Blind Rivets

Thickness to be rivetted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #10		Drill #5						
			CR163		CR179		1195	LS1127	9SP-B	DR-204A	1195
.184	3/16	18343	-6-6	19742	-6-6	463-6-14	-6B-18	-6-6	-A6-3	-18	-6A-18
.185	3/16	18343	-6-6	19742	-6-6	463-6-14	-6B-18	-6-6	-A6-3	-20	-6A-20
.203	3/16	18343	-6-6	19742	-6-6	463-6-14	-6B-18	-6-6	-A6-3	-20	-6A-20
.204	3/16	19363	-6-8	19743	-6-8	463-6-20	-6B-25	-6-8	-A6-3	-20	-6A-20
.205	3/16	19363	-6-8	19743	-6-8	463-6-20	-6B-25	-6-8	-A6-3	-22	-6A-22
.224	3/16	19363	-6-8	19743	-6-8	463-6-20	-6B-25	-6-8	-A6-3	-22	-6A-22
.225	3/16	19363	-6-8	19743	-6-8	463-6-20	-6B-25	-6-8	-A6-3	-24	-6A-24
.244	3/16	19363	-6-8	19743	-6-8	463-6-20	-6B-25	-6-8	-A6-3	-24	-6A-24
.245	3/16	19363	-6-8	19743	-6-8	463-6-20	-6B-25	-6-8	-A6-3	-26	-6A-24
.264	3/16	19363	-6-8	19743	-6-8	463-6-20	-6B-25	-6-8	-A6-3	-26	
.265	3/16	19363	-6-8	19743	-6-8	463-6-20	-6B-25	-6-8	-A6-3	-28	
.266	3/16	19734	-6-10	19776	-6-10	463-6-26	-6B-31	-6-10	-A6-5	-28	
.284	3/16	19734	-6-10	19776	-6-10	463-6-26	-6B-31	-6-10	-A6-5	-28	
.285	3/16	19734	-6-10	19776	-6-10	463-6-26	-6B-31	-6-10	-A6-5	-30	
.304	3/16	19734	-6-10	19776	-6-10	463-6-26	-6B-31	-6-10	-A6-5	-30	
.305	3/16	19734	-6-10	19776	-6-10	463-6-26	-6B-31	-6-10	-A6-5	-32	
.324	3/16	19734	-6-10	19776	-6-10	463-6-26	-6B-31	-6-10	-A6-5	-32	
.325	3/16	19734	-6-10	19776	-6-10	463-6-26	-6B-31	-6-10	-A6-5	-34	
.328	3/16	19734	-6-10	19776	-6-10	463-6-26	-6B-31	-6-10	-A6-5	-34	
.329	3/16	19364	-6-12	19777	-6-12	463-6-32	-6B-31	-6-12	-A6-5	-34	

Typical callout - column 8 = 1195-6B-18 Protruding head aluminum alloy

Figure 5-34 (Sheet 15 of 17) Interchangeability of Blind Rivets

Thickness to be riveted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #10		Drill #5						
			CR163		CR179		1195	LS1127	9SP-B	DR-204A	1195
.344	3/16	19364	-6-12	19777	-6-12	463-6-32	-6B-31	-6-12	-A6-5	-34	
.345	3/16	19364	-6-12	19777	-6-12	463-6-32	-6B-31	-6-12	-A6-5	-36	
.364	3/16	19364	-6-12	19777	-6-12	463-6-32	-6B-31	-6-12	-A6-5	-36	
.365	3/16	19364	-6-12	19777	-6-12	463-6-32	-6B-31	-6-12	-A6-5	-38	
.384	3/16	19364	-6-12	19777	-6-12	463-6-32	-6B-31	-6-12	-A6-5	-38	
.385	3/16	19364	-6-12	19777	-6-12	463-6-32	-6B-31	-6-12	-A6-5	-40	
.390	3/16	19364	-6-12	19777	-6-12	463-6-32	-6B-31	-6-12	-A6-5		
.391	3/16	19364	-6-14	19777	-6-14	463-6-39	-6B-38	-6-14	-A6-7	-40	
.404	3/16	19364	-6-14	19777	-6-14	463-6-39	-6B-38	-6-14	-A6-7	-40	
.405	3/16	19364	-6-14	19777	-6-14	463-6-39	-6B-38	-6-14	-A6-7	-42	
.424	3/16	19364	-6-14	19777	-6-14	463-6-39	-6B-38	-6-14	-A6-7	-42	
.425	3/16	19364	-6-14	19777	-6-14	463-6-39	-6B-38	-6-14	-A6-7	-44	
.444	3/16	19364	-6-14	19777	-6-14	463-6-39	-6B-38	-6-14	-A6-7	-44	
.445	3/16	19364	-6-14	19777	-6-14	463-6-39	-6B-38	-6-14	-A6-7	-46	
.453	3/16	19364	-6-14	19777	-6-14	463-6-39	-6B-38	-6-14	-A6-7	-46	
.454	3/16	19364	-6-16	19777	-6-16	463-6-45		-6-16	-A6-7	-46	
.464	3/16	19364	-6-16	19777	-6-16	463-6-45		-6-16	-A6-7	-46	
.465	3/16	19364	-6-16	19777	-6-16	463-6-45		-6-16	-A6-7	-48	
.484	3/16	19364	-6-16	19777	-6-16	463-6-45		-6-16	-A6-7	-48	
.515	3/16	19364	-6-16	19777	-6-16	463-6-45		-6-16	-A6-7		

Typical callout - column 9 = LS1127-6-12 Protruding head aluminum alloy

Figure 5-34 (Sheet 16 of 17) Interchangeability of Blind Rivets

Thickness to be rivetted	Rivet diameter	Section 28 Reference No.	Nominal Cherry Rivet	Section 28 Reference No.	Oversize Cherry Rivet	USAF Type B Cherry Rivet	NAF Type B Cherry Rivet	L.S. Series Cherry Rivet	Huck Blind Rivet	Dupont Explosive Rivet	NAF Type A Explosive Rivet
1	2	3	4	5	6	7	8	9	10	11	12
			Drill #10		Drill #5						
			CR163		CR179		1195	LS1127	9SP-B	DR-204A	1195
.516	3/16	19364	-6-18	19777	-6-18	463-6-51		-6-18	-A6-7		
.578	3/16	19364	-6-18	19777	-6-18	463-6-51		-6-18	-A6-7		
			Drill #F		Drill 273						
.079	1/4	19364	-8-4	19777	-8-4	463-8-7		-8-4	-A8-1		
.141	1/4	19364	-8-6	19777	-8-6	463-8-14		-8-6	-A8-3		
.204	1/4	23018	-8-8	19777	-8-8	463-8-20		-8-8	-A8-3		
.266	1/4	23018	-8-10	19777	-8-10	463-8-26		-8-10	-A8-5		
.329	1/4	23018	-8-12	19777	-8-12	463-8-32		-8-12	-A8-5		
.391	1/4	23018	-8-14	19777	-8-14	463-8-39		-8-14	-A8-7		
.454	1/4	23018	-8-16	19777	-8-16	463-8-45		-8-16	-A8-7		
.516	1/4	23018	-8-18	19777	-8-18	463-8-51		-8-18	-A8-9		
			Drill .288								
.079	9/32	23018	-9-4	19777		463-9-7		-9-4			
.141	9/32	23018	-9-6	19777		463-9-14		-9-6			
.204	9/32	23018	-9-8	19777		463-9-20		-9-8			
.266	9/32	23018	-9-10	19777		463-9-26		-9-10			
.329	9/32	23018	-9-12	19777		463-9-32		-9-12			
.391	9/32	23018	-9-14	19777		463-9-39		-9-14			
.454	9/32	23018	-9-16	19777		463-9-45		-9-16			
.516	9/32	23018	-9-18	19777		463-9-51		-9-18			

Typical callout - column 10 = 9SP-B-A6-7 Protruding head aluminum alloy

Figure 5-34 (Sheet 17 of 17) Interchangeability of Blind Rivets

Cherry Rivet	Dia.	Material	Canadian Standard Rivet	Chobert Rivet	Tucker Rivet
1	2	3	4	5	6
CR162-4	1/8	Alum Alloy	CS-R-107-4	TK-CD or TK-CNA	
CR162-5	5/32	Alum Alloy	CS-R-107-5	TL-CD or TL-CNA	
CR162-6	3/16	Alum Alloy	CS-R-107-6	TX-CD or TX-CNA	
CR162-6	3/16	Alum Alloy		R220/-CD or R220-CNA	
CR162-8	1/4	Alum Alloy		R221-CNA	
CR162-8	1/4	Alum Alloy		TZ-CNA	
CR156-4	1/8	Mag.Alloy 56S	CS-R-105-4		TAC/K/4 - or TAP/K/BH4 - or TAP/K/BS4-
CR156-5	5/32	Mag.Alloy 56S	CS-R-105-5		TAC/K/5 - or TAP/K/BH5 - or TAP/K/BS5-
CR156-6	3/16	Mag.Alloy 56S	CS-R-105-6		TAP/K/BH6 - or TAP/K/BS6-
CR562-4	1/8	Monel		TK-CS	ANP/K/4-/BH or ANP/K/4-/BS or TLP/K/BH4- or TLP/K/BS4- or TLC/K/4-
CR562-5	5/32	Monel		TL-CS	ANP/K/5-/BH or ANP/K/5-/BS or TLP/K/BH5 - or TLP/K/BS5 - or TLC/K/5-
CR562-6	3/16	Monel		TX-CS	ANP/K/6-/BH or ANP/K/6-/BS or TLP/K/BH6 - or TLP/K/BS6 - or TLC/K/6-
CR562-6	3/16	Monel		R220/-CS	
CR562-8	1/4	Monel		R221/-CS	

Figure 5-35 (Sheet 1 of 2) Interchangeability of Canadian and British Blind Rivets (Countersunk Head)

Cherry Rivet	Dia.	Material	Canadian Standard Rivet	Chobert Rivet	Tucker Rivet
1	2	3	4	5	6
CR163-4-	1/8	Alum Alloy	CS-R-108-4	TK-SD or TK-SNA	
CR163-5-	5/32	Alum Alloy	CS-R-108-5	TL-SD or TL-SNA	
CR163-6-	3/16	Alum Alloy	CS-R-108-6	TX-SD or TX-SNA	
CR163-6-	3/16	Alum Alloy	CS-R-108-6	R220/-SD or R220/-SNA	
CR163-8-	1/4	Alum Alloy	CS-R-108-8	R221/-SNA	
CR163-8-	1/4	Alum Alloy	CS-R-108-8	TZ-SNA	
CR157-4-	1/8	Mag.Alloy 56S	CS-R-106-4		TAC/D/4-or TAC/F/4 -or TAP/D/BH4 -or TAP/F/BH4-or TAP/D/BS4-or TAP/F/BS4
CR157-5-	5/32	Mag.Alloy 56S	CS-R-106-5		TAC/D/5-or TAC/F/5-or TAP/D/BH5-or TAP/F/BH5-or TAP/D/BS5-or TAP/F/BS5-
CR157-6-	3/16	Mag.Alloy 56S	CS-R-106-6		TAC/D/6- or TAC/F/6-
CR157-8	1/4	Mag.Alloy 56S	CS-R-106-8		TAP/D/BH6- or TAP/F/BH6- or TAP/D/BS6-
CR563-4	1/8	Monel	CS-R-109-4	TK-SS-	TLC/D4- or TLC/F4- or TLP/D/BH4- or TLP/F/BN4- or TLP/F/BS4-
CR563-5	5/32	Monel	CS-R-109-5	TL-SS-	TLC/D5-or TLC/F5-or TLP/D/BH5-or TLP/F/BH5- or TLP/D/BS5- or TLP/F/BS5-
CR563-6	3/16	Monel	CS-R-109-6	TX-SS-	TLC/D6-or TLC/F6-or TLP/D/BH6-or TLP/F/BH6-or TLP/D/BS6-or TLP/F/BS6-
CR563-6	3/16	Monel	CS-R-109-6	R220/-SS	
CR563-8	1/4	Monel	CS-R-109-8	R221/-SS	

Figure 5-35 (Sheet 2 of 2) Interchangeability of Canadian and British Blind Rivets (Protruding Head)

74 The hollow pull-through type operates as follows:

(a) The blind head of the stem, made of steel, first forms a head on the end of the rivet, pressing the sheets together.

(b) The blind head then expands the rivet shank throughout its length as the stem pulls completely through the rivet.

Cherry Rivet Head Styles

75 There are two head styles of the Cherry blind rivets; Universal (corresponding to AN470), and Flush 100° countersunk (corresponding to AN426). (See Figure 5-36.)

Rivet		Standard Size						Oversize	
Material		(A17S-T) Aluminum Alloy		(56S) Aluminum Alloy		Monel	Diameters Available	(A17S-T) Al. Alloy	Diameters Available
Call-out		Comm.	Military Standard	Comm.	Military Standard	Comm.		Comm.	
Self-Plugging	Universal Head	CR163	MS20600AD	CR157	MS20600B	CR563	1/8 5/32 3/16 1/4 9/32	CR179	1/8, 5/32 3/16, 1/4
	C'sunk Head	CR162	MS20601AD	CR156	MS20601B	CR562		CR178	1/8, 5/32 3/16, 1/4
Hollow Pull-through	Universal Head	CR117				CR517			
	C'sunk Head	CR116				CR516			
Ident. Colour		Yellowish Green		Orange	Orange	Cadmium Plated		Blue	
Note: For USAF, NAF and LS callouts, see interchangeability tables.									

Figure 5-36 Cherry Rivet Types

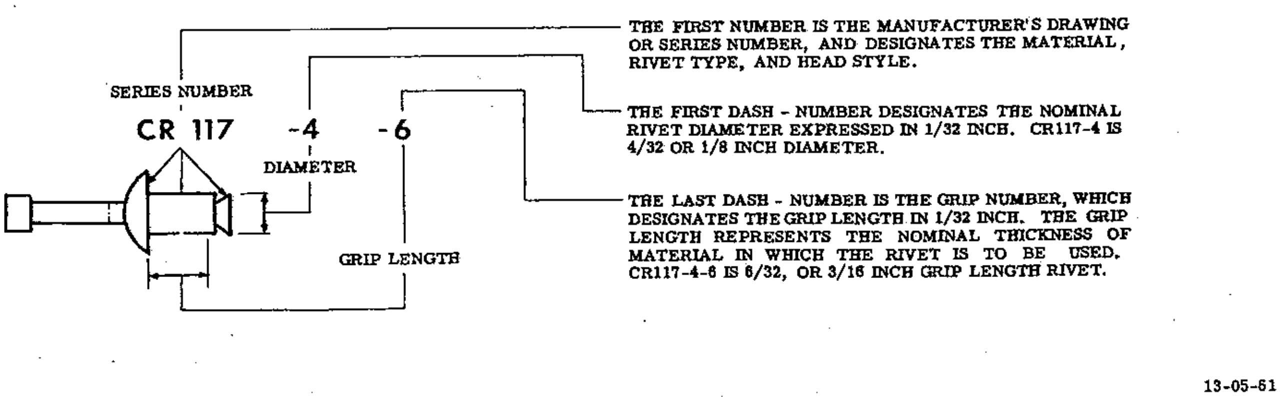


Figure 5-37 Cherry Rivet Numbering Code

76 The blind Cherry rivets are available in five standard diameters; 1/8, 5/32, 3/16, 1/4 and 9/32. In addition, a 3/32 diameter is available in hollow pull-through type only. Oversize (1/8, 5/32 and 3/16) rivets are also manufactured 0.009 to 0.016 inch over nominal shank diameters.

Numbering Code

77 For Cherry rivet numbering code, see Figure 5-37.

Rivet Storage

78 Store rivets in the boxes in which they are received from the manufacturers or in moisture-proof containers, properly labelled, giving all the information that appears on the manufacturer's boxes. Do not remove protective film from Cherry blind rivets. The lubricant on Cherry blind rivets is necessary for proper stem installation and shank expansion. Protect rivets from dirt or grit. Use oldest rivets in stock first.

Drilling and Countersinking

79 Use standard drilling and countersinking procedures as for solid shank rivets. If parts have not been prepunched, pilot drill, if necessary, to properly locate holes. For final hole sizes, see Figures 5-34 and 5-35.

Dimpling

80 Holes to be dimpled should be pilot drilled, dimpled and redrilled to size. Make sure that the dimpling punch pilot is of such a diameter that the hole size, after dimpling, is within the inspection limits of the Cherry hole size gauge, (see Figure 5-38). Holes which are beyond the maximum limit should be redrilled to take an oversize rivet.

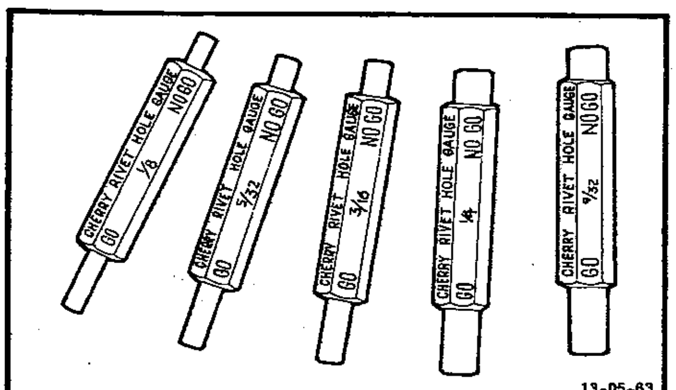


Figure 5-38 Cherry Rivet Hole Size Gauges

81 Minimum sheet thickness for dimpling for standard Cherry rivets is as follows:

Rivet Dia.	Thickness
1/8	.040
5/32	.050
3/16	.063

Grip Length Determination

82 The last dash number for any Cherry rivet indicates the grip length expressed in sixteenths of an inch for MS standards, and thirty-secondths of an inch for commercial part numbers. See Figures 5-34 and 5-35 for grip length range. The grip length of the rivet to be used should be checked, using a Cherry rivet selector gauge, (see Figure 5-39).

NOTE

Do not confuse the length of the rivet shank with grip length.

83 Rivets must be allowed adequate clearance on the blind side. If clearance is insufficient for Cherry self-plugging rivets, hollow pull-through type may be used. (See Figure 5-40.)

Rivetting

84 Use proper tools for rivetting. The drawbolt of the gun should correspond to the diameter of the rivet, and the sleeve to the diameter and head style of the rivet. For easy identification, the rivet diameter is stamped on these tools.

85 When using either the hand gun or the power gun, push the gun against the work with enough force to seat the head of the rivet firmly.

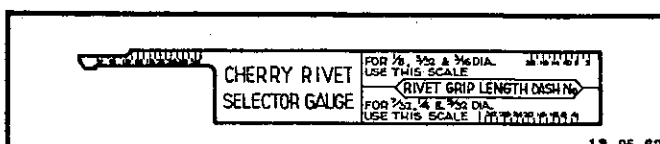
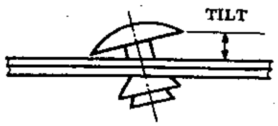


Figure 5-39 Cherry Rivet Selector Gauge

Installed Rivets

86 The maximum acceptable head tilt of installed protruding head rivets must not exceed the following values:



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Rivet Size	Maximum Tilt
1/8	0.004
5/32	0.006
3/16	0.008

87 Whether the blind end is visible or not, inspect installed rivets from the open side before trimming off the broken stem. Check that a minimum of 1/32 inch of the enlarged stem is visible above the manufactured head, (see Figure 5-41). If the enlarged portion of the stem does not protrude 1/32 inch, the hole is too small or the rivet is too short and should be replaced. For rivets in clusters covering the same grip length, the stem should be a reasonably uniform height above the work surface.

88 Trim the fractured stem of expanded rivets. Flat ground nippers must be used as shown in Figure 5-42. Do not use chisel or curved nippers. Do not tap or hit heads of expanded rivets, as this will produce loose rivets.

Grip	Min. Clearance C
1/32 to 5/64	9/16
5/64 to 9/64	5/8
9/64 to 13/64	3/4
13/64 to 17/64	7/8
17/64 to 21/64	1

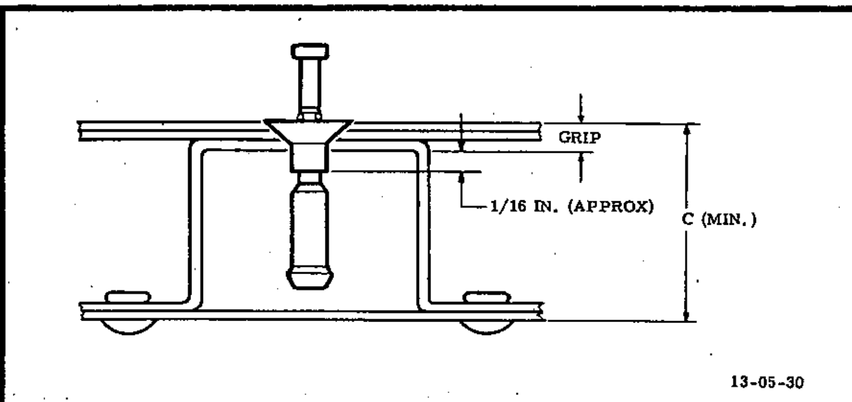


Figure 5-40 Cherry Rivet Stem Clearance

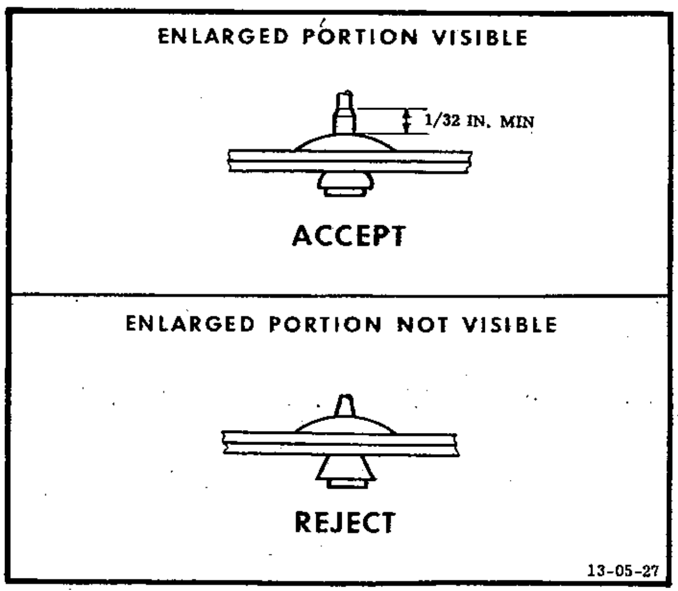


Figure 5-41
Cherry Rivet Stem Protrusion Measurement

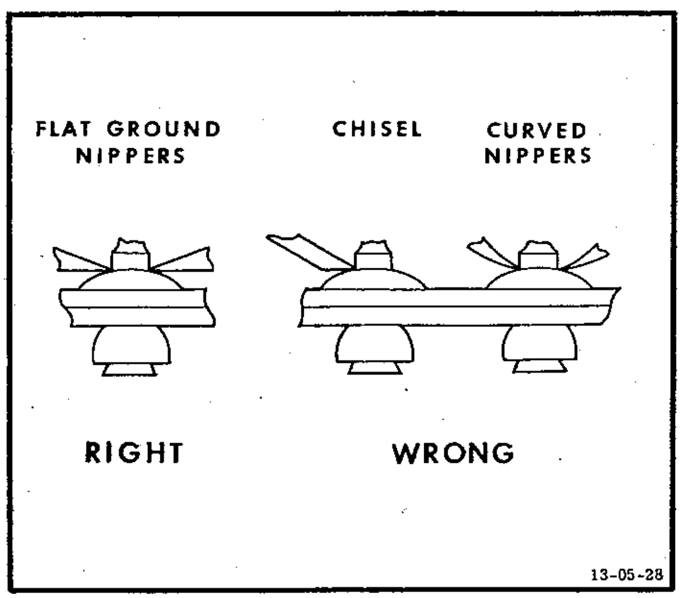


Figure 5-42 Trimming Cherry Rivet Stems

89 If the blind end is visible after expansion, inspect for proper head formation, which must be tulip shaped, and for the position of the stem end in relation to the end of the rivet sleeve as shown in Figure 5-43.

90 Perform a stem push-out test on trimmed rivets by applying a force of 10 pounds on the stem, using a Cherry 352B1 stem inspection gauge. This should preferably be done several hours after the installation. If the stem can be pushed out or is loose, either the rivet is too long or the hole is too large. Remove the rivet and replace either by the next size larger, or the next size shorter rivet length.

Removing Rivets

91 Using a punch, first drive out the stem of the self-plugging rivet. Using the hole in the rivet as a pilot, with a drill slightly smaller than the shank diameter, drill through the head only. Pry off the head with a punch. Push out the remainder of the rivet shank with a punch.

Rivetting Equipment

92 For rivetting guns, attachments and their description, refer to EO 70-1C-2.

EXPLOSIVE RIVETS

NOTE

Explosive rivets are not used in the RCAF due to the hazards in storing and handling. The information contained here is to be used only when specific instructions and tools are issued for a special project.

General

93 Explosive blind rivets, manufactured by the DuPont Co., contain an explosive charge packed into a concentric cavity. Heat applied to the rivet head with a hot iron expands the rivet by igniting the explosive charge in the rivet shank, (see Figure 5-44). These rivets have a strength in shear and tension of approximately 85% of the standard 17S-T rivets. Identification of rivet length is by colour, (see Figure 5-45).

Rivet Coding System

94 For explosive rivet coding system, see Figure 5-46.

Hole Size

95 For hole sizes see Figure 5-47. Holes to be dimpled should be pilot drilled, dimpled and redrilled to size.

Clearance

96 Clearance, (see Figure 5-40), is required to protect the opposite skin from corrosion caused by the blast effect of the exploding rivet. If this clearance is unobtainable, the opposite skin must be protected by some other means.

Rivet Storage

97 Store explosive rivets in the boxes in which they are received from the manufacturer or in moistureproof containers, properly labelled, giving all the information that appears on the manufacturer's box. Observe the following precautions:

(a) Storage rooms must be cool and dry.

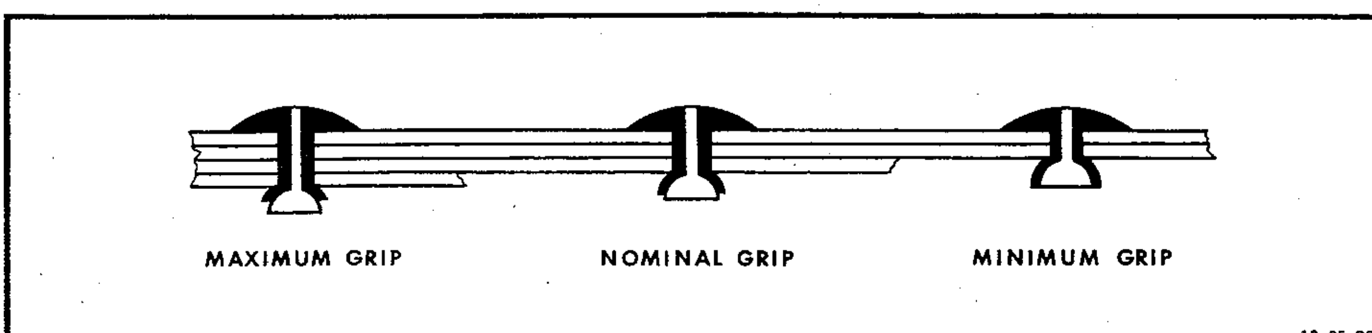


Figure 5-43 Cherry Rivet Blind End Formation

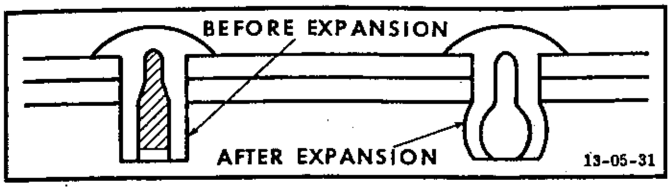


Figure 5-44
Cross-sectional View of Explosive Rivet

(b) Do not store nor place explosive rivets, even for a short time, near hot equipment, such as radiators, furnaces, etc.

(c) Do not remove the protective film on the rivets. The film is necessary for proper heating, firing and expanding of the rivet.

56S RIVETS								
Grip Length	Dash No.	1/8 Dia.		5/32 Dia.		3/16 Dia.		Colour Ident-ification
		Length	Clear-ance	Length	Clear-ance	Length	Clear-ance	
.005-.045	4	.150	7/16					Yellow
.046-.085	8	.190	1/2					Red
.086-.125	12	.230	9/16					Brown
.126-.165	16	.270	9/16					Black
.166-.205	20	.310	5/8					Blue
.206-.245	24	.350	11/16					Yellow
.246-.285	28	.390	11/16					Red
.286-.325	32	.430	3/4					Brown
.326-.365	36	.470	13/16					Black
.025-.085	8			.235	13/16			Red
.086-.145	14			.295	7/8			Yellow
.146-.205	20			.355	15/16			Blue
.206-.265	26			.415	1			Black
.266-.325	32			.475	1-1/16			Brown
.326-.385	38			.535	1-1/8			Red
.085-.104	10					.290	1-1/8	Blue
.105-.165	16					.350	1-3/16	Black
.166-.245	24					.430	1-1/4	Yellow
.246-.325	32					.510	1-5/16	Brown
.326-.405	40					.590	1-7/16	Blue
.406-.485	48					.670	1-1/2	Red

Figure 5-45 (Sheet 1 of 2)
Explosive Rivet Grip, Length, Clearance and Colour Identification

A17S RIVETS								
		1/8 Dia.		5/32 Dia.		3/16 Dia.		
Grip Length	Dash No.	Length	Clear-ance	Length	Clear-ance	Length	Clear-ance	Colour Ident-ification
.025-.045	4	.150	7/16					Yellow
.046-.065	6	.170	1/2	.215	3/4			Black
.066-.085	8	.190	1/2	.235	13/16	.270	1-1/16	Red
.086-.105	10	.210	1/2	.255	13/16	.290	1-1/8	Blue
.106-.125	12	.230	9/16	.275	13/16	.310	1-1/8	Brown
.126-.145	14	.250	9/16	.295	7/8	.330	1-1/8	Yellow
.146-.165	16	.270	9/16	.315	7/8	.350	1-3/16	Black
.166-.185	18	.290	5/8	.335	7/8	.370	1-3/16	Red
.186-.205	20	.310	5/8	.355	15/16	.390	1-3/16	Blue
.206-.225	22	.330	5/8	.375	15/16	.410	1-1/4	Brown
.226-.245	24	.350	11/16	.395	15/16	.430	1-1/4	Yellow
.246-.265	26	.370	11/16	.415	1	.450	1-1/4	Black
.266-.285	28	.390	11/16	.435	1	.470	1-5/16	Red
.286-.305	30	.410	3/4	.455	1	.490	1-5/16	Blue
.306-.325	32	.430	3/4	.475	1-1/16	.510	1-5/16	Brown
.326-.345	34	.450	3/4	.495	1-1/16	.530	1-3/8	Yellow
.346-.365	36	.470	13/16	.515	1-1/16	.550	1-3/8	Black
.366-.385	38			.535	1-1/8	.570	1-3/8	Red
.386-.405	40					.590	1-7/16	Blue
.406-.425	42					.610	1-7/16	Brown
.426-.445	44					.630	1-7/16	Yellow
.446-.465	46					.650	1-1/2	Black
.466-.485	48					.670	1-1/2	Red

Figure 5-45 (Sheet 2 of 2)
Explosive Rivet Grip, Length, Clearance and Colour Identification

Safety Precautions

98 Observe the following safety precautions when using explosive rivets:

(a) Do not expand explosive rivets in the presence of any explosive vapours or fluids, such as gasoline, paints, thinners, alcohol, etc. If such vapours are present, consult engineering authority for the method of dispersing them before proceeding.

(b) Explosive rivets must not be fired when any part of the body of the operator or others is in a direct line with the open end of the rivet.

(c) Return unused rivets to stores. Do not keep them in a tool box. Destroy discarded rivets.

(d) Before changing a heating or rivetting iron tip, make sure that the iron is disconnected from the electrical supply and the tip cooled off with water or compressed air.

Assembly of Parts Prior to Rivetting

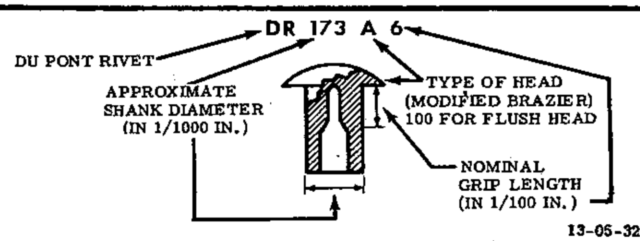
99 Fasten the parts to be rivetted together with skin fasteners at intervals of not more than six inches. Hold the parts tightly, since the rivets have no ability to draw the parts together.

Grip Length Selection

100 Grip length is governed by the Interchangeability Tables (see Figures 5-34 and 5-35).

Rivetting Tools

101 Any soldering iron with a tip that can be machined to the dimensions shown in Figure 5-48, and capable of exploding the rivet within two to six seconds is suitable. For continuous rivetting, a No. 6 DuPont air cooled iron, which requires a transformer and a shop air line, is recommended. Tips must always be selected according to rivet diameter and head type. Plug the soldering iron into a standard elec-



Type of Head	Rivet Size	(A17S) Aluminum Alloy		(56S) Aluminum Alloy	
		Commercial	MS	Commercial	MS
Brazier	1/8	DR-134A-	MS20602AD4-	56S-134A-	MS20602B4-
	5/32	DR-173A-	MS20602AD5-	56S-173A-	MS20602B5-
	3/16	DR-204A-	MS20602AD6-	56S-204A-	MS20602B6-
Flush	1/8	DR-134-100-	MS20603AD4-	56S-134-100-	MS20603B4-
	5/32	DR-173-100-	MS20603AD5-	56S-173-100-	MS20603B5-
	3/16	DR-204-100-	MS20603AD6-	56S-204-100-	MS20603B6-
For callouts of NAF type explosive rivets, see interchangeability tables.					

Figure 5-46 Explosive Rivet Coding

Rivet Diameter	1/8	5/32	3/16
Pilot Hole Diameter	0.129 (No. 30)	0.159 (No. 21)	0.191 (No. 11)
Final Hole Diameter	0.135-0.139 (No. 29)	0.172-0.176 (No. 17)	0.203-0.207 (No. 6)

Figure 5-47 Explosive Rivet Hole Sizes

trical supply of 110 volts and allow 20 to 30 minutes for heating. Plug in the input side of the transformer of the No. 6 rivetting iron similarly and connect the air line from the iron to a standard air supply. The No. 6 rivetting iron does not require a period for heating up.

Installation

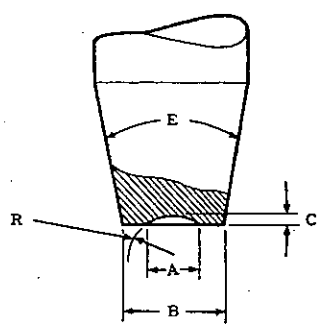
102 Fit a rivet of the proper grip length into the prepared hole. If the rivet does not go in easily, do not tap or force, but clean the hole with the final hole size drill shown in Figure 5-47. Should the rivet still not go in the hole easily, discard it.

103 Where the clearance is less than that given in Figure 5-45, insert strips of wood or metal under the end of the rivet prior to firing as a temporary shield to receive the explosive charge. If temporary shielding cannot be used, use permanent shielding in the form of tape (Item 12)

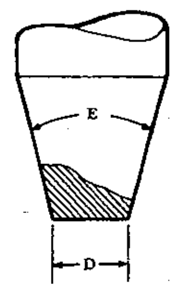
Rivetting

104 For satisfactory rivetting, it is essential that the correct tip at the correct temperature be applied and held properly to the rivet head. Heating iron tips must be reworked or replaced as soon as the tip contour becomes worn, distorted or splayed out. Soldering iron tips may be reworked repeatedly as shown in Figure 5-48. The No. 6 DuPont tip is not suitable for rework.

105 When using a heating or rivetting iron, press the tip firmly and squarely against the rivet head with sufficient force to hold together the parts to be rivetted and to seat the rivet head. With the No. 6 rivetting iron, squeeze the trigger of the iron a few seconds prior to



TIP FOR BRAZIER HEAD RIVET



TIP FOR FLUSH HEAD RIVET

13-05-33

Rivet Dia.	Brazier Head A Dia.	Brazier Head B Dia.	Brazier Head C Depth	Brazier Head R Rad.	E Angle	Flush Head D Dia.
1/8	.170	.220	.020	.181	See Note	.134
5/32	.210	.260	.025	.226		.171
3/16	.250	.300	.030	.272		.202

No.6 DuPont Rivetting Iron Tips

	Brazier Head Rivets			Flush Head Rivets		
Tip	1/8	5/32	3/16	1/8	5/32	3/16
Code No.	6-B-4	6-B-5	6-B-6	6-C-4	6-C-5	6-C-6
Part No.	5562	5563	5564	5565	5566	5567

NOTE

The angle E is normally 45° for straight head tips, but this angle may be altered as desired and the tips offset as required, providing that the other dimensions shown are maintained.

Figure 5-48 Explosive Rivet Rivetting Iron Tip Dimensions applying the tip to the rivet and keep the trigger squeezed during the application. Regulate the temperature of the iron by connecting and disconnecting the electrical current. Regulate the temperature of the No. 6 rivetting iron by using the high or low switch setting on the transformer and by adjusting the air pressure valve on the transformer.

106 All rivets must explode within two to six seconds after the application of the iron. Two seconds is the optimum time. Where a rivet has not exploded within six seconds, discard. In such a case the rivet may be faulty but the operator should check that the iron tip is in good condition. Rivets will not normally explode in less than two seconds unless the iron is too hot.

107 Centre the iron tip on the rivet head, so that the surrounding material is not touched (see Figure 5-49). Hold the iron at right angles

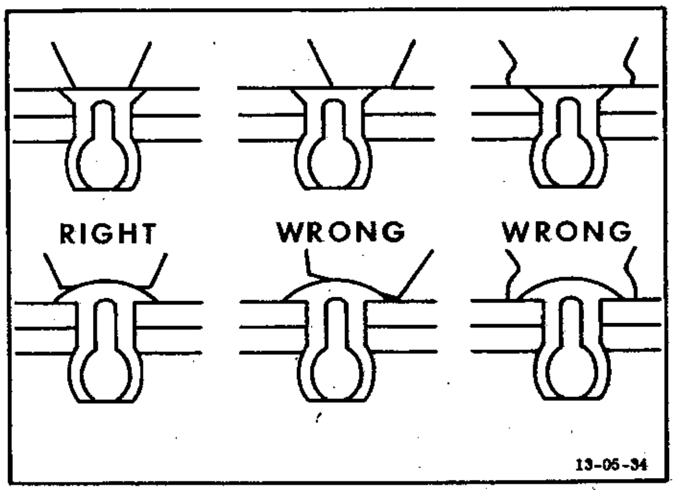


Figure 5-49
Correct Use of Explosive Rivet Tools

to the parts being rivetted. Failure to conform to the above will result in poor expansion of the rivet. Remove the iron immediately from the head of the rivet when the rivet explodes.

108 Clean iron tips with fine wire wool frequently during operation. Dirty or oxidized tips will prevent rivets from exploding properly.

WARNING

Do not leave rejected or defective rivets on the work bench or shop floor. All such rivets should be collected in a box and periodically transferred to a wire basket and destroyed.

109 Do not tap or hit heads of installed rivets as this will produce loose rivets.

Rivet Inspection

110 For maximum acceptable head tilt and gap, refer to Paragraph 85, preceding. If blind side is visible after installation, inspect for proper head formation and splits. The exploded end must be barrel shaped as shown in Figure 5-49.

CHOBERT RIVETS

General

111 Chobert rivets, (Item 7) manufactured in England, are blind rivetting devices similar to hollow Cherry blind rivets. The Chobert rivet is a hollow rivet with a tapered bore through which a mandrel is drawn, thus forming a head on the blind side of the work, (see Figure 5-50). To increase the shear strength of a

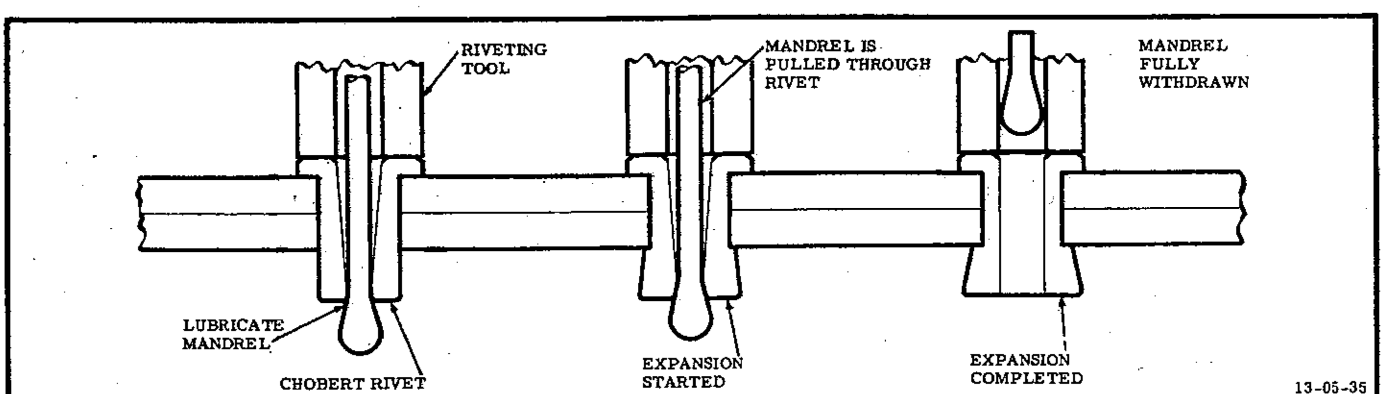


Figure 5-50 Chobert Rivet Expansion

joint made by the use of Chobert rivets, special pins may be driven into the bore.

Operation of the Chobert Rivetter

112 Operate the Chobert rivetter as follows:

(a) Smear the mandrel head with lubricant. A small quantity is sufficient and a fresh application should be made after every rivet.

(b) Select the proper diameter, length, and type Chobert rivet, (see Figure 5-51) and place on the mandrel.

(c) Before loading, make sure that there is no swarf on the head of the mandrel.

(d) Turn the operating handle counter-clockwise as far as it will go, to ensure that the gripping collets are open.

(e) Insert the mandrel and push until the head of the rivet rests on the nose of the rivetter.

(f) Place the rivet in the hole and push well home, holding the rivetter normal to the surface of the work. Do not use the mandrel head or rivet to jockey the plates into line or to enlarge an undersize hole. The rivet must enter the hole easily.

(g) Whenever possible, steady the rivetter against the body and turn the operating handle in a clockwise direction. When resistance ceases, the rivet has been placed, (see Figure 5-50). If the mandrel slips, do not continue to use it, since the collet serrations will become damaged. Slipping may be due to the serrations being clogged. To clean, unscrew the chuck by the flats provided after removing the nose-piece. Remove the plug in the base of the chuck and shake out the spring, thrust piece and collets. The collets can be parted without dismantling and any accumulated dirt removed.

(h) The mandrels are of such a length as to bottom against the plug in the base of the jaw holder, at the same time leaving the correct amount of protrusion at the nose of the rivetter. If, for any reason, the mandrel is shortened, there is a danger of the head jamming in the hole of the nosepiece. The stroke of the rivetter is 1/2 inch. If the mandrel head protrudes for a greater distance, as when a long rivet is being placed, it

DRILL SIZES

Diameter	Drill No.	Decimal Size	Edge Distance
1/8	30	.1285	1/4
5/32	20	.1610	5/16
3/16	10	.1935	3/8

GRIP TABLE

Length (Grip+.100)	Grip	Code
1/8 (.125)	.025 to .056	TK2C(S)D
1/8 (.125)	.025 to .056	TL2C(S)D
1/8 (.125)	.025 to .056	TX2C(S)D
3/16 (.188)	.044 to .108	TK3C(S)D
3/16 (.188)	.044 to .108	TL3C(S)D
3/16 (.188)	.044 to .108	TX3C(S)D
1/4 (.250)	.108 to .172	TK4C(S)D
1/4 (.250)	.108 to .172	TL4C(S)D
1/4 (.250)	.108 to .172	TX4C(S)D
5/16 (.313)	.172 to .240	TK5C(S)D
5/16 (.313)	.172 to .240	TL5C(S)D
5/16 (.313)	.172 to .240	TX5C(S)D

Coding Breakdown

T X 4 C (S) D

- D — Material - Dural
- (S) — Flathead
- C — Countersunk
- 4 — Lengths in 16ths
- X — Dia. 3/16 (K=1/8, L=5/32)
- T — Taper Bore

Figure 5-51
Chobert Rivet Drill Size and Grips

will not pull clear on completion of one turn of the handle. After completion of the turn, give the handle one turn counterclockwise and push the rivetter back against the face of the work, thus gripping the mandrel higher up. A second clockwise turn of the handle will then complete the withdrawal of the mandrel.

Removal of Chobert Rivets

113 Chobert rivets must be removed by drilling off the head as required for a standard solid rivet. The use of a hand drill is recommended as the high speed of an electric drill is liable to spin the rivet, producing an oversize hole.

Interchangeability

114 For permissible substitutions, see Figures 5-34 and 5-35.

TUCKER POP RIVETS

General

115 Tucker (Item 8) pop rivets are blind, hollow, pull-through fasteners of British design. They are available in aluminum alloy, monel and mild steel; flush and domed head, and with break head or break stem mandrels, (see Figures 5-52 and 5-53). For rivet code, see Figure 5-54. For standard sizes and code numbers, see Figure 5-55.

NOTE

Rivet lengths are measured from under the head, both domed and flush head. The thicknesses shown for use with flush head rivets are those where the sheets have been countersunk. For dimpled work, measure the grip, see Figure 5-34, and use dome head table. Head angle is 120°.

Drill Sizes

116 For recommended drill sizes, see Figure 5-56.

Failing Loads

117 For table of failing loads, see Figure 5-57.

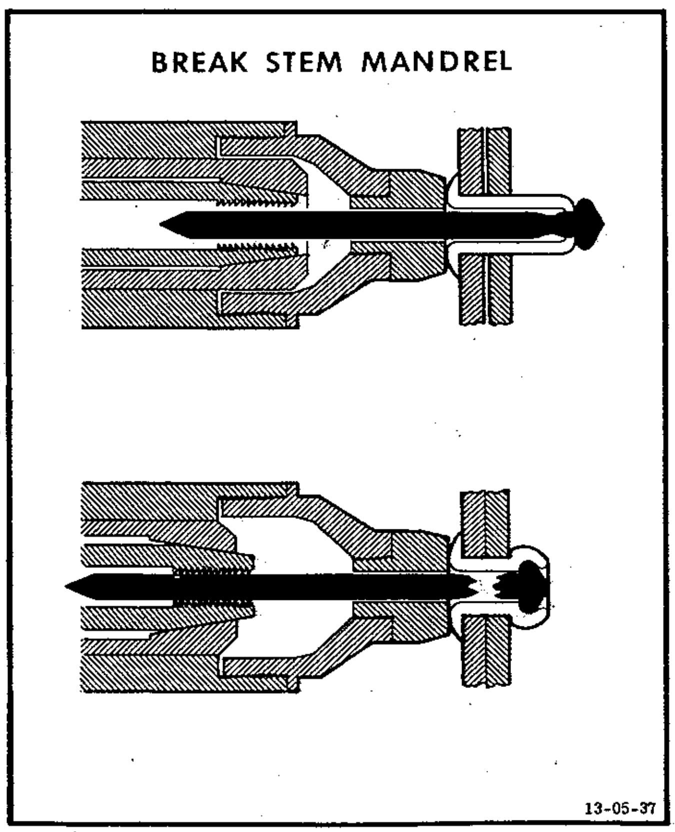


Figure 5-52 Tucker Break Stem Mandrel

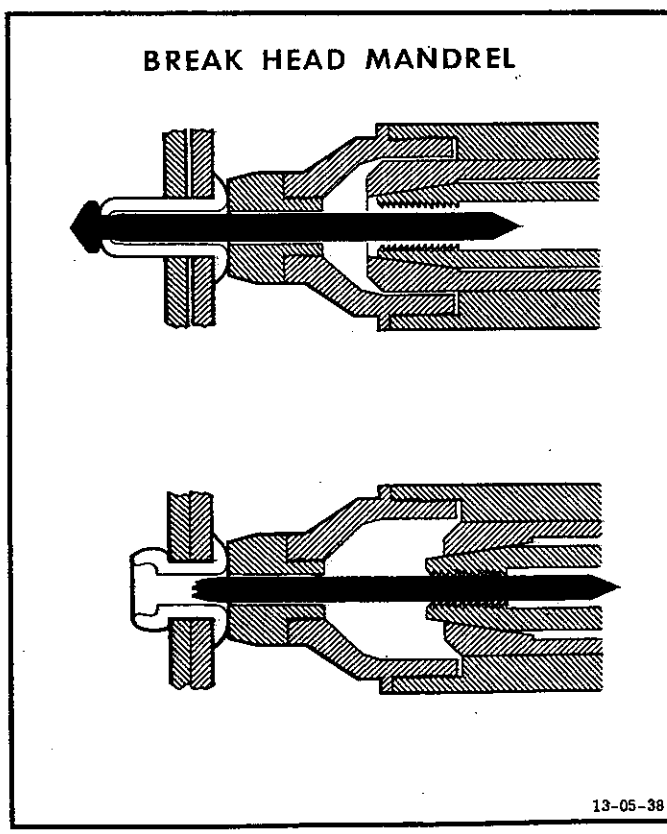


Figure 5-53 Tucker Break Head Mandrel

Rivetting Tools

118 There is a large variety of tools suitable for Tucker rivet installation. Some of the more common are:

(a) Lazy Tong, AML8995/10.

(b) Cranked Pliers, AML500.

(c) Pneumatic Gun AML8997/20.

(d) Pneumatic Gun AML8937/30.

HUCK FASTENERS

General

119 The various Huck fasteners (Item 6) are as follows: (See Figure 5-58.)

(a) Huck AL (Aircraft Lockbolts): A high strength fastener, similar in function to the Hi-Shear rivet. It does not require bucking, although it is not a blind fastener. Pin is steel (SAE 4037) heat-treated to 160,000 to 180,000 pounds per square inch tensile strength.

(b) Huck BL (Blind Lockbolts): A blind fastener of steel. Pin material and heat-treat same as AL bolts. Blind sleeve and filler sleeve SAE 1035, 1040 or 1042. Collar mild steel.

(c) Huck ALS (Aircraft Lockbolt Stumps): Similar in function and installation to the Hi-Shear rivet. Driven with regular rivetting equipment except that a special swaging tool is required. Material and heat treat same as AL bolts.

(d) Huck 9SP (Self Plugging) Blind Rivets: Similar to Cherry blind rivets. (See Figures 5-34 and 5-35.)

(e) Huck CKL (Conical Keystone Lock) Blind Rivets: A blind rivet in which the pin is firmly locked in place, giving the rivet shear characteristics approaching those of solid rivets.

(f) Huck PT (Pull Through) Blind Rivets: Similar to the Cherry hollow rivet.

(g) Huck OS (Oversize Structural) Blind Rivets: This oversize Structural Blind Rivet is made from a very high strength aluminum alloy, and available in 1/4, 5/16 and 3/8 inch oversize diameters.

Huck Bolts

120 Huck bolts consist of the following types:

(a) Aircraft Lockbolt: (See Figure 5-59.) A high strength fastener used in aircraft primary and secondary structure. It fills the hole, pulls the sheets together, is installed very rapidly with only approximately one half

Code

T=Tucker
L=Monel
A=Alum. Alloy
P=Pop type
C=Cup type
D=Domed Head
K=Countersunk Head
BH=Break Head
BS=Break Stem

Example of Code

TLP D 429 BS

- BS — Break Steam Mandrel
- 429 — 1/8 Diameter
- D — Domed Head
- TLP — Tucker Monel Pop

1st digit indicates diameter in 32ths of an inch, e.g.;
1st digit 4 indicates 1/8 diameter
1st digit 5 indicates 5/32 diameter
1st digit 6 indicates 3/16 and .2 in. diameters
2nd and 3rd digits indicate length in .010 in., e.g.: 1/8 dia., x .29 long-429.

Figure 5-54 Tucker Pop Rivet Code

Thickness to be Rivetted Domed Head Rivet	Monel TLP/D/BH TLP/K/BH	Al. Alloy TAP/D/BH TAP/K/BH	Thickness to be Rivetted C'sunk Head Rivet
7/64 Dia.			
.010 to .090	319		.010 to .110
1/8 Dia.			
.010 to .050	413	414	.010 to .080
.051 to .090	419	420	.081 to .120
.091 to .120	424	423	.121 to .150
.121 to .140	424	429	.151 to .170
.141 to .190	429	429	.171 to .220
.191 to .250	435		.221 to .280
.251 to .300	440		.281 to .330
5/32 Dia.			
.010 to .080	519	518	.010 to .110
.081 to .130	524	523	.111 to .160
.131 to .140	524	529	.161 to .170
.141 to .190	530	529	.171 to .220
.191 to .200	530	537	.221 to .230
.201 to .250	537	537	.231 to .280
.251 to .290	540		.281 to .320
.291 to .340	545		.321 to .370
3/16 Dia.		.200 Dia.	
.010 to .120	624	625	.010 to .150
.121 to .160	630	629	.151 to .190
.161 to .170	630	635	.191 to .200
.171 to .220	636	635	.201 to .250
.221 to .230	636	640	.251 to .260
.231 to .250	639	640	.261 to .280
.251 to .360	650	649	.281 to .390
.361 to .510	665	665	.391 to .540
.511 to .610	675		.541 to .640

Thickness to be Rivetted Domed Head Rivet	Monel TLP/D/BS TLP/K/BS	Al. Alloy TAP/D/BS TAP/K/BS	Thickness to be Rivetted C'sunk Head Rivet
7/64 Dia.			
.020 to .070	319		.020 to .090
1/8 Dia.			
.020 to .070	419	420	.030 to .100
.071 to .100	424	423	.101 to .130
.101 to .120	424	429	.131 to .150
.121 to .170	429	429	.151 to .200
.171 to .230	435		.201 to .260
.231 to .280	440		.261 to .310
5/32 Dia.			
.020 to .050	519	518	.040 to .080
.051 to .100	524	523	.081 to .130
.101 to .160	530	529	.131 to .190
.161 to .230	537	537	.191 to .260
.231 to .260	540		.261 to .290
.261 to .310	545		.291 to .340
3/16 Dia.		.200 Dia.	
.020 to .090	624	625	.050 to .120
.091 to .100	630	625	.121 to .130
.101 to .140	630	629	.131 to .170
.141 to .150	630	635	.171 to .180
.151 to .200	636	635	.181 to .230
.201 to .230	639	640	.231 to .260
.231 to .320	650	649	.261 to .350
.321 to .340	650	665	.351 to .370
.341 to .480	665	665	.371 to .510
.481 to .490	665		.511 to .520
.491 to .590	675		.521 to .620

Figure 5-55 Tucker Standard Sizes and Code Numbers

the weight of bolts. The lockbolt cannot loosen under vibratory conditions because of the swaged lock between pin and collar. Part No. ALPP, pan head type, and Part No. ALP509 flush head; are available for steel material, in 3/16 and 1/4 inch diameters, and for aluminum alloy material, in 3/16, 1/4, 5/16 and 3/8 inch diameters. Part No. R1028, pan head type and Part No. R1029, flush head, steel material, are both available in 5/16 and 3/8 inch diameters.

(b) Aircraft Lockbolts Stumps (ALS): Also called A/C Huckbolt Stumps: (See Figure 5-60.) A companion fastener to the aircraft lockbolt, used primarily where clearance will not permit effective installation of the aircraft lockbolt. It is installed with standard air hammers and produces high quality work. Part No. ALSF, pan head type and Part No. ALS509, flush head, both steel and aluminum alloy materials, are available in 3/16, 1/4, 5/16 and 3/8 inch diameters.

(c) Blind Lockbolts (BL): (See Figure 5-61.) The blind lockbolt is a heat-treated alloy

Rivet Dia.	Drill No.	Drill Dia.
7/64	33	.113
1/8	30	.128
5/32	20	.161
3/16	11	.191
.200	6	.204

Figure 5-56
Tucker Pop Rivet Recommended Drill Sizes

Rivet Dia.	Monel (Pound)	Aluminum Alloy (Pound)	A17S-T Solid (For comparison)
7/64	300		
1/8	420	220	388
5/32	560	310	596
3/16	940		862

Figure 5-57 Failing Loads on Tucker Rivets

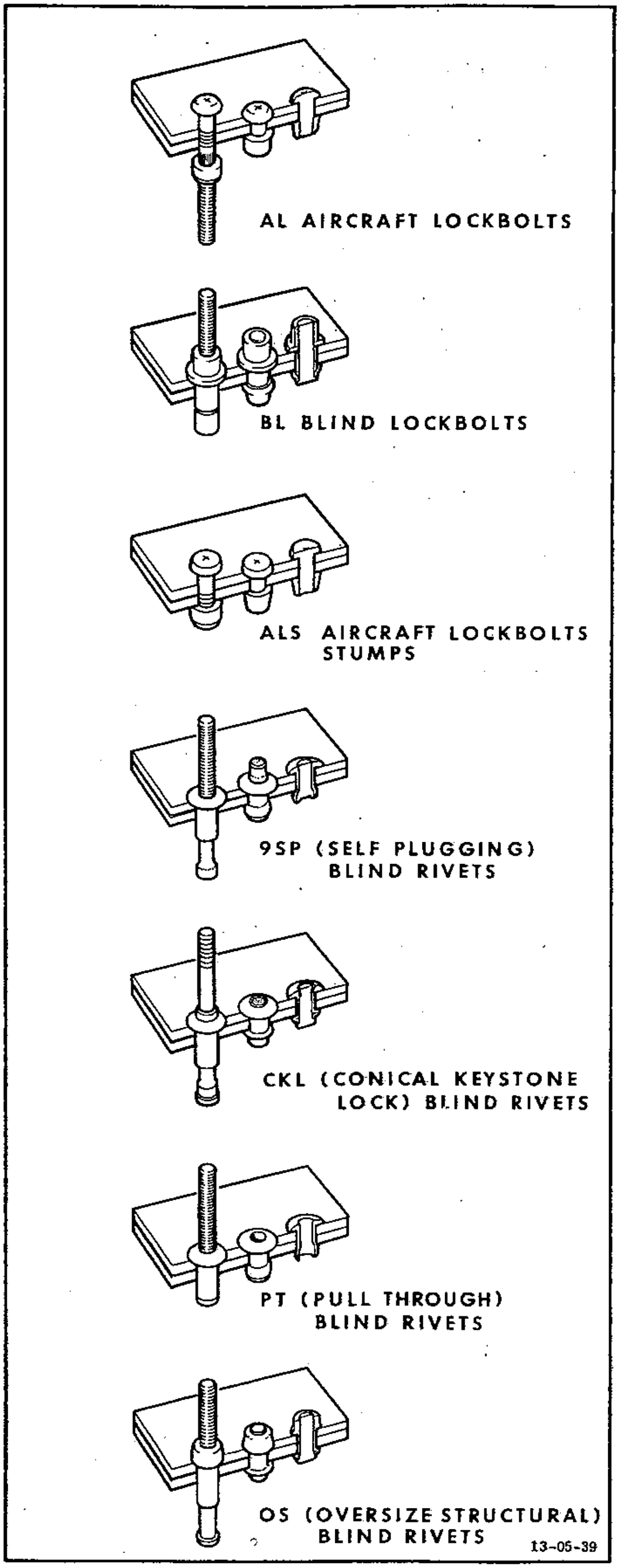


Figure 5-58 Huck Fasteners

steel blind fastener that is positively locked together. Exceptional strength and sheet pull together make the blind lockbolt suited for structural repair from one side of the work. Part No. BL, steel material, is available in 1/4 and 5/16 inch diameters only.

Huck Lockbolts

121 For code for aircraft lockbolt pins and aircraft lockbolt stump pins, see Figure 5-62.

Hole Sizes

122 For table of Huck Lockbolt hole sizes, see Figure 5-63.

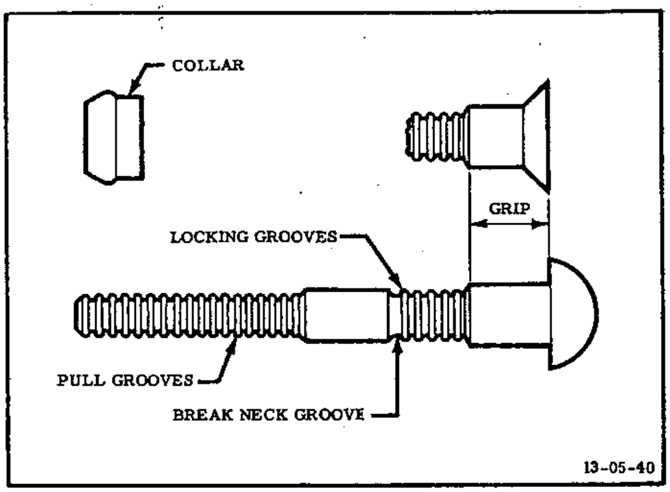


Figure 5-59 Huck AL Aircraft Lockbolt

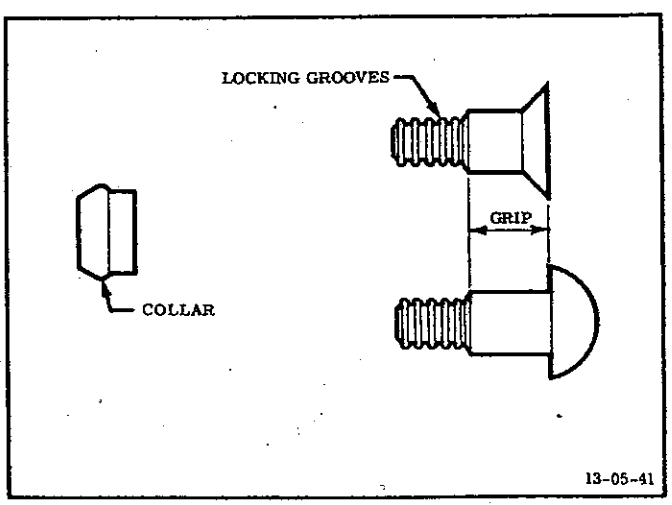


Figure 5-60 Huck ALS Stump Lockbolt

Tensile Strengths

123 For table of ultimate single shear and tensile strengths, see Figure 5-64.

HUCK LOCKBOLTS

Countersinking and Dimpling

124 Flush head Huckbolts are not interchangeable with flush head Hi-Shear rivets, since the Huckbolt heads are of larger diameter. Flush Huckbolts are dimensionably similar to AN509 screws. For dimpling table, refer to Part 6, following.

Grip Dash Numbers

125 The grip dash numbers in Figure 5-65 are applicable to all three types of lockbolts.

Angular or Curved Surfaces

126 The blind head or the collar and washer of blind lockbolts can be formed against a surface not exceeding 7° from perpendicular with the axis of the hole, or on curved surfaces with a minimum radius of curvature of three times the pin diameter. The pin head should be installed on a surface normal to the pin axis.

127 For spotface diameters to provide clearance for the pull gun where spotfacing is required, see Figure 5-66.

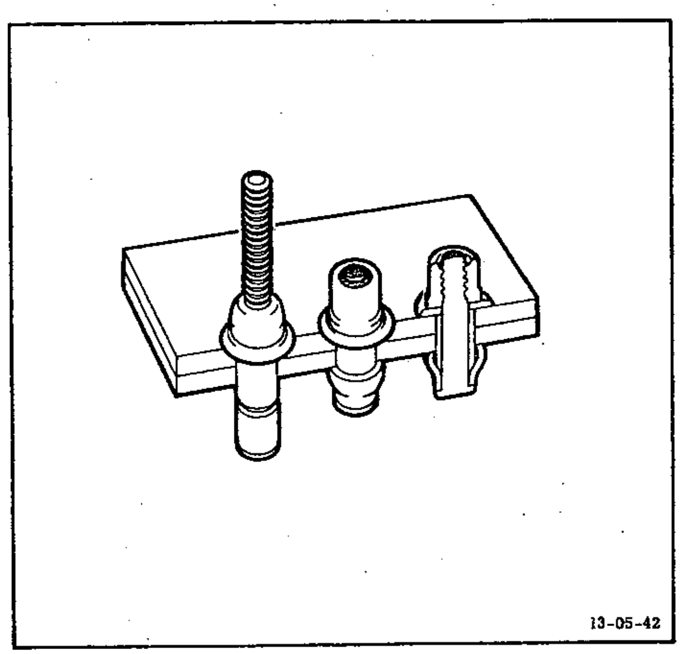


Figure 5-61 Huck Blind Lockbolt

The part number code for aircraft lockbolt pins and aircraft lockbolt stump pins is as follows:

ALP H - T 8 - 8

- 8 — Grip dash number
- 8 — Diameter in 32nds
- T — Material: T = Heat treated alloy steel
  - E = 75S-T aluminum alloy
- H — Class of fit: H = Hole filling
  - N = Non-hole filling
- ALP — Basic part number

The part number code for blind lockbolt pins is as follows:

BL 10 - 8

- 8 — Grip dash number
- 10 — Diameter in 32nds (available in 8 and 10 only)
- BL — Basic part number (only this one)

NOTE

Use an AN960-10 washer under the collar for BL-8, and NAS143-4 for BL-10.

The same type of collar is used with all of the pins. Part number code for collar is as follows:

LC - C - 8

- 8 — Diameter in 32nds
- C — Collar material: C = 24S-T4 aluminum alloy (with heat treated pins only)
  - F = 61S-T6 aluminum alloy (with 75S-T aluminum alloy pins)
  - R = Mild steel (with heat treated steel pins for high temperature applications and with lockbolt pins)
- LC — Basic part number (only this one)

Figure 5-62 Huck Lockbolt and Collar Code

Installation of Aircraft Lockbolts

128 To install aircraft lockbolts, proceed as follows:

(a) Insert the locking collar over the lockbolt pin tail extending through the hole.

(b) Apply the gun as shown in Figure 5-67.

(c) Depress the trigger. By depressing the trigger, a pull is exerted on the pin. As the pull increases, the anvil of the tool is drawn over the locking collar, swaging the collar into the locking grooves of the pin to form a rigid, permanent lock. (See Figure 5-67.) Continued build-up of pressure automatically breaks the lockbolt pin in tension at the breakneck groove.

Installation of Lockbolt Stumps

129 Install Huck lockbolt stumps with conventional rivet guns. Use a special swaging tool, as listed in Figure 5-68 for collar swaging.

Installation of Blind Lockbolts

130 Install blind lockbolts with the rivet pull gun, using the nose assemblies as shown in Figure 5-68.

Size	Aircraft Lockbolt & Lockbolt Stump		Blind Lockbolt	
	Hole Filling	Non-hole Filling	Hole Filling	Non-hole Filling
3/16	.185	.191		
	.187	.203		
1/4	.242	.250	.2598	.261
	.246	.265		
5/16	.305	.3125	.3437	.348
	.309	.330		
3/8	.368	.375		
	.371	.395		

Figure 5-63 Huck Lockbolt Hole Sizes

NOTE

Do not de-grease pins or collars before installation. The gun must be in full return position before insertion on the next pin to be driven.

Inspection of Blind Lockbolts

131 For inspection procedure for blind lockbolts, see Figure 5-69.

Inspection of Aircraft Lockbolt Stump

132 For inspection dimensions, see Figure 5-70.

Lockbolt Pin Material	Heat treated alloy steel (SAE 4037)		75S-T6	
Lockbolt Collar Material	24S-T4		61S-T6	
	Loading			
Diameter	Single shear Pounds	Tension Pounds	Single shear Pounds	Tension Pounds
3/16	2,620	2,210	1,330	1,375
1/4	4,650	4,080	2,280	2,535
5/16	7,300	6,500	3,620	4,025
3/8	10,500	10,100	5,270	6,275

NOTE

Lockbolts are pull gun driven, lockbolt stumps are hammer or squeeze driven.

Heat treated alloy steel Huck pull type lockbolts are available only in 3/16 and 1/4 inch diameters. Heat treated alloy steel Huck lockbolt stumps are available in 3/16, 1/4, 5/16 and 3/8 inch diameters.

Figure 5-64 Huck Lockbolt Ultimate Allowable Single Shear and Tensile Strengths

Removal of Blind Lockbolts

133 For blind lockbolt removal procedure, see Figure 5-71.

Huck Self Plugging Blind Rivet

134 This rivet, (see Figure 5-72), is similar to the Cherry self plugging blind rivet. It is available in A17S-T, 56S and mild steel, flush and brazier head.

Coding

135 The code 9SP-100-A designates flush head A17S-T; 9SP-100-B designates flush head 56S; 9SP-100-R designates flush head mild steel. For brazier head, letter B replaces

Grip Number	Grip Range	
	Min.	Max.
1	.031	.094
2	.094	.156
3	.156	.219
4	.219	.281
5	.281	.344
6	.344	.406
7	.406	.469
8	.469	.531
9	.531	.594
10	.594	.656
11	.656	.718
12	.718	.781
13	.781	.843
14	.843	.906
15	.906	.968
16	.968	1.031
17	1.031	1.094
18	1.094	1.156
19	1.156	1.219
20	1.219	1.281

Grip Number	Grip Range	
	Max.	Min.
21	1.281	1.343
22	1.343	1.406
23	1.406	1.469
24	1.469	1.531
25	1.531	1.594
26	1.594	1.656
27	1.656	1.718
28	1.718	1.781
29	1.781	1.844
30	1.844	1.906
31	1.906	1.968
32	1.968	2.031
33	2.031	2.094

NOTE

Types H - Hole filling available in Grip No. 1 to 16 for 3/16 Dia.
1 to 13 for 1/4 Dia.
1 to 12 for 5/16 and 3/8 Dia.

Type N - Non-hole filling for remaining grip lengths.

Grip No. 2: 5/16 and 3/8 Dia. are not available in flush heads.

Figure 5-65 Huck Lockbolt Grip Dash Numbers

100. Number with material code is the diameter in thirty-seconds of an inch. Last dash number is grip code. For grip, see Figures 5-34 and 5-35.

Drilling and Driving Tools

136 For drill sizes and driving tools, see Figure 5-73.

Inspection

137 For inspection procedure, refer to Paragraphs 86 to 90, inclusive, preceding.

Huck Keystone Lock Blind Rivet

138 The Huck Keystone lock blind rivet consists of two parts, a hollow sleeve made of 56S

Pin Dia.	Spotface Dia.	Fillet R.
3/16	.812	.062
1/4	.812	.062
5/16	1.125	.062
3/8	1.125	.062

Figure 5-66 Spotface Diameters

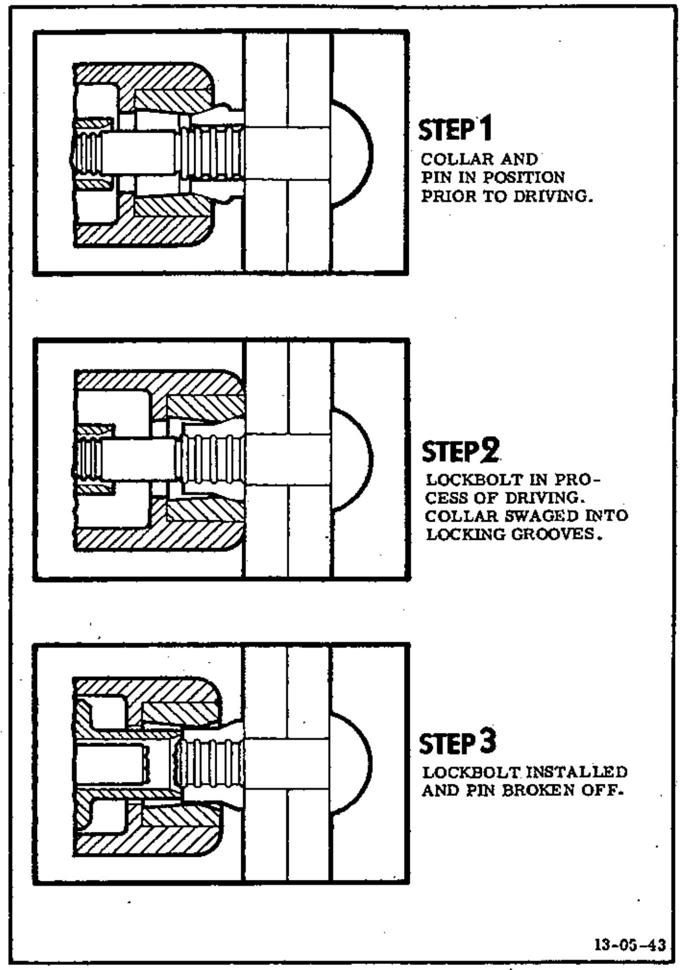
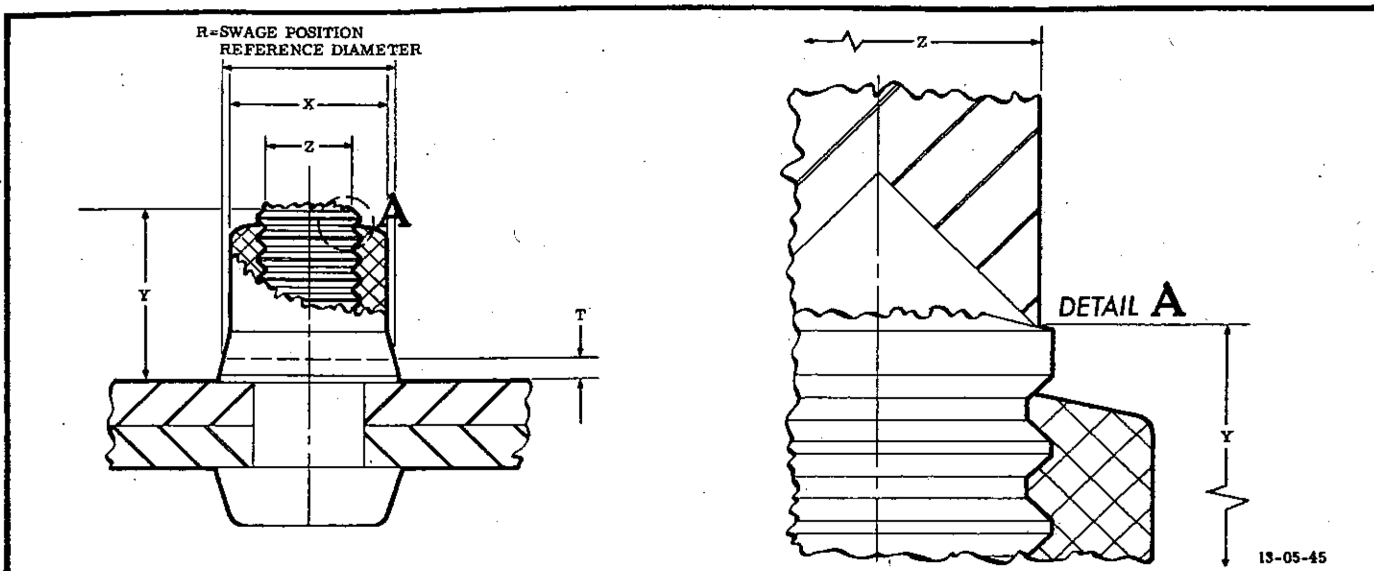


Figure 5-67 Huck Lockbolt Installation

Tools	Aircraft Lockbolts	Lockbolt Stumps	Blind Lockbolts
3/16	CP 352 or CP 353	CP 3X for Al. Stumps	
		CP 5X for Steel Stumps	
1/4	CP 352 Al. Alloy only	CP 5X for Al. Stumps	CP 352-L-6 Nose Assy
	CP 353 Al. Alloy and Al. Steel	CP 7X for Steel Stumps	CP 353-L-6 Nose Assy
5/16	CP 353	CP 7X for Al. Stumps	CP 353 BL-10 Nose Assy
		CP 40 Boyer for Steel Stumps	
3/8	CP 353	CP 40 Boyer	
Chicago Pneumatic Air Hammer or Equivalent Tools			

Figure 5-68 Huck Tools



Lock-bolt Dia.	Lockbolt Pin Material	X Max.	Y	Z Ref.	R	T Min.	T Max.	T When Y is	Assured Minimum Ultimate Tensile Load
3/16	Alloy Steel	.2812	.240(±.050)	.165	.304	.013	.039	.190 to .225	Alloy Steel 2,210
	75S-T6 Alum						.059	.226 to .291	75S-T6 Alum 1,375
1/4	Alloy Steel	.3672	.337(±.059)	.225	.401	.011	.039	.278 to .310	Alloy Steel 4,080
	75S-T6 Alum						.046	.311 to .396	75S-T6 Alum 2,535
5/16	75S-T6 Alum	.4545	.389(±.060)	.269	.487	.044	.084	.339 to .358	75S-T6 Alum 4,025
							.094	.359 to .459	
3/8	75S-T6 Alum	.5525	.480(±.069)	.340	.063	.017	.063	.411 to .444	75S-T6 Alum 6,275
							.083	.455 to .459	
5/16	Alloy Steel	.4572	.365(±.056)	.269	.487	.044	.137		Alloy Steel 4,225
							.185		Alloy Steel 3,250
3/8	Alloy Steel	.5572	.460(±.060)	.340	.590	.042	.125		Alloy Steel 5,050

1. Inspect for completeness of swage (T dimension) first.
2. If T falls between its minimum and the lesser of the two maximums shown, the driven lockbolt is acceptable for the range of Y tabulated in column Y.
3. If T falls between the two maximums shown, the driven lockbolt is acceptable only if the Y dimension falls within the specified range shown following the larger of the maximum allowable T dimensions.
4. If T is less than the minimum tabulated, pin motion after the beginning of collar swage is indicated, and the driven lockbolt should be rejected unless direct inspection establishes the fact that both pin head and collar are in intimate contact with the work.
5. Under any conditions, pin position must be such that Y falls within the limits tabulated under column Y.

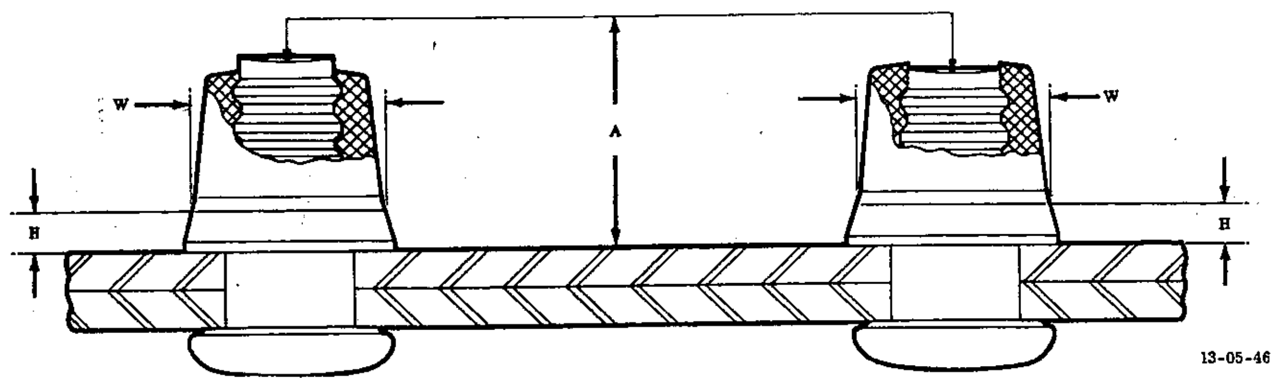
Figure 5-69 Huck Lockbolt Inspection Dimensions having a head (either brazier or countersunk) with a conical recess and locking collar at the other end, and a pin made of 24SRT which is pressed into the sleeve. The pin is provided with pull grooves which fit the jaws of the rivet gun, and has an extruding angle and land, a break neck groove, a locking groove and a head. (See Figures 5-74 and 5-75.)

Types and Sizes

139 Standard Huck blind rivets are available in 1/8, 5/32, and 3/16 inch diameters with AN456 brazier and AN426 100° countersunk heads, in grip lengths to rivet material thicknesses ranging from .020 to .605 inch.

Part Number Identification

140 The first letter of the part number indicates the head type. Thus, P represents a brazier head (AN426), 100V indicates a 100° countersunk head (AN426). The figure following the first letter indicates the nominal rivet shank diameter in thirty-seconds of an inch. The last letter is the grip code



Dia.	Pin Mat'l.	A	W	H Maximum
3/16	Steel	.255 (± .043)	.298	.0595
	75S-T	.280 (± .043)		.0685
1/4	Steel	.330 (± .047)	.395	.0805
	75S-T	.353 (± .047)		.0745
5/16	Steel	.414 (± .031)	.487	.1075
	75S-T	.439 (± .041)	.500	.0655
3/8	Steel	.514 (± .031)	.590	.1575
	75S-T	.539 (± .044)		.1205

NOTE

Inspection of Blind Lockbolt: use L-6 G24 Inspection gauge for BL-8 bolts, and L-8 for BL-10 bolts.

Figure 5-70 Huck Lockbolt Stump Inspection Dimensions letter which is stamped on the head of every rivet pin. This indicates the grip range as listed in Figure 5-76. For example, P5C indicates a brazier head rivet (P), 5/32 inch in diameter (5), having a grip range from .077 inch to .107 inch inclusive (grip code letter C). Likewise, 100V6E indicates a 100° countersunk head rivet (100V), 6/32 inch or 3/16 inch in diameter (6), for grips ranging from .236 to .272 inch inclusive (E). For tables of grip lengths, see Figures 5-76 and 5-77 .

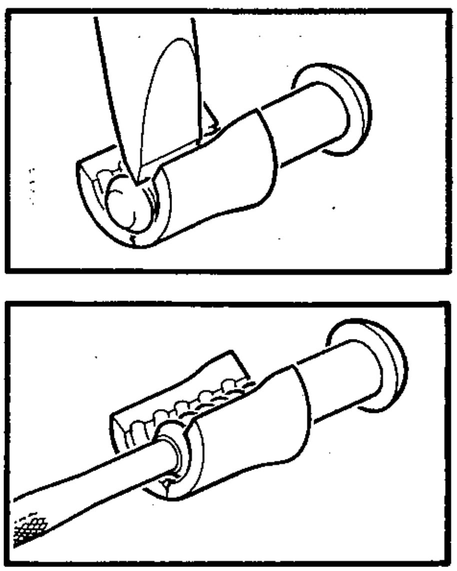


Figure 5-71 Huck Lockbolt Removal

Drilling

141 For accuracy, predrill holes, then size drill. For sizes, see Figure 5-78.

Installation Tools

142 The gun used for driving Huck rivets is known as the CP350RP blind rivet gun. The nose of the gun includes the following parts:

(a) A set of chuck jaws which fit the pull grooves in the rivet pin and pull it through the sleeve to drive the rivet.

(b) An outer anvil which bears against the outer part of the accessible rivet head during the driving operation.

(c) An inner anvil which advances automatically to drive the locking collar home after

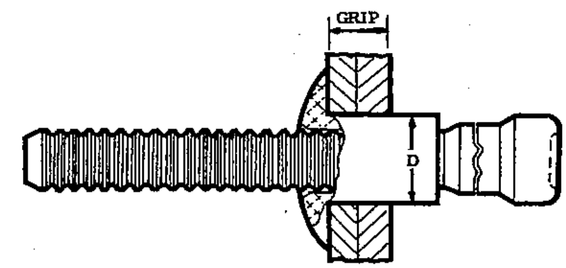


Figure 5-72 Huck Blind Rivet

Dia.	D (Alum.)	D (Steel)	Recomended Drilling Procedure			Driving Tools				
						Huck		Chicago Pneumatic		
			Pre-drill	Size Drill	Hole Limits	No. 120	No. 93 94	CP 349	CP 352	CP 353
1/8	.124 to .128	.124 to .128	No.32(.116)	No.30(.128)	.128 to .132	X	X	X	X	
5/32	.155 to .159	.155 to .160	No.26(.147)	No.20(.161)	.160 to .164		X	X	X	
3/16	.186 to .190	.186 to .191	No.16(.177)	No.10(.193)	.192 to .196		X	X	X	
1/4	.249 to .253	.249 to .254	A (.234)	F (.257)	.256 to .261				X	X

Figure 5-73 Huck Blind Rivet Drill Sizes and Driving Tools

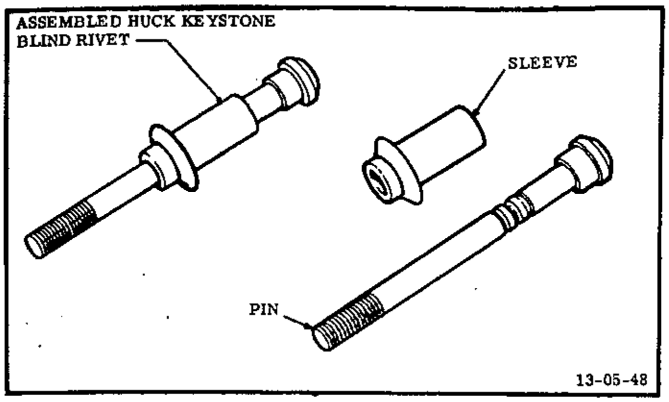


Figure 5-74 Huck Keystone Blind Rivet Parts

the blind head is formed. A gun with standard nose is shown in Figure 5-79. A short nose assembly, interchangeable with the standard nose, can be used as optional equipment.

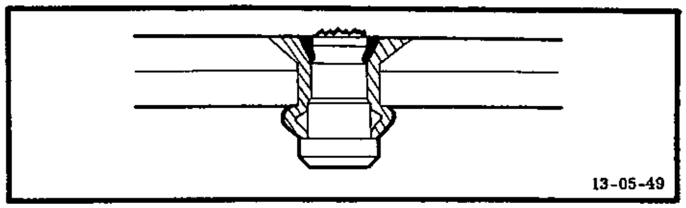


Figure 5-75 Huck Blind Rivet Installed

Rivet Dia.	Grip Range	Grip Code Letter													
		A	B	C	D	E	F	G	H	J	K	L	M	N	P
1/8	Min.	.020	.037	.062	.087	.112	.137	.162	.187*	.212*					
	Max.	.036	.061	.086	.111	.136	.161	.186	.211*	.236*					
5/32	Min.	.025	.046	.077	.108	.139	.170	.201	.232	.263*	.294*	.325*	.356*	.387*	
	Max.	.045	.076	.107	.138	.169	.200	.231	.262	.293*	.324*	.355*	.386*	.417*	
3/16	Min.	.030	.055	.092	.129	.166	.203	.240	.277	.314	.351*	.388*	.425*	.462*	.499*
	Max.	.054	.091	.128	.165	.202	.239	.276	.313	.350	.387*	.424*	.461*	.498*	.535*
*Special Grip Lengths.															

Figure 5-76 Huck Brazier Head Rivet Grip Lengths

Rivet Dia.	Grip Range	Grip Code Letter													
		A	B	C	D	E	F	G	H	J	K	L	M	N	P
1/8	Min.	.062	.079	.104	.129	.154	.179	.204	.229*	.254*					
	Max.	.078	.103	.128	.153	.178	.203	.228	.253*	.278*					
5/32	Min.	.080	.101	.132	.163	.194	.225	.256	.287	.318*	.349*	.380*	.411*	.442*	
	Max.	.100	.131	.162	.193	.224	.255	.286	.317	.348*	.379*	.410*	.441*	.472*	
3/16	Min.	.100	.125	.162	.199	.236	.273	.310	.347	.384	.421*	.458*	.495*	.532*	.569*
	Max.	.124	.161	.198	.235	.272	.309	.346	.383	.420	.457*	.494*	.531*	.568*	.605*
*Special Grip Lengths.															

Figure 5-77 Huck Countersunk Rivet Grip Lengths

143 A change in diameter of the rivets to be driven requires a change in chuck jaws, outer anvil, inner anvil and inner anvil thrust bushing, plus an adjustment of the shift valve operating pressure as described in Paragraph 145, following. A change in type of rivet head from brazier to countersunk or from countersunk to brazier, requires a change of outer anvil only, provided there is no change in rivet diameter.

144 A special chuck jaw assembly tool is furnished with the gun. To facilitate insertion of the chuck jaws into the chuck sleeve, first mount the three jaws on this assembly tool to form a cone, and lower the inverted chuck sleeve over the jaws .

Rivet Dia.	Not Dimpled Pre-Drill	Dimpled Pilot Drill	Size Drill
1/8	No.32(.116)	No.32(.116)	No. 30 (.128)
5/32	No.26(.147)	No.27(.144)	No. 20 (.161)
3/16	No.16(.177)	No.17(.173)	No.10(.193)

Figure 5-78 Huck Blind Rivet Drill Sizes

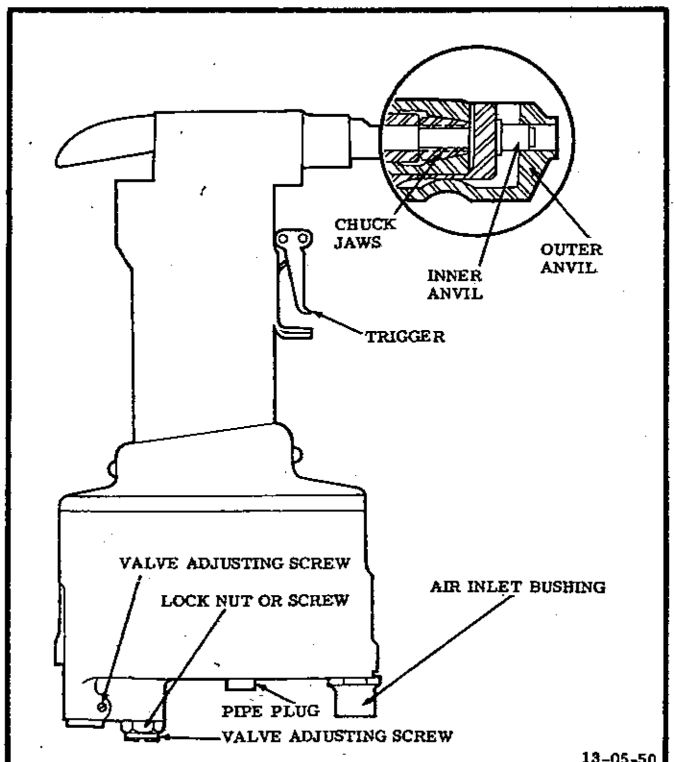


Figure 5-79 Huck Rivet Gun - CP350RP

Installation

145 Check to see that the pull gun is equipped with correct size chuck jaws and outer and inner anvils to fit the rivets to be driven. Check that the relief valve is properly adjusted for correct pressure. When setting up the machine for a different size rivet, install the pressure gauge in the cylinder head after removing the plug. The following pressures as indicated on this gauge will be found correct: For a 1/8 inch rivet the gauge reading should be 31 pounds, for a 5/32 inch rivet it should be 47 pounds, for a 3/16 inch rivet, 67 pounds. When rivets of extremely long grip length are to be driven, an adjustment to the high pressure limit is desirable. Figure 5-75 shows the correct break in relation to the rivet head and the conical lock. This is obtained by correct grip and pressure. For efficient operation of the gun, the line pressure should be from 90 psi to approximately 110 psi. To be sure that the rivets will be driven quickly and with little effort, the following points should be kept in mind:

(a) Hold the head of the gun steady and at right angles to the work.

(b) Press on the gun hard enough to hold the head of the rivet firmly against the work. Do not use great pressure unless necessary to bring the parts being rivetted into contact.

(c) Squeeze the trigger of the gun and hold it until the rivet pin breaks. Then release the trigger. The next rivet should not be driven until the return action has caused the gun to latch, as evidenced by a distinct click.

Removal

146 Remove blind rivets as follows:

(a) Shear the lock by driving out the rivet pin, using a tapered steel drift pin not over

Rivet Diameter	Drill Size	Drill Diameter
1/8	No.31	.120
5/32	No.24	.152
3/16	No.15	.180

Figure 5-80
Drill Sizes for Huck Blind Rivet Removal

3/32 inch in diameter at the small end. Back up thin sheets.

(b) Pry the remainder of the locking collar out of the rivet head, using the drift pin.

(c) Using the size of drill listed in Figure 5-80, drill nearly through the rivet head.

(d) Break off the head, using the drift pin as a pry.

(e) Drive out the remainder of the rivet.

Oversize Blind Rivets

147 Oversize structural blind rivets are available in nominal sizes of 1/4, 5/16 and

Nominal Dia.	Oversize Dia.	Drilling Procedure			Driving Tools	
		Pre-Drill	Size Drill	Hole Limits	Tool Model	Nose Assembly
1/4	.270 to .265	F (.257)	I (.272)	.271 to .275	CP352 or CP353	OS-8
5/16	.341 to .335	21/64	11/32	.342 to .348	CP353	OS-10
3/8	.403 to .396	3/8	13/32	.404 to .411	CP353	OS-12

Figure 5-81 Drill Sizes and Driving Tools for Huck Oversize Blind Rivets

1/4 Diameter (Oversize)			5/16 Diameter (Oversize)			3/8 Diameter (Oversize)		
Part Number	Grip Range		Part Number	Grip Range		Part Number	Grip Range	
	Min.	Max.		Min.	Max.		Min.	Max.
OS-8A	.050	.100	OS-10A	.062	.125	OS-12A	.075	.150
OS-8B	.100	.150	OS-10B	.125	.187	OS-12B	.150	.225
OS-8C	.150	.200	OS-10C	.187	.250	OS-12C	.225	.300
OS-8D	.200	.250	OS-10D	.250	.312	OS-12D	.300	.375
OS-8E	.250	.300	OS-10E	.312	.375	OS-12E	.375	.450
OS-8F	.300	.350	OS-10F	.375	.437	OS-12F	.450	.525
OS-8G	.350	.400	OS-10G	.437	.500	OS-12G	.525	.600
OS-8H	.400	.450	OS-10H	.500	.562	OS-12H	.600	.675
OS-8J	.450	.500	OS-10J	.562	.625			
OS-8K	.500	.550	OS-10K	.625	.687			
OS-8L	.550	.600						
OS-8M	.600	.650						
OS-8N	.650	.700						

Figure 5-82 Huck Oversize Rivet Grip Ranges

3/8 inch. For oversize diameters, drill sizes and driving tools, see Figure 5-81. For grip ranges, see Figure 5-82.

RIVNUTS

General

148 The Rivnut (Item 9) is a rivet-type nut, an internally threaded and counterbored tubular rivet that can be headed blind. The rivets are of one-piece construction, heads are 100° countersunk or flat and rivet ends are open or closed. Rivnuts can be installed with or without keys but the former is preferred. Rivnuts were designed principally for the attachment of de-icer boots. For Rivnut coding, see Figure 5-83.

Drilling

149 For table of Rivnut drill sizes, see Figure 5-84.

Rivnut Number Code: A8KB120

A 8 KB 120

- 120 — Max. grip in thousands
- KB — Closed end with key
- 8 — Size (see drilling table for code)
- A — Material (aluminum alloy)

Materials: A = Aluminum alloy (53S-W)

S = Steel

SS = Stainless steel

BR = Brass

The dash or letters between the figures designates the following:

Dash(-) = Open end keyless

B = Closed end keyless

K = Open with key

KB = Closed end with key

Figure 5-83 Rivnut Coding

Grip Coding

150 For table of Rivnut grip coding, see Figure 5-85.

Accessory Screws

151 The use of accessory screws is highly desirable with Rivnut installation. The screws are of two types; attachment and plug. Attachment screws are used to fasten parts that are to be joined by means of Rivnuts. Both types increase the shear strength and plug the hole. Any screw of suitable size and head may be used as a plug.

Rivnut Installation

152 A special key seating tool, such as shown in Figure 5-86, is used for notching the keyway in the sheet. Both pneumatic and hand operated tools are used for installation of Rivnuts. Similar tools are available for straight heading and also for heading performed at angles of 45° and 90° to the head of the Rivnut. When using the hand tool, hand thread the Rivnut on the mandrel until the head rests against the anvil of the heading tool. It is important that the mandrel (screw) be at a 90° angle to the surface of the sheet at all times. Unless both of these points are observed, the Rivnut will be easily bent or broken. After threading the Rivnut on the mandrel, position it in the work and upset by slowly drawing the handles together until

Size	Coding	Nominal O.D.	Lead Drill	Finish Drill Recom.	Max.
4	4	.156	29 (.136)	22 (.157)	.160
6	6	.187	19 (.166)	12 (.189)	.193
8	8	.219	8 (.199)	2 (.221)	.226
10	10	.249	1 (.228)	E (.251)	.257
1/4	25	.330	N (.302)	Q (.332)	.342
5/16	31	.411	3/8 (.375)	Z (.413)	.425

Figure 5-84 Rivnut Drill Sizes

solid resistance is felt. Excessive pressure beyond this point is unnecessary and may strip the threads.

NOTE

There is a series of Rivnuts with British threads.

DILL LOK-SKRU

General

153 The Dill Lok-Skru (Item 10) is an internally threaded blind fastener similar to the Rivnut. The heading up action differs from the Rivnut in that a barrel (A) slides over the rivet head (B) and grips the sheet, see Figure 5-88.

Selection

154 Lok-Skrus are made in four different types. (See Figures 5-87 and 5-88.) For table of part numbers, see Figure 5-89.

(a) Flat head.

(b) Flush head, for countersunk sheets; takes a round head screw.

(c) Countersunk, for dimpled sheet, takes a countersunk screw.

(d) Hexagon, for fluid tight application.

Size	Flat Head		Countersunk	
	Grip Range	Marks on Rivet	Grip Range	Marks on Rivet
4-40	.010 - .060	Type number	.050 - .081	Type number
	.060 - .085	Type number	.081 - .106	Type number
	.085 - .110	Type number	.106 - .131	Type number
6-32	.010 - .075	1 mark	.065 - .106	Blank
	.075 - .120	3 marks	.106 - .161	2 marks
	.120 - .160	5 marks	.161 - .221	5 marks
8-32	Same as 6-32		Same as 6-32	
10-32	.020 - .075	1 mark	.065 - .136	1 mark
	.075 - .140	4 marks	.136 - .201	4 marks
	.140 - .190	Type number	.201 - .261	Type number
1/4-20	.020 - .080	Type number	.089 - .151	Type number
	.080 - .140	Type number	.151 - .211	Type number
	.140 - .200	Type number	.211 - .271	Type number
5/16-18	.050 - .125	Blank	.106 - .181	Type number
	.125 - .200	1 mark	.181 - .256	Type number
	.200 - .275	2 marks	.256 - .331	Type number

Figure 5-85 Rivnut Grip Coding

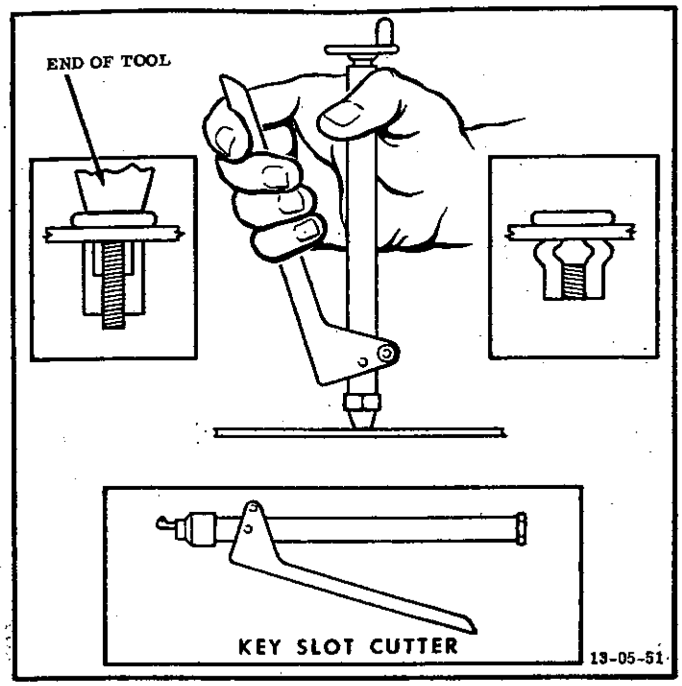


Figure 5-86 Rivnut Installation

155 Dill Lok-Skrus have close or open end barrels. For close end barrel add suffix B to part number. Countersunk head type is for dimpled sheets. Measure metal thickness only, not the grip length. If top sheet is dimpled and undersheet is countersunk, make dimple size suitable for flat head screw. If countersunk head is used, length must be found by trial.

Lok-Rivet Fastener

156 Lok-Rivet is similar to the Lok-Skru but is not tapped for a screw. It is made in flush and flat-head types with steel or aluminum alloy and has either closed or open ends.

Selection

157 Lok-Rivets are made in three diameters. Sizes and part numbers for the various lengths are shown in Figure 5-89.

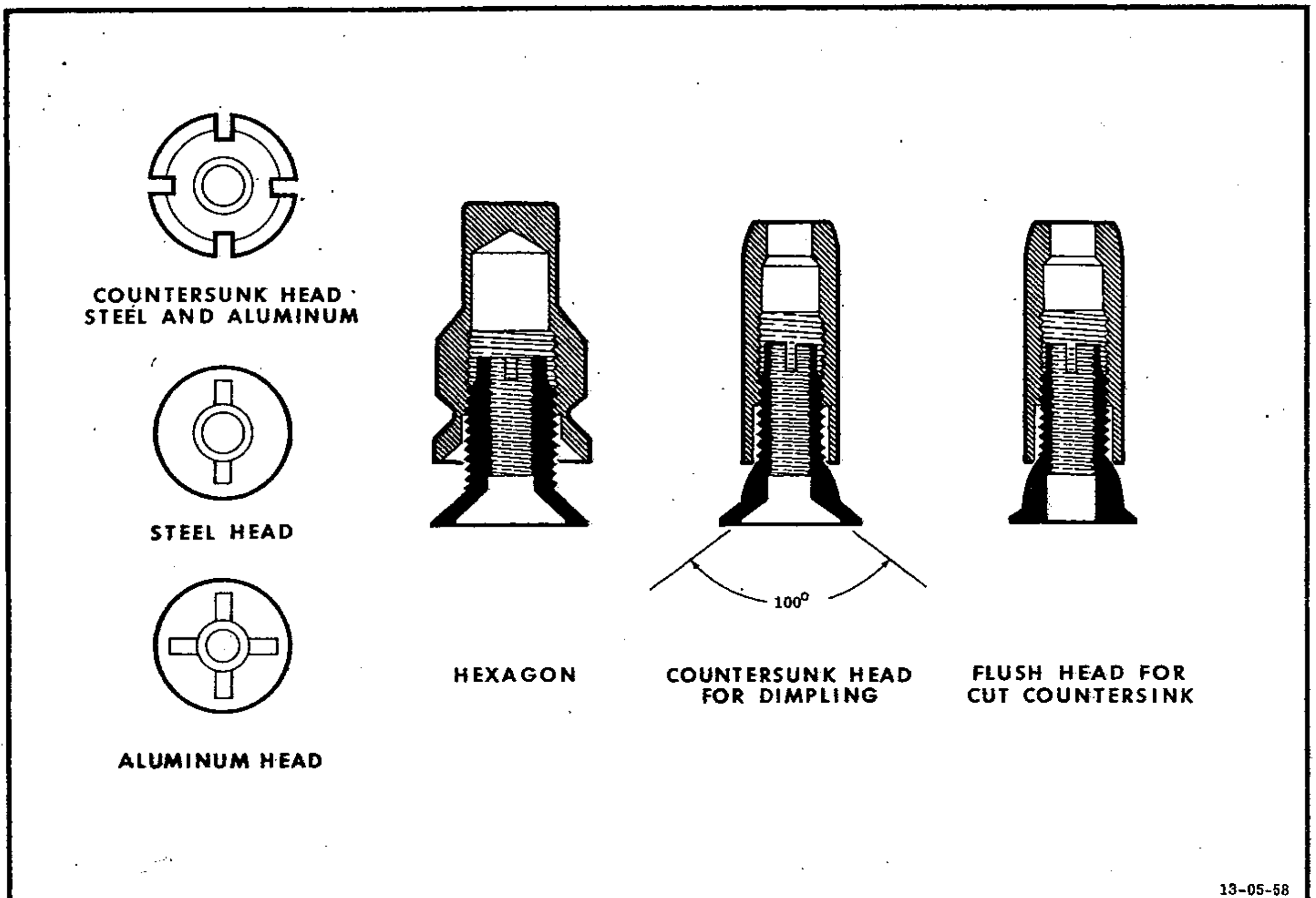


Figure 5-87 Dill Lok-Skrus

Drilling

158 The drilling procedure is identical to that for common solid shank rivets. Recommended drill sizes are shown in Figure 5-90.

Installation

159 Since both Lok-Skrus and Lok-Rivets are similarly installed, the following description of the Lok-Rivet applies also to the Lok-Skru. The construction of the fastener and the method of installation is such that, when these fasteners are used as nut plates, manipulation of the key and slot required for the Rivnut is unnecessary. Figure 5-91 illustrates the special tool used to install a Lok-Rivet.

Lok-Skru and Lok-Rivet Installation

160 Make certain that adequate clearance exists for the Lok-Rivet on the underside of the sheet, since the Lok-Rivet is longer than the Rivnut. Drill the hole to a snug, push fit. Predrilling and reaming are recommended. Insert the tool blade into the Lok-Rivet so that the tool blade and driver are held in the slots of the Lok-Rivet. (See Figure 5-91.) Hold the ratchet handle stationary and turn the barrel blade handle to the left until the sleeve or barrel has come up firmly against the sheet on the other side. Make the final tightening by taking a quarter-turn or less on the ratchet handle while the handle blade is held stationary. The head of the Lok-Rivet is then drawn tightly into the sheet as shown. Test the Lok-Rivet for tightness with a small screwdriver.

THE JO-BOLT

General

161 Jo-Bolts are used primarily where loads are in shear and the fastener is considered a permanent part of the structure. Usage is limited to applications where standard fasteners are not suitable. Advantages claimed for the Jo-Bolt are as follows:

(a) Use of narrower, lighter sub-structure flanges.

(b) Reduction of blind clearances.

(c) Reduction of precision tool drilling.

(d) Shear strength approaching AN3 series values in thick sheets and protruding head applications.

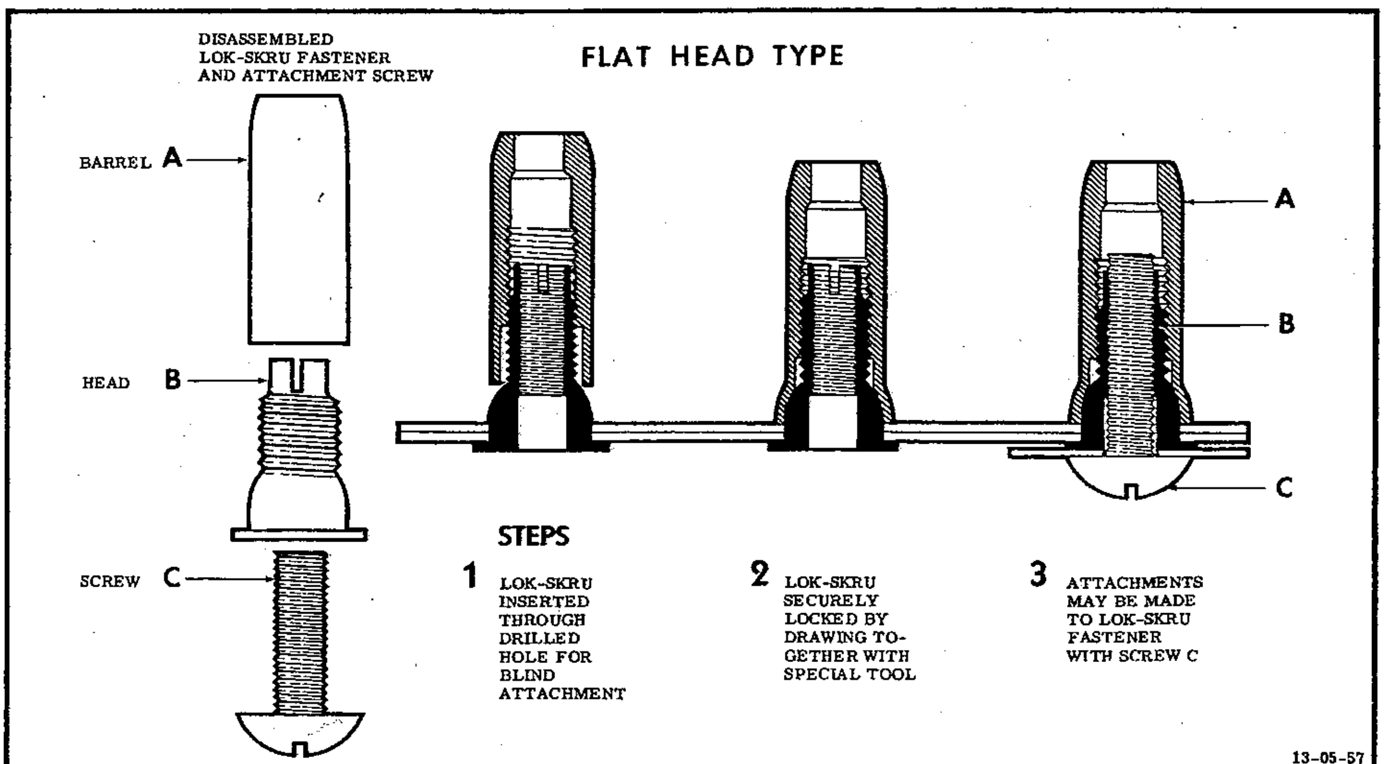


Figure 5-88 Dill Lok-Skru Components

Part Nos for Dill Lok-Skru						
Metal Thickness	Steel Flat Head			Aluminum Flat Head		
Skru	6-32	8-32	10-32	6-32	8-32	10-24
Hole Size	.234	.265	.297	.265	.297	.297
.010 - .045	6865	6480	6980	6760	6860	8455
.045 - .080	6866	6481	6981	6761	6861	8456
.080 - .115	6867	6482	6982	6762	6862	8457
.115 - .150	6868	6483	6983	6763	6863	8458
.150 - .185	6869	6484	6984	6764	6864	8459
.185 - .220	6865 x 5	6480 x 5	6980 x 5	6760 x 5	6860 x 5	8455 x 5
.220 - .255	6865 x 6	6480 x 6	6980 x 6	6760 x 6	6860 x 6	8455 x 6
.255 - .290	6865 x 7	6480 x 7	6980 x 7	6760 x 7	6860 x 7	8455 x 7
Use Adapter No.	15	15	15	16	16	16
Use Blade No.	10	4	4	10	4	4
Material Thickness	Steel Flush Head			Aluminum Flush Head		
Skru	6-32	8-32	10-32	6-32	8-32	10-24
Hole Size	.234	.265	.297	.265	.297	.297
.045 - .085	6895	6780	6880	6790	6890	8450
.085 - .120	6896	6781	6881	6791	6891	8451
.120 - .155	6897	6782	6882	6792	6892	8452
.155 - .190	6898	6783	6883	6793	6893	8453
.190 - .225	6899	6784	6884	6794	6894	8454
.225 - .260	6895 x 5	6780 x 5	6880 x 5	6790 x 5	6890 x 5	8450 x 5
.260 - .295	6895 x 6	6780 x 6	6880 x 6	6790 x 6	6890 x 6	8450 x 6
.295 - .330	6895 x 7	6780 x 7	6880 x 7	6790 x 7	6890 x 7	8450 x 7
Use Adapter No.	15	15	15	16	16	16
Use Blade No.	10	4	4	10	4	4

Figure 5-89 (Sheet 1 of 3) Dill Lok-Skru and Lok-Rivet Sizes and Part Numbers

Part Nos. for Dill Lok-Skru				
Type	Countersunk Head			
Material	Steel			Aluminum
Screw	6-32	8-32	10-32	6-32
Hole Size	.234	.265	.297	.265
.020 - .050		6801	6965	6806
.050 - .080		6802	6966	6807
.065 - .100	6945			
.080 - .110		6803	6967	6808
.100 - .135	6946			
.110 - .140		6804	6968	6809
.135 - .170	6947			
.140 - .170		6805	6969	6810
.170 - .205	6948			
.170 - .200		6801 x 5	6965 x 5	6806 x 5
.200 - .230		6801 x 6	6965 x 6	6806 x 6
.205 - .240	6949			
.230 - .260		6801 x 7	6965 x 7	6806 x 7
.240 - .275	6945 x 5			
.275 - .310	6945 x 6			
.310 - .345	6945 x 7			
Use Adapter No.	19	17	20	17
Use Blade No.	10	4	4	10

Hexagon Lok-Skru Size and Part Nos.					
Type	Material Thickness		Hole Size	Adapter No.	Blade No.
Countersunk	.000 to .125	.125 to .250			
Steel Head for 8-32 Screw	6950	6951	.250	17	4
Steel Head for 10-32 Screw	6955	6956	.281	20	4
Aluminum Head for 6-32 Screw	6970	6971	.250	17	10
Aluminum Head for 8-32 Screw	6975	6976	.281	20	4
Chamet Bronze Head for 8-32 Screw	6990	6991	.250	17	4

Figure 5-89 (Sheet 2 of 3) Dill Lok-Skru and Lok-Rivet Sizes and Part Numbers

(e) Tensile strength approximately 85% AN3 series with protruding head applications.

(f) Weight savings averaging 50% compared to screw and nut assembly.

(g) Positive sheet clamp-up.

(h) Faster and easier installation.

CAUTION

Do not use Jo-Bolts in locations where bolt or nut portions, in event of looseness, could fall or be drawn into engine intake.

NOTE

Paint the break-off end with zinc chromate primer as necessary to comply with the general airplane finish schedule applicable to nuts, bolts and other attaching parts.

Jo-Bolt Driving Tools

162 Standard type pneumatic piston, right-angle offset, and ratchet hand tools have been engineered specifically to drive Jo-Bolts. These tools have been designed for minimum clearance and maximum access. For installation procedure, general data, driving tools and salvage procedure, see Figures 5-92 and 5-93.

DEUTSCH DRIVE PIN BLIND RIVET

General

163 The Deutsch Drive Pin blind rivet (Item 11) previously known as the Barker

Metal Thickness	Aluminum Flat Head Rivet Part No.			Steel Flat Head Rivet Part No.		
Hole Size	.187	.234	.265	.187	.234	.265
.010 - .045	6811	6875	6915	6816	6870	6910
.045 - .080	6812	6876	6916	6817	6871	6911
.080 - .115	6813	6877	6917	6818	6872	6912
.115 - .150	6813	6878	6918	6819	6873	6913
.150 - .185	6815	6879	6919	6820	6874	6914
Use Adapter No.	18	16	16	18	15	15
Use Blade No.	10	10	4	10	10	4
Metal Thickness	100° CSK Flush Head Rivet Part No.					
.045 - .085	6935	6905	6925	6930	6900	6920
.085 - .120	6936	6906	6926	6931	6901	6921
.120 - .155	6937	6907	6927	6932	6902	6922
.155 - .190	6938	6908	6928	6933	6903	6923
.190 - .225	6939		6929	6934		
Use Adapter No.	18	16	16	18	15	15
Use Blade No.	10	10	4	10	10	4

Any Lok-Rivet (except the 3/16-inch size) may be had in the closed-end barrel type by adding suffix B to part number.

Figure 5-89 (Sheet 3 of 3) Dill Lok-Skru and Lok-Rivet Sizes and Part Numbers

rivet, consists of two parts; either a flush or a protruding brazier head sleeve of stainless steel and a hardened steel pin. The rivet is driven by striking the projecting pin with a hammer. The pin currently used is stainless steel of approximately 180,000 pounds per square inch heat treat. The pin and sleeve are impregnated with a molysulphide compound which acts as a driving lubricant as well as a corrosion inhibitor.

Coding

164 Deutsch rivets are coded as follows:

(a) Code 6950-D-06-10 indicates flush head dural, 3/16 inch diameter, 5/8 inch grip.

Rivet Diameter	Drill Size	Drill Diameters
.187	3/16	.187
.234	A	.234
.265	17/64	.265

Figure 5-90 Dill Lok-Rivet Drill Sizes

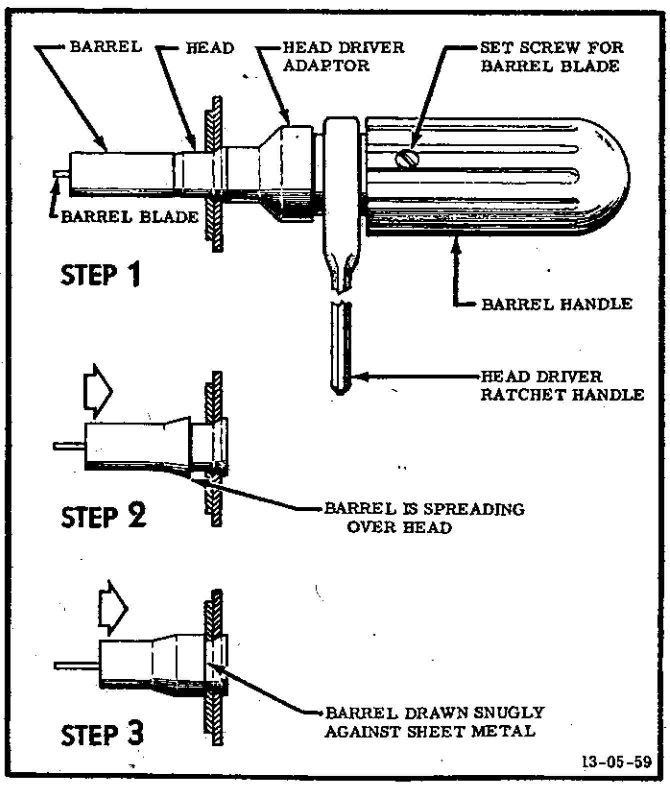


Figure 5-91 Dill Lok-Rivet Installation

(b) Code 6951-S-06-10 indicates brazier head stainless steel, 3/16 inch diameter, 5/8 inch grip.

Dimpling and Countersinking Limits

165 For dimpling and countersinking limits, see Figure 5-26. When the inmost sheet is to be sub-countersunk, dimensions in Paragraph 166, following, are valid for remaining thickness of sheet. For drill sizes, see Figure 5-94.

Grip Length Selection

166 For Deutsch rivet grip selection table, see Figure 5-96.

Installation

167 Driving may be accomplished by using a pneumatic rivet gun with an ordinary flat set. When space permits, a hammer will suffice to form the upset, which is a particularly adaptable feature in field repair. The pin is driven into the sleeve after the rivet is firmly seated in the drilled or reamed hole. The action of the pin in pushing out the restricting walls of the sleeve forms the upset. This begins with a swelling action in the second sheet and progresses into a formed head on the blind side. A feature of the rivet is the firm locking of the pin by the protruding ridge on top of the

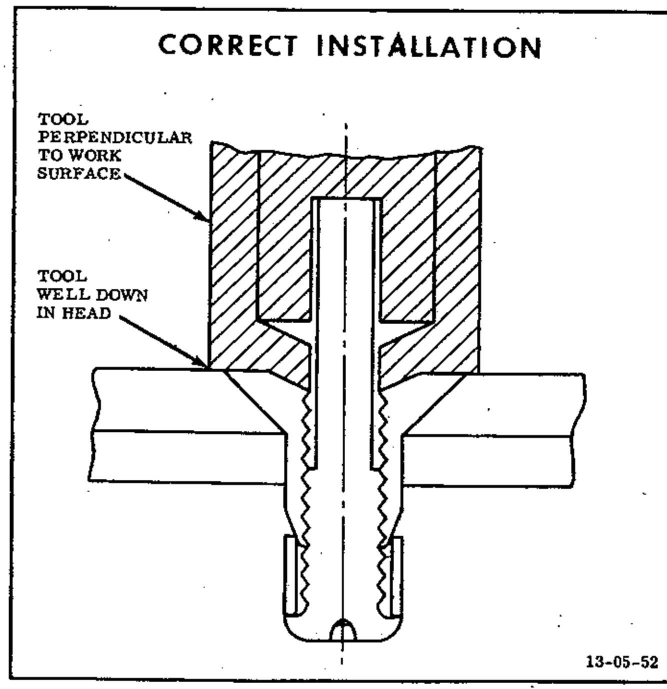
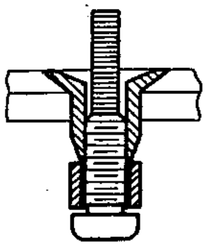
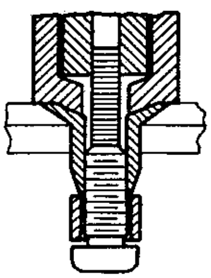


Figure 5-92 Jo-Bolt Installation



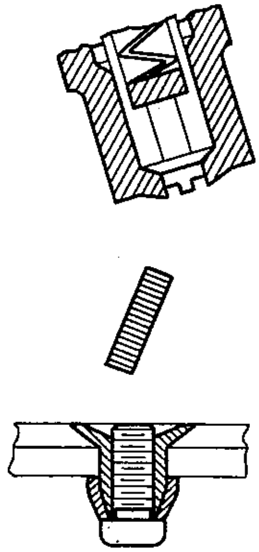
STEP 1

JO-BOLT ASSEMBLY OF PROPER GRIP LENGTH IS INSERTED IN HOLE DRILLED THROUGH MEMBERS TO BE JOINED. THE JO-BOLT CAN BE PUSHED THROUGH THE PROPERLY PREPARED HOLE WITH EASE...PRIOR TO DRIVING.



STEP 2

NOSE ADAPTER OF PNEUMATIC POWER TOOL (OR SPECIAL HAND WRENCH) NOW ENGAGES NUT AS WELL AS SLABBED PORTION OF BOLT SHANK. ALTERNATIVE METHOD IN OVERHEAD WORK: ENGAGE NUT AND SLABBED SHANK IN NOSE ADAPTER FIRST, AND INSERT JO-BOLT IN HOLE BY UPWARD PRESSURE WITH THE TOOL.

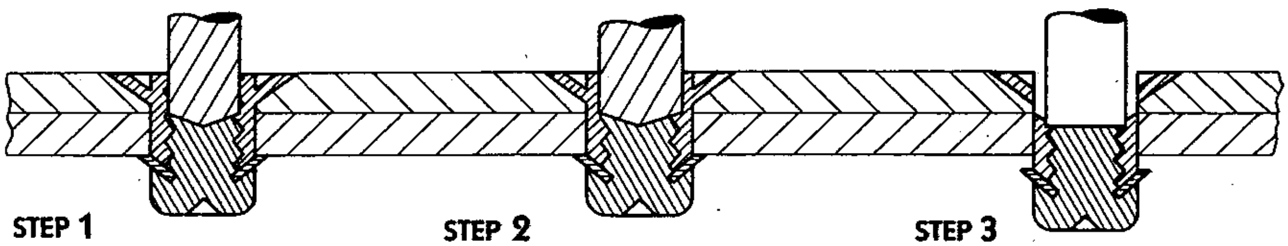


STEP 3

POWER IS TURNED ON. BOLT IS WRENCHED WHILE NUT IS HELD. SLEEVE, COMPRESSED BETWEEN BOLT HEAD AND CONICAL END OF NUT, IS DRAWN OVER THE TAPER. SLEEVE IS EXPANDED, FORMS A HEAD THAT GRIPS THE MATING SURFACE OF THE MEMBER BEING JOINED. POSITIVE SHEET CLAMP-UP IS SIMULTANEOUSLY EFFECTED. POWER TOOL SNAPS OFF AND EJECTS SLABBED PORTION OF BOLT SHANK AS SOON AS THE JO-BOLT IS FULLY DRIVEN, LEAVING THE NUT FLUSH WITH THE SURFACE OF THE WORK WHEN EMPLOYING THE FLUSH HEAD TYPE.

	TABLE 1	TABLE 2
JO-BOLT SERIES	DRILL SIZE	DRILL SIZE
F, P, FA, OR PA-200	NO. 35 (0.110)	NO. 12 (0.189)
F, P, FA, OR PA-260	NO. 24 (0.152)	D (0.246)
F OR P-312	NO. 17 (0.173)	M (0.295)
F OR P-375	NO. 5 (0.2055)	23/64 (0.3594)

REMOVAL OF JO-BOLTS



STEP 1

SELECT DRILL IN ACCORDANCE WITH TABLE 1. DRILL TO BELOW HEAD-SHANK JUNCTURE.

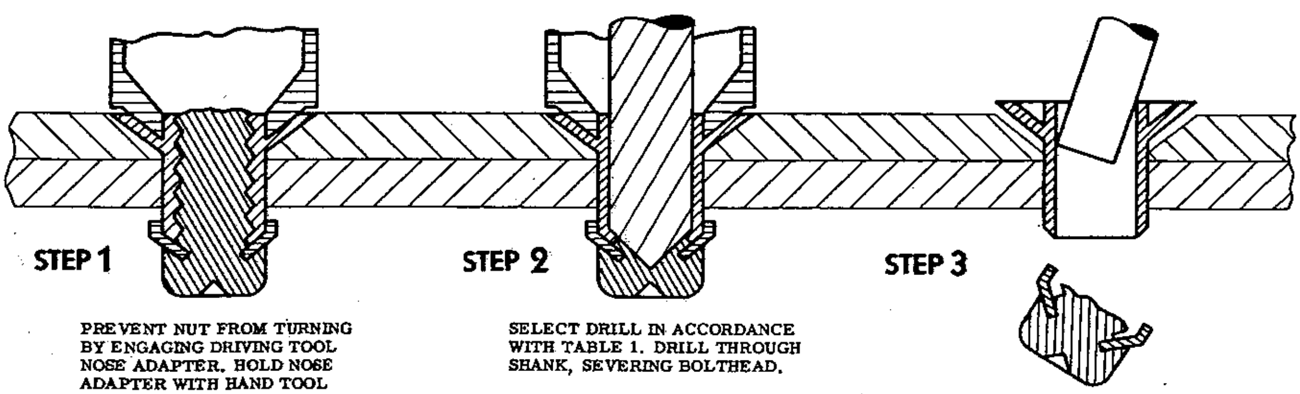
STEP 2

SELECT DRILL IN ACCORDANCE WITH TABLE 2. DRILL TO DEPTH OF PILOT HOLE.

STEP 3

WITH HAMMER AND NOMINAL SIZE PUNCH, SEVER HEAD AND DRIVE OUT SHANK AND BLIND HEAD.

JO-BOLTS CLAMPING UP BUT OUT OF GRIP RANGE. SELECT DRILL TURNING NOT OVER 500 RPM



STEP 1

PREVENT NUT FROM TURNING BY ENGAGING DRIVING TOOL NOSE ADAPTER. HOLD NOSE ADAPTER WITH HAND TOOL HANDLE OR VISE GRIP PLIERS.

STEP 2

SELECT DRILL IN ACCORDANCE WITH TABLE 1. DRILL THROUGH SHANK, SEVERING BOLTHEAD.

STEP 3

PICK NUT OUT OF HOLE WITH PUNCH.

JO-BOLTS TOO LONG BUT NOT CLAMPED UP. SELECT DRILL TURNING NOT OVER 500 RPM

13-05-53

Figure 5-93 Jo-Bolt Assembly and Removal Instructions sleeve head, which is nested against the pinhead chamber by the last stroke of the upsetting action. The pin cannot be lost in service. It is installed from the outside and cannot be driven through. The structure being rivetted, however, must be heavy enough to support the driving forces. Minimum backing member thicknesses are:

Rivet Dia.	Thickness
3/16	.125
1/4	.188
5/16	.250
3/8	.375

Installation Precautions

168 When installing Deutsch rivets, observe the following precautions:

(a) Do not drive Deutsch drive pin blind rivets into tight holes by hammering on the pin; use a hollow drift that will clear the pin and lip section, preventing premature expansion.

(b) After the pin has been seated in the recess, smooth out the locking lip section with a rotary or rolling action of the driving tool. Installed rivets must not be milled or shaved to meet flushness requirements.

Removal of Deutsch Rivets

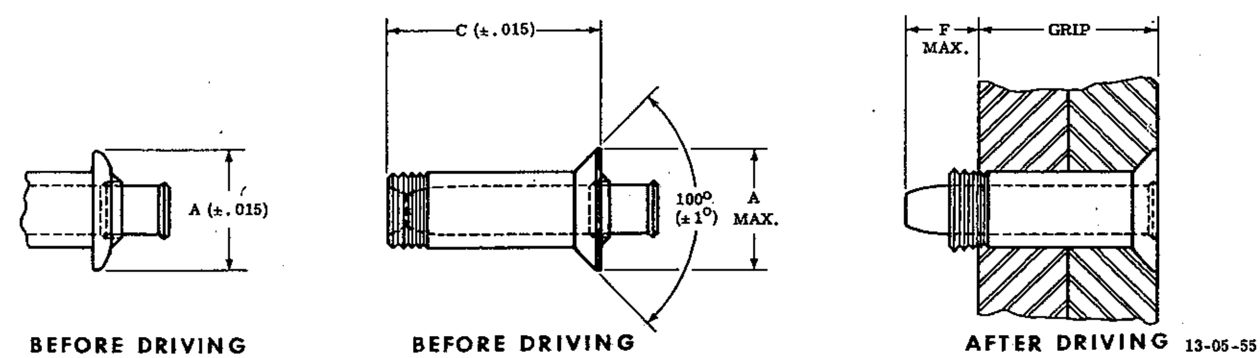
169 For removal procedure, see Figure 5-95.

Inspection

170 In addition to pin protrusion F, (see Figure 5-96), the blind end of the rivet sleeve must extend beyond the material so that a minimum of one and a maximum of three thread-like rings are visible, unless the rivet is installed in a buried hole.

171 If rivet is installed in a buried hole, make certain that at least one diameter or rivet shank length (including locking rings) extends into the plate into which the buried hole has been drilled.

172 For table showing item numbers, materials, specifications and manufacturers, see Figure 5-97.



Dash No.	Dia.	A (Max.)	F	Hole Preparation	
				Pre-Drill	Size Drill
-06	3/16	.3047	5/32	No. 16 (.177)	No. 11 (.191)
-08	1/4	.3988	7/32	A (.234)	G (.261)
-10	5/16	.4787	15/64	M (.295)	O (.316)
-12	3/8	.5062	17/64	T (.358)	W (.386)

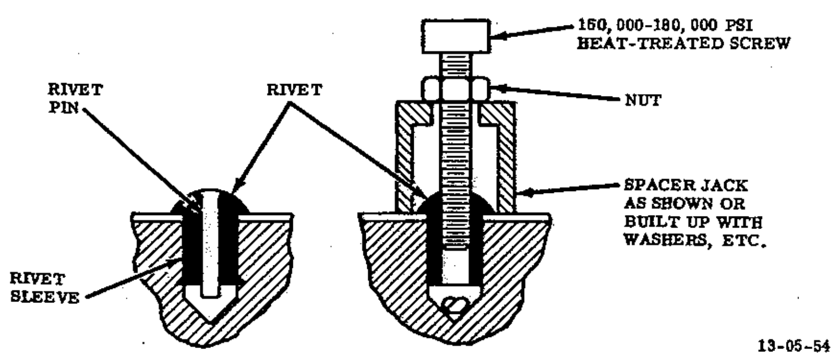
Figure 5-94 Deutsch Rivet Drill Sizes

	Deutsch Rivet (-) No.	Drill Size A	Punch Size B	Pin Size C	Punch Size D
1. Drill rivet pin head off, using drill size A.	-06 (3/16)	No. 21 (.1590)	3/32	.1215	5/32
2. Drive pin through using punch B.	-08 (1/4)	No. 1 (.2280)	1/8	.1625	7/32
3. *Drill sleeve, using drill size A. Drill to nominal grip depth only.	-10 (5/16)	9/32 (.2812)	5/32	.1975	1/4
4. Drive remainder of sleeve through.	-12 (3/8)	No. 5 (.3480)	7/32	.2425	11/32
* Step 3 may be omitted by use of larger punch in step 4.	-16 (1/2)	15/32 (.4687)	9/32	.3235	7/16

NOTE

Where rivet does not extend through material use table and the following procedure:

1. Drill out rivet pin approximately one-half the depth, using recommended drill size.
2. Tap sleeve, using recommended tap size. If rivet sleeve rotates during tapping operation use slightly larger drill for step 1 providing less cutting effort of tap.
3. Drill out remainder of pin.
4. Insert Allen-head screw through spacer into tapped sleeve and tighten nut.
5. Continue tightening nut until rivet sleeve is removed from work.
6. Hole is re-usable with same size rivet if within recommended hole limits. Use minimum of 1-1/2 x screw diameter thread engagement in rivet sleeve.



Rivet Dia.	Drill Size	Screw and Tap Size
3/16	29	8-32
1/4	19	10-32
5/16	3	1/4-28
3/8	1	5/16-24
7/16	Q	3/8-24
1/2	25/64	7/16-20

Figure 5-95 Deutsch Rivet Removal Instructions

3/16 Diameter				1/4 Diameter			
Part Number	C	Grip		Part Number	C	Grip	
		Min.	Max.			Min.	Max.
6950-S-06-3	.233	.188	.227				
6950-S-06-4	.295	.227	.290	6950-S-08-4	.312	.227	.290
6950-S-06-5	.357	.290	.353	6950-S-08-5	.379	.290	.353
6950-S-06-6	.420	.353	.415	6950-S-08-6	.437	.353	.415
6950-S-06-7	.482	.415	.478	6950-S-08-7	.500	.415	.478
6950-S-06-8	.545	.478	.540	6950-S-08-8	.562	.478	.540
6950-S-06-9	.607	.540	.603	6950-S-08-9	.625	.540	.603
6950-S-06-10	.670	.603	.665	6950-S-08-10	.687	.603	.665
6950-S-06-11	.732	.665	.728	6950-S-08-11	.749	.665	.728
6950-S-06-12	.795	.728	.790	6950-S-08-12	.817	.728	.790
6950-S-06-13	.857	.790	.853	6950-S-08-13	.877	.790	.853
6950-S-06-14	.920	.853	.915	6950-S-08-14	.940	.853	.915
6950-S-06-15	.982	.915	.978	6950-S-08-15	1.000	.915	.978
6950-S-06-16	1.045	.978	1.040	6950-S-08-16	1.062	.978	1.040
6950-S-06-17	1.107	1.040	1.103	6950-S-08-17	1.125	1.040	1.103
6950-S-06-18	1.170	1.103	1.165	6950-S-08-18	1.187	1.103	1.165
6950-S-06-19	1.233	1.165	1.228	6950-S-08-19	1.253	1.165	1.228
6950-S-06-20	1.295	1.228	1.290	6950-S-08-20	1.315	1.228	1.290
6950-S-06-21	1.357	1.290	1.353	6950-S-08-21	1.379	1.290	1.353
6950-S-06-22	1.420	1.353	1.415	6950-S-08-22	1.437	1.353	1.415

NOTE

For Brazier Head Rivet use Part Number 6951-S. Where grip measurement is a borderline case between two rivets, select the shorter rivet. If the thickness of the inmost sheet is greater than 1-1/2 x rivet diameter, and is necessary to conserve the blind side clearance, it is permissible to use a rivet whose sleeve is flush with the inner face of that sheet. (The locking will then be similar to the locking in a blind hole.)

Figure 5-96 (Sheet 1 of 2) Deutsch Rivet Grip and Length Selection

5/16 Diameter				3/8 Diameter			
Part Number	C	Grip		Part Number	C	Grip	
		Min.	Max.			Min.	Max.
6950-S-10-5	.391	.290	.353				
6950-S-10-6	.453	.353	.415	6950-S-12-6	.468	.353	.415
6950-S-10-7	.516	.415	.478	6950-S-12-7	.530	.415	.478
6950-S-10-8	.578	.478	.540	6950-S-12-8	.593	.478	.540
6950-S-10-9	.641	.540	.603	6950-S-12-9	.656	.540	.603
6950-S-10-10	.703	.603	.665	6950-S-12-10	.718	.603	.665
6950-S-10-11	.766	.665	.728	6950-S-12-11	.780	.665	.728
6950-S-10-12	.828	.728	.790	6950-S-12-12	.843	.728	.790
6950-S-10-13	.891	.790	.853	6950-S-12-13	.905	.790	.853
6950-S-10-14	.953	.853	.915	6950-S-12-14	.969	.853	.915
6950-S-10-15	1.016	.915	.978	6950-S-12-15	1.030	.915	.978
6950-S-10-16	1.078	.978	1.040	6950-S-12-16	1.093	.978	1.040
6950-S-10-17	1.140	1.040	1.103	6950-S-12-17	1.155	1.040	1.103
6950-S-10-18	1.203	1.103	1.165	6950-S-12-18	1.218	1.103	1.165
6950-S-10-19	1.266	1.165	1.228	6950-S-12-19	1.281	1.165	1.228
6950-S-10-20	1.328	1.228	1.290	6950-S-12-20	1.343	1.228	1.290
6950-S-10-21	1.390	1.290	1.353	6950-S-12-21	1.405	1.290	1.353
6950-S-10-22	1.453	1.353	1.415	6950-S-12-22	1.468	1.353	1.415

NOTE

For Brazier Head Rivet use Part Number 6951-S. Where grip measurement is a borderline case between two rivets, select the shorter rivet. If the thickness of the inmost sheet is greater than 1-1/2 x rivet diameter, and is necessary to conserve the blind side clearance, it is permissible to use a rivet whose sleeve is flush with the inner face of that sheet. (The locking will then be similar to the locking in a blind hole.)

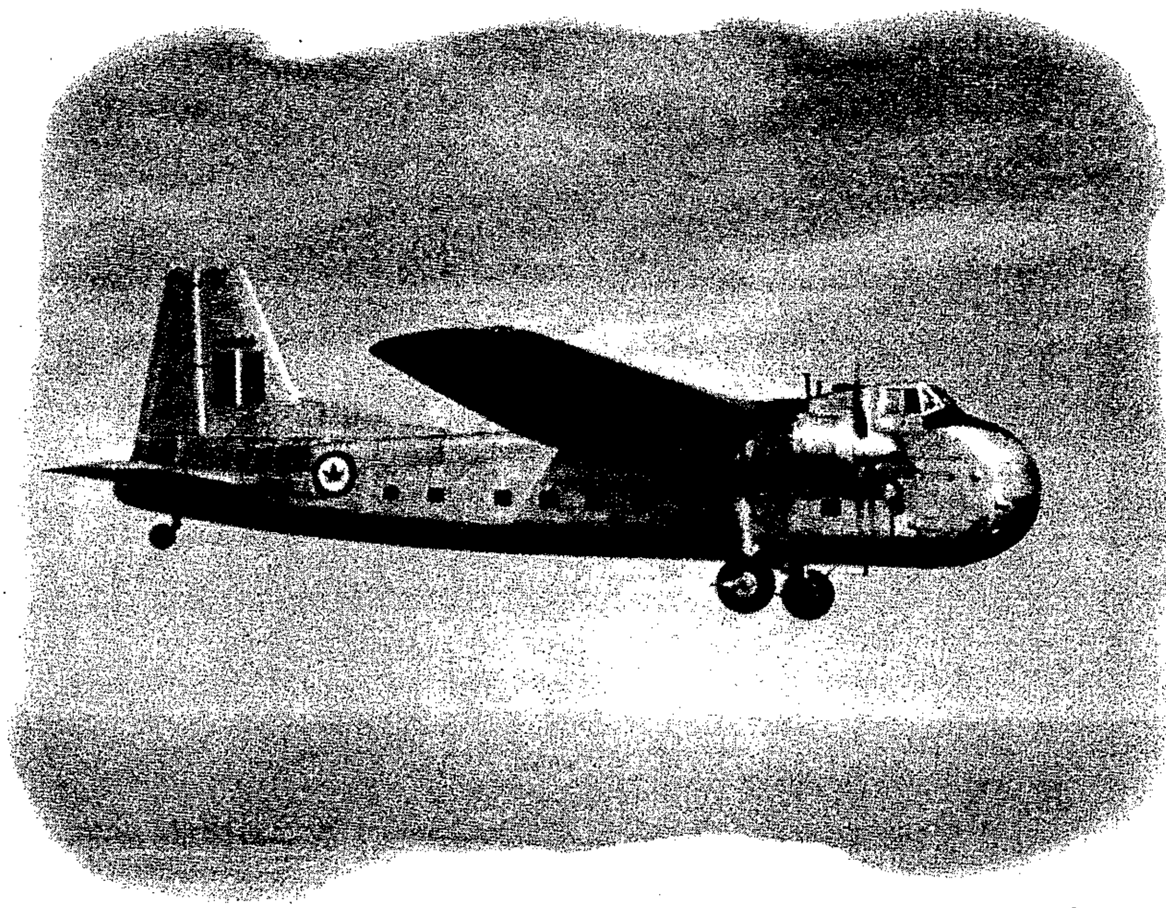
Figure 5-96 (Sheet 2 of 2) Deutsch Rivet Grip and Length Selection

Item No.	Material	RCAF Ref	Specification	Manufacturer
1	Fastener, Spring, Cleco			
2	Rivet, Solid, AN426, AN470	28/	MIL-R-5674; AN-R-19	
3	Rivet, Tubular AN450	28/	AN-R-19	
4	Compound, Sealing, No. RL3868			W.P. Fuller & Co., 135 N Los Angeles St., Los Angeles 12 Calif.
5	Rivet, Cherry	28NS/		Cherry Rivet Co., 231 Winston, Los Angeles, 13, Calif.
6	Rivet, Huck	28NS/		Huck Co., 2480 Bellevue Ave., Detroit 7, Mich.
7	Rivet, Chobert			Aviation Development Ltd 229 High Holburn, London, England.
8	Rivet, Tucker Pop			G. Tucker Eyelet Co. Ltd. Birmingham 22, England.
9	Rivnuts	28NS/		B.F.Goodrich, 251 King St., Kitchener, Ontario.
10	Lok-Skru	28NS/		Dill Co., 700 E. 82nd St., Cleveland 8, Ohio.
11	Rivet, Deutsch			Huck Co., 2480 Bellevue Ave., Detroit 7, Mich.
12	Tape		JAN-P-127 Type 2 Grade B	

Figure 5-97 Table of Material Specifications

PART 6

THREADS, BOLTS, SCREWS, NUTS & WASHERS



PART 6

THREADS, BOLTS, SCREWS, NUTS AND WASHERS

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PART 6 - SECTION 2 - BOLTS

PART 6 - SECTION 3 - SCREWS, NUTS AND WASHERS

LIST OF ILLUSTRATIONS

PART 6 - SECTION 1 - THREADS

PART 6 - SECTION 2 - BOLTS

(Continued)

PART 6 - SECTION 3 - SCREWS, NUTS AND WASHERS

(Continued)

(Continued)

PART 6 SECTION 1

THREADS

THREADS

General

1 American threads are classified by pitch into several general series such as Coarse Thread, Fine Thread, Extra Fine Thread, and others not normally used in aircraft production. The common British threads are classified by pitch into three general series called: British Standard Fine, British Standard Whitworth (coarse), and British Association.

Thread Symbols

2 The symbols used to designate different thread series are found in the following list.

SYMBOL	THREAD SERIES
NC	National Coarse Thread Series.
NF	National Fine Thread Series.
UNC	Unified National Coarse Thread Series.
UNF	Unified National Fine Thread Series.
UN or UNS	Unified National Special Thread.
N	National Thread in Constant Pitch Series.
UNEF	Unified National Extra Fine Thread Series.
NEF	National Extra Fine Thread Series.
BSW	British Standard Whitworth comparable to NC Series.
BSF	British Standard Fine comparable to NF Series.
BA	British Association comparable to NEF Series.

3 The American Standard Thread Series was formerly known as the National Thread Series. The revised American Standard is interchangeable with the old standard and includes the Unified Thread Series.

Unified Thread Series

4 The Unified Thread Series was established in 1948 by representatives from the United Kingdom, Canada, and the United States to obtain screw thread interchangeability among these nations. For table of unified threads refer to Part 25, following.

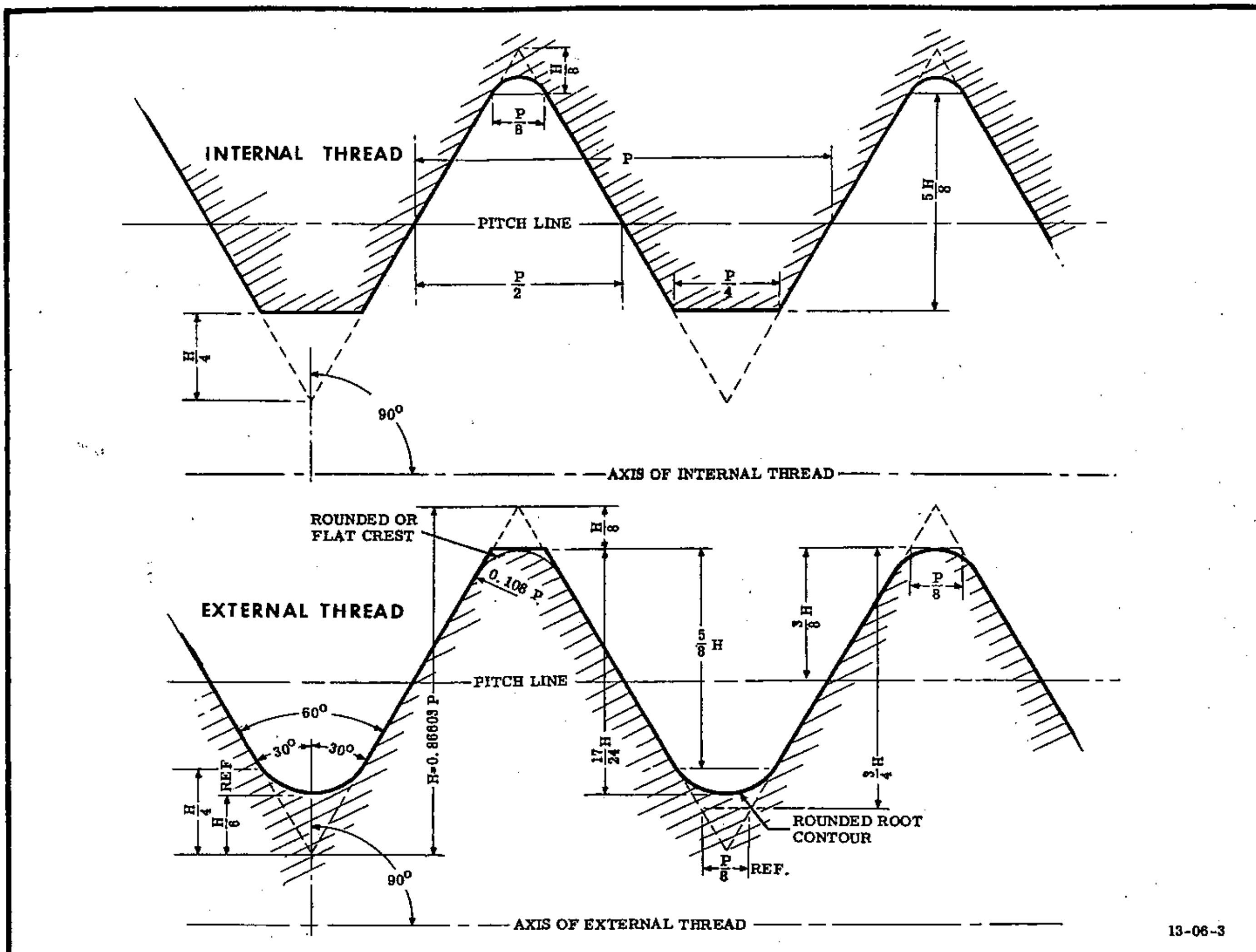
Unified Thread Form

5 The Unified and American Standard thread form is practically the same as the form which has long been used in the United States. The Unified thread may have an optionally flat or rounded crest and root. The basic depth of an external thread now equals 0.61343 times the pitch instead of 0.64952 times the pitch. (See Figures 6-1, 6-2 and 6-3 for additional formulae and tabulated data.) The preferred American practice is to retain the truncated flat crest, and the preferred British practice is to round the crest. The root of the thread, according to American practice, may be flat or have a radius as a result of tool wear. The standard British root contour is round. These minor variations will not interfere with interchangeability in these threads. The Unified thread provides greater fatigue strength, greater root clearance, easier assembly and longer life for cutting tools.

BRITISH STANDARD THREADS

British Standard Whitworth Thread (BSW)

6 This form of thread, the first ever to be standardized, was designed principally for use in the commercial field and has very limited application in aircraft industry. For section of thread, see Figure 6-4. The angle is 55° and the crest of the thread is round, this being



General Formulas for Finding Basic Dimensions of Unified and American Standard Threads			
Pitch =	$\frac{1}{\text{Number of threads per inch}}$	Crest truncation, external thread	= 0.10825 x pitch - H/8
Depth, external thread	= 0.61343 x pitch	Crest truncation, internal thread	= 0.21651 x pitch x H/4
Depth, internal thread	= 0.54127 x pitch	Root truncation, external thread	= 0.14434 x pitch - H/6
Flat at crest, external thread	= 0.125 x pitch	Root truncation, internal thread	= 0.10825 x pitch - H/8
Flat at crest, internal thread	= 0.25 x pitch	Addendum, external thread	= 0.32476 x pitch
Flat at root, internal thread	= 0.125 x pitch	Pitch diameter, external and internal	= Major Diameter - 2 x addendum

Figure 6-1 Thread Form and Formulae

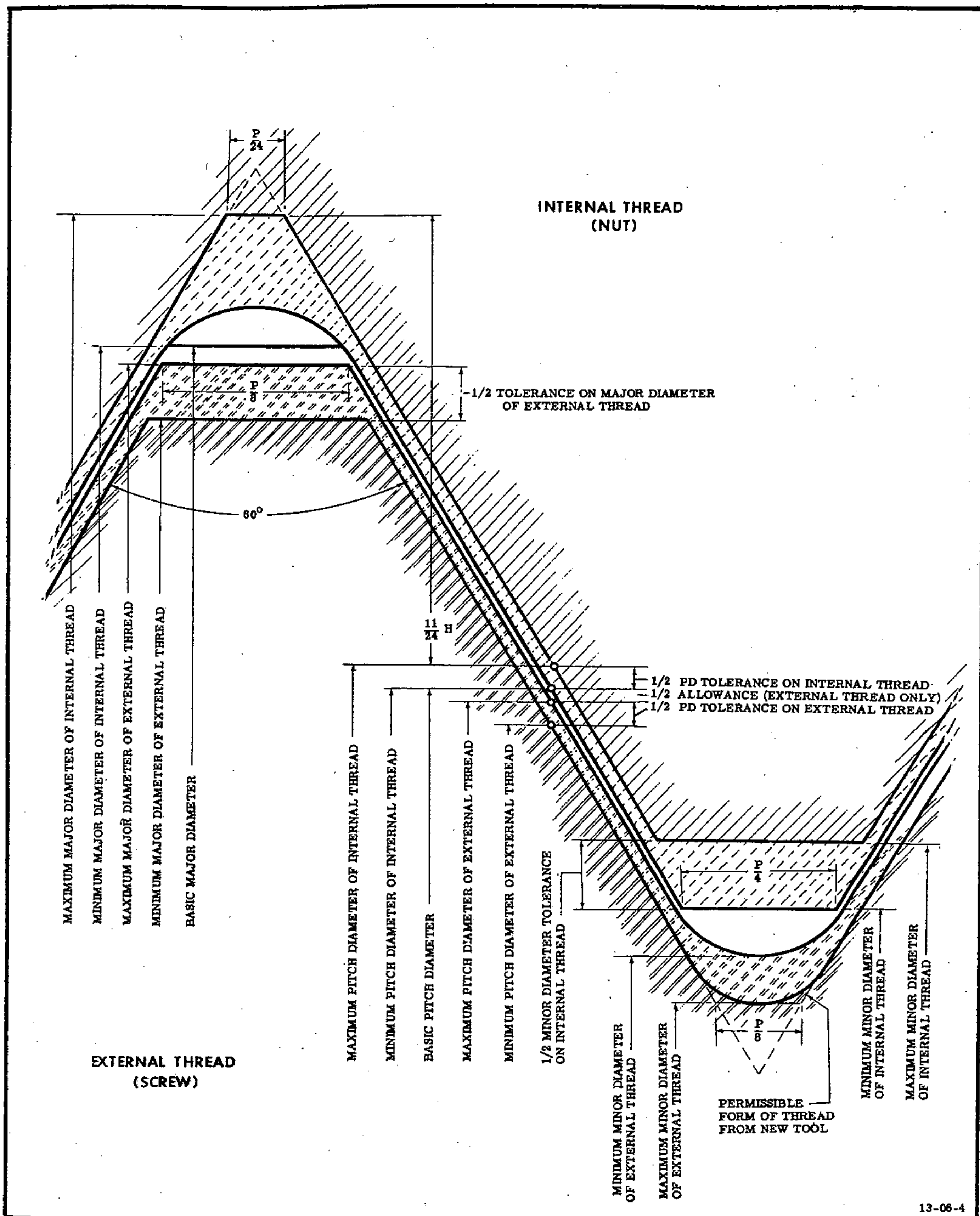


Figure 6-2 Thread Form Tolerances - Unified and American, Classes 2A and 2B

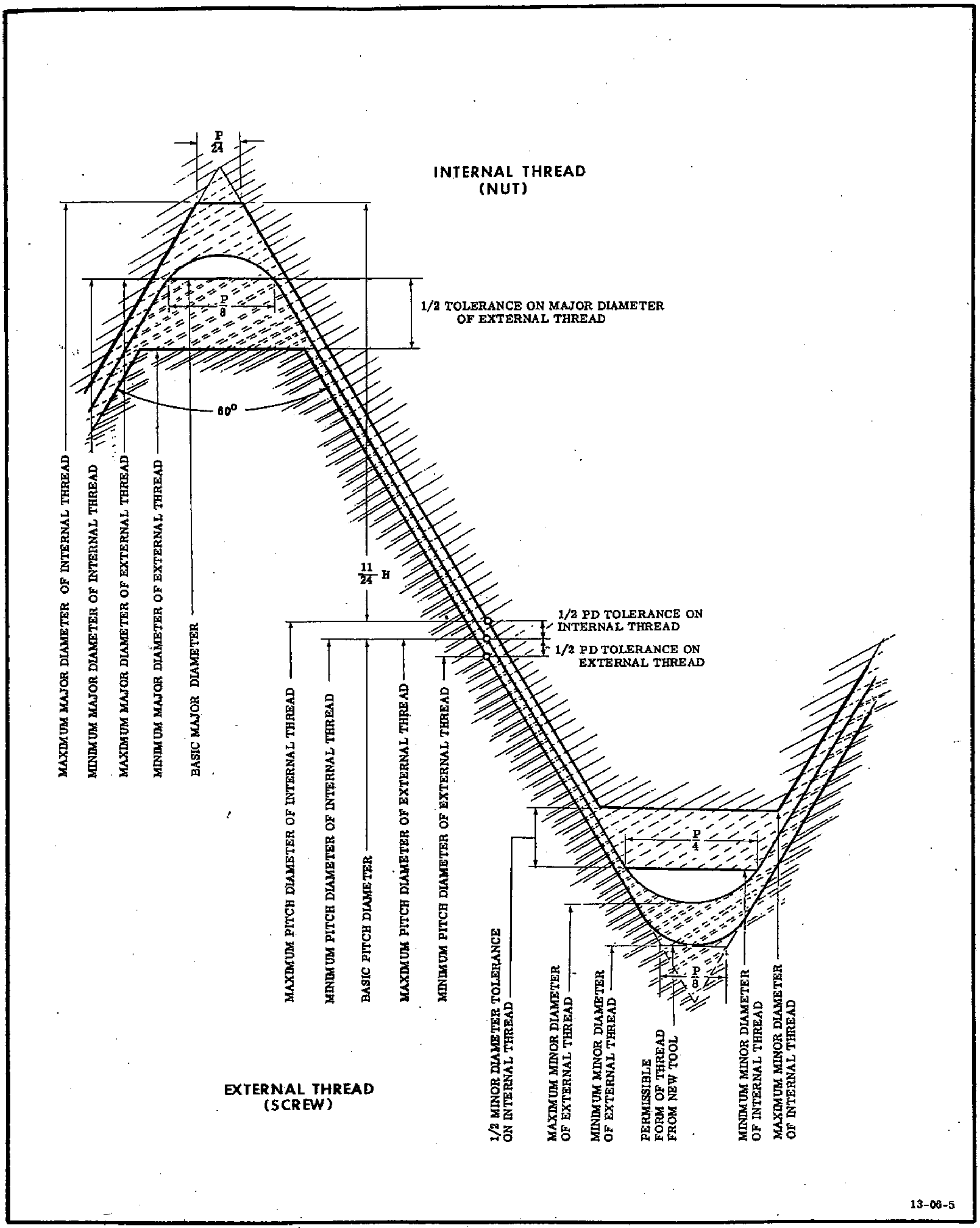


Figure 6-3 Thread Form Tolerances - Unified and American, Classes 3A, 3B, 2 and 3

a distinguishing feature of British threads in comparison to the American Threads, which usually have a flat crest. Where p = pitch, d = actual depth of thread, r = radius of crest, then:

$$p = \frac{1}{\text{No. Thds/Inch}}$$

$$d = 0.6403p$$

$$r = 0.1373p$$

British Standard Fine Thread (BSF)

7 This system supplements the Whitworth Standard where finer pitches are required. The thread form is the same as Whitworth, (see Figure 6-4). The dimensions given in the table, (refer to Part 25, following), for the major, effective and minor diameters are, respectively, the maximum limits of these diameters for bolts and the minimum limits for nuts. In view of the tendency for closely fitting bolts and nuts of stainless steel to seize when tightened together, it is recommended that the maximum permissible size for all stainless steel bolts should be .001 inch below their basic size. The same manufacturing tolerances should be allowed as for bolts of other materials.

8 Under this specification, three grades of fit are provided. The close fit grade applies to screw threads requiring a fine, snug fit and is recommended only for special work where refined accuracy of pitch and thread form are particularly required. The medium fit applies to the better class of ordinary interchangeable screw threads. The free fit applies to the great bulk of screw threads of ordinary commercial quality. The three grades of fit are not intended to be applied to screw threads which have to mate with an interference fit.

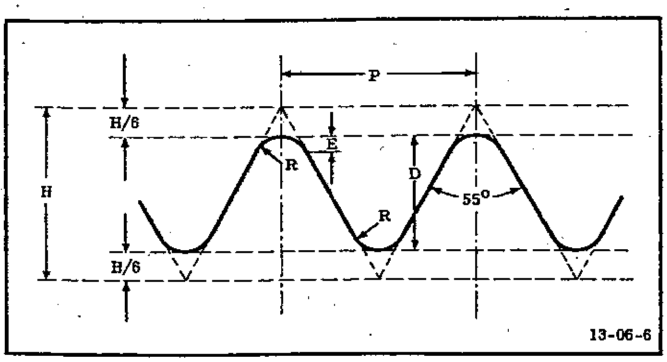


Figure 6-4
British Standard Whitworth Thread Form

British Association Standard Thread (BA)

9 This standard thread is recommended by the British Standards Institution for screws below 1/4 inch diameter, excepting the 7/32 inch BSF size which is slightly smaller in diameter than the No. 0 BA and should be used as a continuation of the BSF Series in preference to the No. 0 BA. The thread form is shown in Figure 6-5. The angle between the sides of the thread is 47° 30'. If p = pitch of thread, d= depth of thread and r= radius at top and bottom of thread, then:

$$d = 0.6p$$

$$r = \frac{2p}{11}$$

10 The depth of the thread is smaller in relation to the pitch than the depth of a Whitworth standard thread. The sizes usually recommended are Nos. 0, 2, 4, 6, 8 and 10.

British Standard Screw Thread Tolerance Formulae

11 The British Standards Institution has issued a revised three-term tolerance formula (BSI Report No. 84-1940), which includes, as factors, the diameter, length of engagement and pitch. In this formula, T = tolerance on effective diameter in inches; D = major diameter; L = length of engagement; p = pitch of thread.

$$T = 0.002 \times \sqrt[3]{D} + 0.003 \times \sqrt{L} + 0.005 \times \sqrt{p}$$

This formula is for British Standard Whitworth and British Standard Fine Screw Threads. Tolerances established by it are comparable to

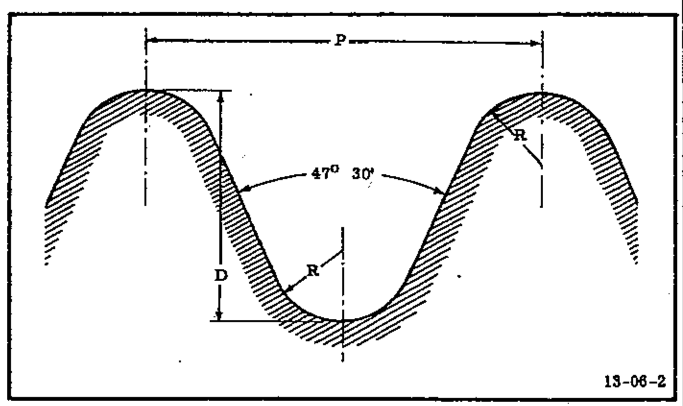


Figure 6-5 BA Thread Form

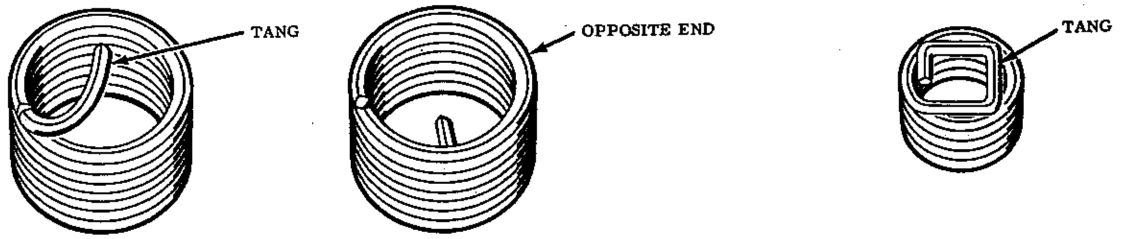


Figure 6-6 Heli-Coil Inserts

A	B	C	D +.020 -.000	E	F	G	H	J Non-Self-Locking Type For Blind Holes	J Non-Self-Locking Type For Through Holes
#4-40	#31(.120)	.168	.140	.025	04CSB	.1283 +.0016 -.0000	1688-04	1185-04C x L	1185-04CN x L
#6-32	#26(.147)	.203	.173	.032	06CSB	.1583 +.0018 -.0000	1688-06	1185-06C x L	1185-06CN x L
#8-32	#17(.173)	.205	.199	.032	2CSB	.1843 +.0019 -.0000	1688-2	1185-2C x L	1185-2CN x L
#10-32	#8 (.199)	.205	.225	.032	3FSB	.2103 +.0020 -.0000	1694-3	1191-3C x L	1191-3CN x L
1/4-28	G(.261)	.229	.290	.036	4FSB	.2732 +.0022 -.0000	1694-4	1191-4C x L	1191-4CN x L
5/16-24	21/64	.262	.360	.042	5FSB	.3395 +.0026 -.0000	1694-5	1191-5C x L	1191-5CN x L
3/8-24	W(.386)	.262	.422	.042	GFSB	.4020 +.0027 -.0000	1694-6	1191-6C x L	1191-6CN x L
7/16-20	29/64	.307	.494	.050	7FPB	.4700 +.0031 -.0000	1694-7	1191-7C x L	1191-7CN x L
1/2-20	33/64	.307	.556	.050	8FPB	.5325 +.0032 -.0000	1694-8	1191-8C x L	1191-8CN x L
9/16-18	37/64	.337	.625	.056	9FPB	.5986 +.0034 -.0000	1694-9	1191-9C x L	1191-9CN x L
5/8-18	41/64	.337	.688	.056	10FPB	.6611 +.0035 -.0000	1694-10	1191-10C x L	1191-10CN x L
3/4-16	49/64	.374	.820	.062	12FPB	.7906 +.0039 -.0000	1694-12	1191-12C x L	1191-12CN x L

NOTE

L Indicates basic length of insert. Standard lengths are 1, 1-1/2, 2, 2-1/2, and 3 times the nominal major screw diameter. Non-standard lengths are available in 1/32 inch increments. For blind holes, use insert 1/2 diameter longer than required thread engagement, to avoid interference between end of bolt and tang.

Figure 6-7 (Sheet 1 of 2) Installation Table for Heli-Coil Inserts medium fit tolerances. Tolerance for close fit = 2/3 of the tolerance for free fit = 1-1/2 times the tolerance obtained by basic formula. For the British Association (BA) screw thread (dimensions in millimeters).

$$T = 0.0173 \times \sqrt[3]{D} + 0.0179 \times \sqrt{L} + 0.0218 \times \sqrt{p}$$

HELI-COIL THREADS

General

12 Heli-Coil inserts are made of 18-8 stainless steel helically coiled wire, with a diamond shaped cross-section, which simultaneously accommodates internal and external threads, (see Figure 6-6). When assembled in a Heli-Coil tapped hole, the insert presents a permanent standard internal thread with Class 3B tolerance.

Types of Inserts

13 Heli-Coil inserts are divided into two types, as follows:

(a) The non-self-locking insert is made with a tang which is a portion of the bottom coil, offset in order to provide a driving member. This tang is left on the insert after installation except when its removal is necessary to provide clearance for the end of the bolt. When the tang must be removed, the insert has a notch located adjacent to the tang which provides a break-off point after installation, thereby allowing complete penetration by the bolt.

(b) The self-locking type insert has a specially formed grip coil in place of the conventional tang on the non-self-locking type.

A	J			K		L	M	N	R	S
	Self-Locking Type									
	Type	Short	Long	Non-Self-Locking	Self-Locking					
#4-40				528-04N		1194-04	#4-40	$.0958^{+.0024}_{-.0000}$		
#6-32	2025-06C x	.172	.276	528-06N	2036-06	1194-06	#6-32	$.1177^{+.0027}_{-.0000}$	2044-06	1227-06
#8-32	2025-2C x	.234	.328	528-2N	2036-2	1194-2	#8-32	$.1437^{+.0028}_{-.0000}$	2044-2	
#10-32	2031-3C x	.234		535-3N	2045-3	1196-3	#10-32	$.1697^{+.0029}_{-.0000}$	2046-3	
1/4-28	2031-4C x	.312		535-4N	2045-4	1196-4	1/4-28	$.2268^{+.0032}_{-.0000}$	2046-4	1227-6
5/16-24				535-5N		1196-5	5/16-24	$.2854^{+.0036}_{-.0000}$		
3/8-24				535-6N		1196-6	3/8-24	$.3479^{+.0037}_{-.0000}$		
7/16-20				535-7N		1196-7	7/16-20	$.4050^{+.0041}_{-.0000}$		
1/2-20				535-8N		1196-8	1/2-20	$.4675^{+.0042}_{-.0000}$		
9/16-18				535-9N		1196-9	9/16-18	$.5264^{+.0044}_{-.0000}$		1227-16
5/8-18				535-10N		1196-10	5/8-18	$.5889^{+.0045}_{-.0000}$		
3/4-16				535-12N		1196-12	3/4-16	$.7094^{+.0049}_{-.0000}$		

Note: Threads in column M are class 3B. Sizes #4 to #8 are NC, #10 is NF and 1/4-28 to 3/4-16 are UNF.

Figure 6-7 (Sheet 2 of 2) Installation Table for Heli-Coil Inserts

This grip coil is used first for installation and later for producing a gripping effect on an engaging screw, which must extend a minimum of one full thread through the grip coil.

Installation Procedure

14 To install a Heli-Coil insert, use the following procedure:

(a) With drill of diameter shown in Figure 6-7, column B, drill for thread size to depth called out on drawing, (refer to column A). For reference, the recommended drill depth for plug style taps is determined by adding the dimension shown in column C to the basic length of the required insert, to the next larger 1/32 inch.

(b) Countersink 120° by the diameter shown in column D.

(c) Tap hole for thread size called out on drawing, (refer to column A), with the Heli-Coil tap specified in column F to minimum depth equivalent to the basic length of the insert, plus the dimension shown in column E to the next larger 1/32 inch, using Dypral tapping compound or equivalent.

(d) Use Heli-Coil gauges shown in column H to check tapped hole dimensions to the pitch diameters shown in column G, to the minimum depth equivalent to the basic length of the insert plus the dimension shown in column E, to the next larger 1/32 inch.

(e) Install insert specified on the drawing (refer to column J) 1/4 to 1-1/2 turns below start of the first thread. To install insert, retract the mandrel of the Heli-Coil prewinder inserting tool, referenced in column K, for the required type insert. Place the insert in the opening of the tool with the tang or grip coil, depending on the type of insert, toward the prewinder tip, (see Figure 6-6). Advance the mandrel forward through the insert until the tang or grip coil is fully engaged by the mandrel. Rotate the mandrel clockwise with a very light forward pressure until the insert is flush with the prewinder tip. Do not permit the tang or the grip coil of the insert to screw out of the threaded end of the tool. Position the inserting tool against the face of the work in line with the tapped hole. Rotate the mandrel clockwise without forward pressure until the insert is free of the prewinder body to the required depth below the start of first thread.

(f) If tang removal is required, use tang break-off tool specified in column L. To remove tang, insert break-off tool and tap protruding rod with a hammer.

Installation of Self-locking Heli-Coil Inserts

15 The self-locking type inserts require the use of a seating tool, (see Figure 6-7, column R), for seating the grip coil.

(a) Apply an anti-seizing compound, such as Fel-Pro, Moly-Kote or equivalent, on the first few threads of the seating tool.

(b) Screw the seating tool clockwise, with a slight forward pressure, into the assembled insert. The seating tool will advance freely until it reaches the grip coil of the insert. At this point, some force will be required to turn the seating tool. The torque will continue to increase until the tapered end of the seating tool has passed completely through the grip coil of the insert, seating it firmly in the tapped hole. Continue rotating the seating tool clockwise for at least two complete revolutions after the torque becomes constant. If it is not possible to make two complete revolutions in the case of blind holes, turn the seating tool until it bottoms lightly in the hole. Do not attempt to force it beyond this point.

(c) Reverse the direction of rotation of the seating tool by turning it counterclockwise and remove it from the assembled self-locking insert. Do not remove any anti-seizing compound that remains on the assembled insert since it will aid in assembling the bolt.

(d) After installation of insert (both types) use standard gauges to check final thread dimensions shown in column M, to the final pitch diameters shown in column N. Do not force gauge through grip coil on self-locking type inserts.

Extraction Procedure

16 If it is necessary to extract an insert, use extracting tool (see Figure 6-7, Column S). Insert tool at least 1/4 turn from end of insert and tap lightly so the edges of the tool grips the insert. Apply downward pressure and at the same time rotate counterclockwise until the insert is removed.

PART 6 SECTION 2

BOLTS

BOLTS

General

1 Most bolts used in Canadian and American aircraft structures are AN (Air Force-Navy) series. Other series are NAS (National Aircraft Standards) and MS (Military Standards). MS is gradually replacing NAS, which is a civilian standard. Although each series contains bolts to various specifications, reference to an AN bolt usually means a bolt of the AN3 to AN20 series, with an ultimate tensile strength (UTS) of 125,000 to 145,000 psi, and reference to an NAS bolt usually means a bolt with an UTS of 160,000 to 180,000 psi. British standards include AGS (Aircraft General Spares) and BSI (British Standards Institute).

Special Bolts

2 When necessary, bolts are made to different dimensions or greater strength than standard types. These bolts are made for a particular application and it is of extreme importance to use similar bolts in replacement. If it becomes necessary to fabricate them locally, ensure that material and heat treatment are as specified in the applicable drawings, or an authorized substitute material and its proper heat treatment is used. (Refer to Part 4, preceding.) Such special bolts are identified by the letter S stamped on the head of the bolt.

NOTE

Bolts must be suitably locked or safe-tied in accordance with the method used in the original fabrication of the aircraft. Refer to Part 8, following, for the approved methods of safetying.

Magnetic Inspection of Bolts

3 For Magnaflux inspection of bolts, refer to Part 20, following.

Fitting of Bolts

4 All bolt holes should present a good mechanical fit. Bolt holes should not be oversized or elongated, as the bolt in such a hole will not carry its shear load until the parts have deformed enough to allow the bearing surface of the oversize hole to come in contact with the bolt. Loose bolts may thus cause failure of the other bolts which are forced to carry a greater load than originally intended. In the case of oversize or elongated holes, it is permissible to drill or ream the hole to take the next larger size bolt, provided the greater hole size does not weaken the part. Obtain permission from the engineering authority and ensure that a replacement bolt of the proper specification is available before proceeding with this operation. Particular care must be taken to avoid elliptical, eccentric or otherwise untrue holes which may permit the bolt to be driven according to requirements, but yet not provide the necessary hole contact along the entire grip length.

Light Drive Fits

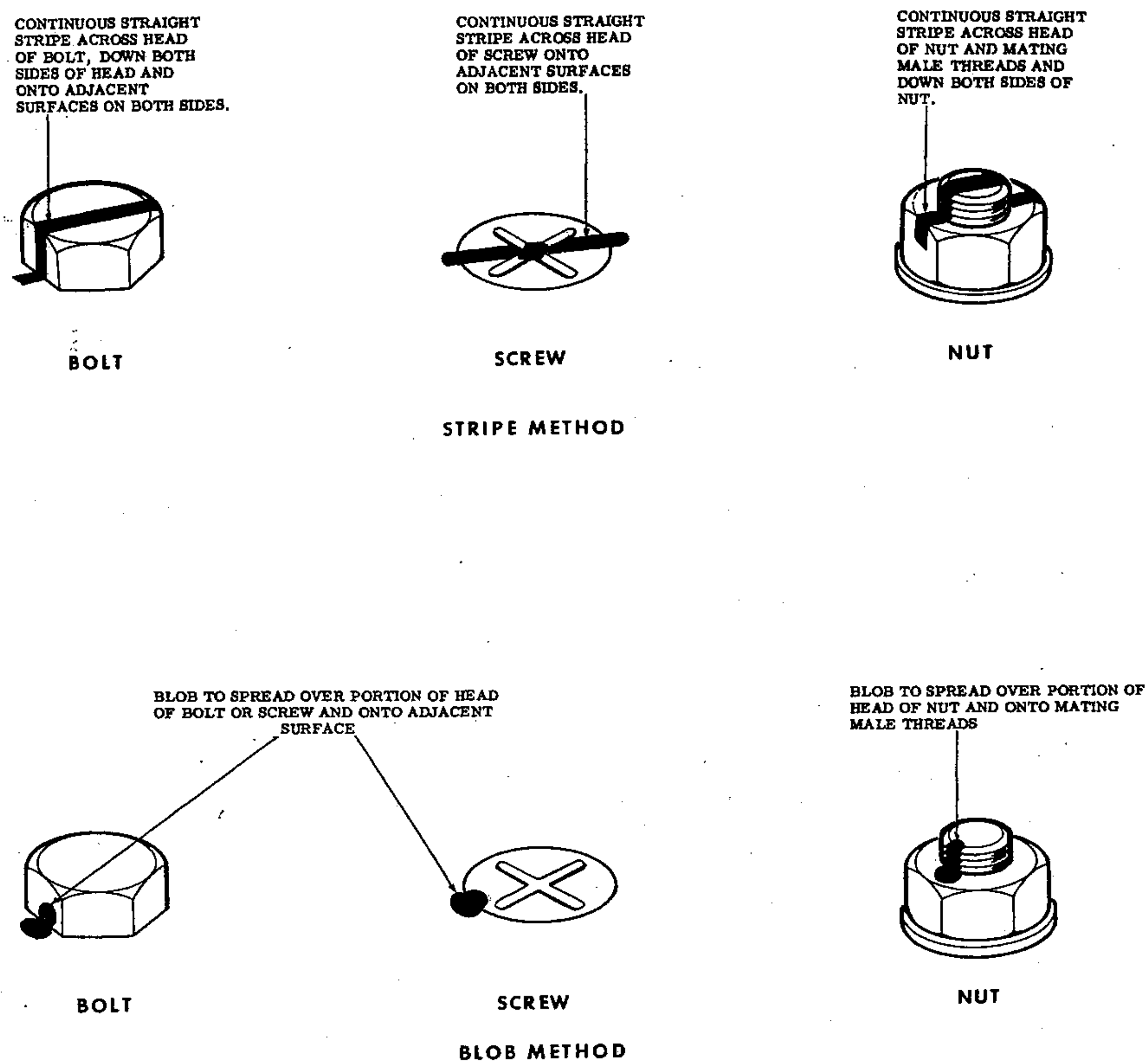
5 A light drive fit may be considered as an interference fit of 0.0006 inch for 5/8 inch diameter, with other sizes in proportion. To obtain a light drive fit, proceed as follows:

(a) Measure several bolts of the correct nominal size with a micrometer and separate them into three groups, large, medium, and small.

(b) Drill initial hole approximately 1/32 inch undersize. Redrill to 1/64 inch undersize.

(c) Select a reamer that is known to cut a hole that will give proper interference when using bolts of the small group. If necessary, test the reamer using a piece of similar material, before drilling the part being repaired.

IDENTIFICATION OF TORQUED THREADED FASTENERS



NOTES:

1 USE RED LACQUER, SPECIFICATION MIL-L-7178 FOR STRIPE AND BLOB.

2 EDGES OF STRIPE AND BLOB MUST BE SHARP AND WELL DEFINED.

3 IDENTIFY NUT RATHER THAN BOLT HEAD OR SCREW HEAD.

13-06-41

Figure 6-8 Identification of Torqued Threaded Fasteners

(d) After reaming the hole, check to see whether bolts from the small, medium or large group will be used on assembly. Ensure that proper number of bolts is available.

Torque

6 Failure in aircraft has occurred because of over-torquing or under-torquing of nuts and bolts, or the failure to torque them at all. To avoid overstressing bolts, it is necessary to torque the bolts to the correct values. Insufficient torque results in a loose joint. Under vibration, a failure will occur sooner or later. Correct torque increases the fatigue life, because the preload is equal to or greater than the alternating load imposed, which means that the joint is rigid enough to prevent wearing vibration. Too much torque results in damage to fasteners or parts. Overtorquing distorts light assemblies and breaks strips or weakens bolts. In general, fastener threads must be clean and free from grease or oil. Oil reduces the friction on the threads, thus changing the torque values. However, corrosion-resistant steel nuts and bolts must be lubricated with anti-seize compound (grease with a white lead base). For tables of torque values, refer to Part 25, following.

Nominal Diameter of Bolt	Basic Width across flats of Hexagon Bolts and Nuts
1/4	7/16
5/16	1/2
3/8	9/16
7/16	11/16
1/2	3/4
9/16	7/8
5/8	15/16
3/4	1-1/16
7/8	1-1/4
1	1-7/16

Figure 6-9 Hexagon Bolt Head and Nut Sizes

NOTE

Corrosion-resistant steel nuts and bolts must be used together. The values in tables may be used for all oil-free cadmium-plated steel nuts. These values were determined with the normal friction of the threads and of the surface of the nut on the work. Tightening to these values with the threads lubricated would result in overstressing. For instructions regarding the lubrication of light alloy threaded parts, refer to EO 05-1-2AJ.

7 For special torque values refer to the respective handbooks for the particular aircraft, or where not specified, use tables (refer to Part 25, following). Tightening of nuts in shear applications is not always necessary, but is desirable in thin sections where the surface tension between the sheets introduced by the tension of the bolt is important in reducing joint deflection. When tightening castellated nuts, should less than the minimum nut torque value be reached at a slot, tighten the nut to the next slot, even though the maximum tabulated torque value may be exceeded in so doing, but make sure that the maximum applied torque does not exceed the values in tables. Never loosen a castellated nut to obtain alignment. After proper torquing, marking of nuts as shown in Figure 6-8 is recommended.

Bolt Head and Nut Sizes

8 For a comparison of standard bolt head and nut sizes, refer to Figure 6-9.

9 USA AN standard drawings for bolts and nuts conform to this table except the 7/16 inch nominal diameter size.

NOTE

It is important to bear in mind that the dimensions of British Standard bolt heads differ from those of American Standard. Use the proper tools to avoid damaging the corners of bolt heads or nuts. The marking on British wrenches corresponds to the diameter of the bolt, while on American it denotes the width of the head across the flats.

Bastard Nuts and Bolts

10 Some aircraft are fitted with a mixture of AN nuts and bolts and British nuts and bolts, also with AN nuts and bolts with British threads. These parts are marked for ease of recognition.

Identification of Bastard Nuts and Bolts

11 AN nuts and bolts with British threads are designated ANB. These bolts will have an X stamped on the end of the stem in addition to the standard AN markings on the head. Nuts with AN hexagon and British threads will have two indentations on their heads. High tensile nuts are indicated by nicks in all corners.

INTERCHANGEABILITY OF BOLTS

General

12 Owing to the difference in material between British Standard Bolts (BSI) and Airforce-Navy Aeronautical Standard Bolts (AN), care must be taken in replacing bolts of one standard by bolts of another standard. Ensure that strength qualities are acceptable. Always use a bolt of equal or greater strength when an exchange is made.

Comparison Table

13 As will be seen from Figure 6-10, B.S.I. A.15 or AN bolts are stronger than B.S.I. A.1 bolts. Consequently, the replacement of B.S.I. A.15 or AN standard bolts in aircraft by B.S.I. A.1 bolts of a similar diameter is expressly forbidden, unless authority has been previously obtained. B.S.I. A.15 bolts may be used to replace AN3 to AN10, AN12, AN14 and AN16 bolts with the appropriate nut. This may only be done where absolutely necessary, as it is not desirable to have bolts of two different thread systems in use on any one aircraft.

(b) It is also shown that for stainless steel bolts, the A.15 and AN bolts are interchangeable up to 3/4 inch diameter. From 3/4 inch to 1 inch diameter, the A.15 bolts may be substituted for the AN, but not vice versa.

INSTALLATION OF BOLTS

General

14 Where clearance and accessibility permit, bolts are to be installed with the head on the high side. Fore and aft bolts are to be installed with the head forward. Bolts must be of the correct grip so that no threads are located inside the parts being assembled. Round or chamfered end bolts must extend at least the full round or chamfer through the fibre or nut. Flat end bolts must extend at least 1/32 inch through the nut. Screws must be of such length that not more than five threads extend outside the nut or fibre unless it can be shown that a higher maximum is necessary. Substitution of self-locking, castellated and plain nuts should not be made without approval of engineering authority.

Washers

15 All bolt connections should have a washer under the bolt head or nut, whichever part is turned during the tightening. Washers shall be made of a material similar to that of the parts being assembled. Not more than two washers may be used under a nut or bolt head to compensate for accumulated tolerances.

Reworking of Bolts

16 Where necessary, the threaded ends of bolts may be trimmed to develop clearance. When this is done, conditions noted in Paragraph 14, preceding must be met. When bolts are reworked for other reasons, the finish dimensions must be the same as those called for by the applicable drawings. That is, where the grip is to be shortened by extending the thread, the end of the bolt must be cut off so that an excessive number of threads will not protrude through the nut.

17 Standard bolts must not be reworked without approval of engineering authority, as consideration has to be given to the matter of rolled threads and upset heads. This also applies in the case of machining these bolts

from bar stock. All reworked bolts must be cadmium plated in the case of steel, and anodized or touched up with a 10% solution of chromic acid in the case of dural. (Refer to Part 23, following.)

Bolt Holes

18 Ensure that bolt holes are chamfered to accommodate the bolt head radius without interference. On unfinished or rough surfaces, a spotface is necessary. Ensure that spotface is at right angles to drilled hole. Refer to Part 25, following for the drilled and reamed hole sizes and spotface diameters for all standard bolts.

Standards Notes

19 The general notes following apply to bolts, unless otherwise noted.

(a) All threads are Unified National, to Specification MIL-S-7742. (Refer to Section 1, preceding.)

(b) All cadmium plating is to Specification QQ-P-416. (Refer to Part 23, following.)

(c) Tolerances are: Decimals ±.010 inch; fractions ±1/64 inch; angles ±5°.

(d) Grip length of protruding head bolts are measured from the underside of the head to the end of the full cylindrical portion of the shank. Grip length of countersunk head fasteners is measured from the top of the head. Complete threads must begin within two-thread pitch maximum. This two-thread pitch may consist of incomplete thread of extrusion angle.

(e) Bolts must be free from hanging burrs or slivers.

(f) Single shear strength is 60% of ultimate tensile strength.

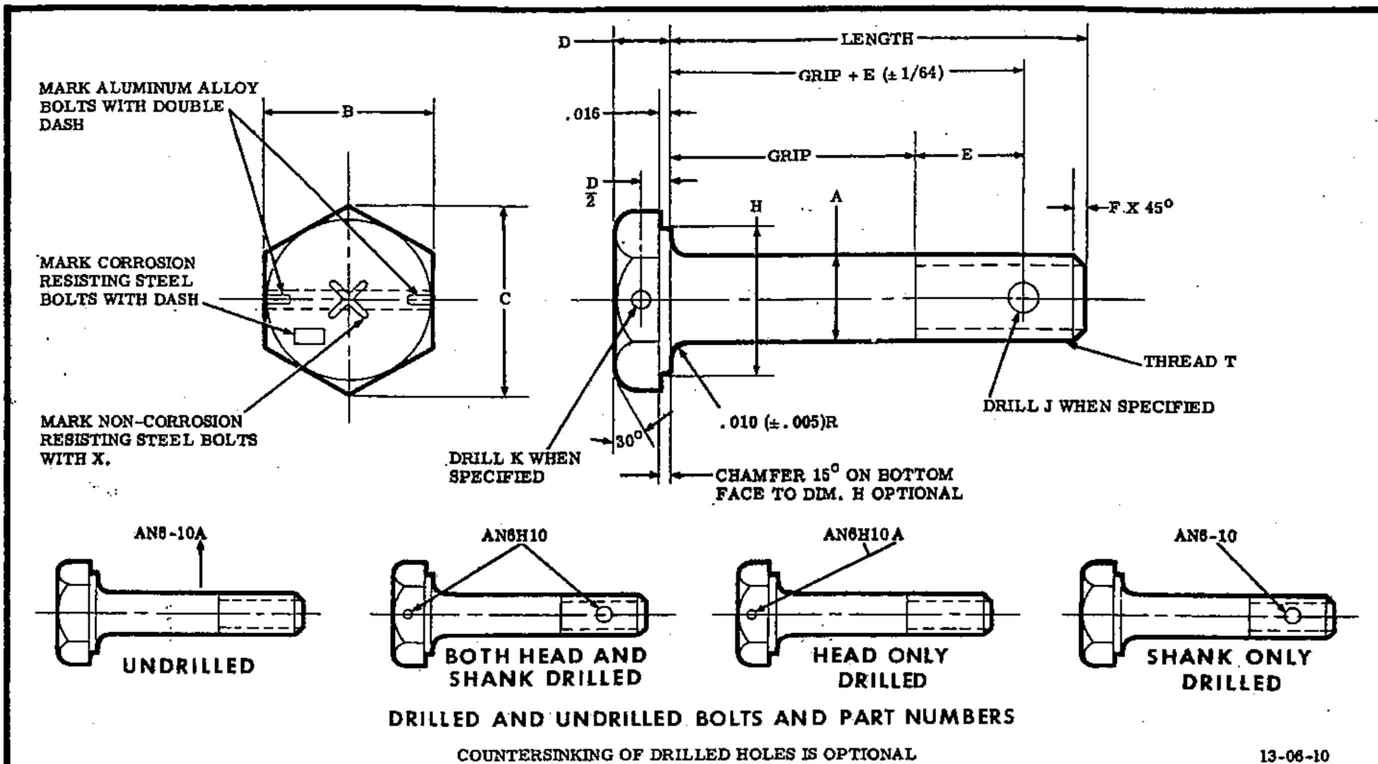
OTHER BOLTS

General

20 The most frequently used bolts are described in Figures 6-11 to 6-16, inclusive. Most of the remaining bolts listed in the AN and NAS standards are described in Figure 6-17.

Specification		Material Specification	U.T.S.	Yield	Elong.	Identification
British	A. 1	S. 1	78,500		15	
	A. 15	S. 2, S. 11	123,000		18	Nicks around side edge of head
	A. 15	S. 80	123,000		15	Z before part number on head
U.S.	AN3 to AN10 12, 14, 16	AN-S-9, AN-S-14 or AN-S-16	125,000	96,000	17	Raised X or Y on head
	AN3C to AN10C	AN-QQ-S-77D up to 3/4 in. dia.	125,000	100,000	12	Raised single dash on head
		3/4 in. to 1 in.	115,000	80,000	15	

Figure 6-10 Comparison of British and American Bolts



Basic AN Part No.	Thread T	A Dia.		B		D		E Ref.	F		K Dia.		J Drill Dia. +.010 -.000	K Drill Dia. +.010 -.000
		Max.	Min.	Max.	Min.	Max.	Min.		Max.	Min.		Min.		
AN3	10-32	.189	.186	.377	.365	.141	.109	17/64	.047	.015	Maximum not to exceed B dia.	.359	.070	.046
AN4	1/4-28	.249	.246	.440	.428	.172	.140	5/16	.047	.015		.422	.076	.046
AN5	5/16-24	.312	.309	.502	.490	.204	.172	24/64	.063	.031		.484	.076	.070
AN6	3/8-24	.374	.371	.565	.553	.235	.203	7/16	.063	.031		.547	.106	.070
AN7	7/16-20	.437	.433	.627	.615	.266	.234	31/64	.063	.031		.609	.106	.070
AN8	1/2-20	.499	.495	.752	.740	.297	.265	39/64	.063	.031		.734	.106	.070
AN9	9/16-18	.562	.558	.877	.885	.328	.296	21/32	.078	.046		.859	.141	.070
AN10	5/8-18	.624	.620	.940	.928	.360	.328	47/64	.078	.046		.922	.141	.070
AN12	3/4-16	.749	.744	1.066	1.053	.422	.390	7/8	.078	.046		1.047	.141	.070
AN14	7/8-14	.874	.869	1.253	1.240	.485	.453	63/64	.094	.062		1.234	.141	.070
AN16	1 -14	.999	.993	1.441	1.428	.547	.515	1-3/32	.094	.062		1.422	.141	.070
AN18	1-1/8-12	1.124	1.118	1.628	1.615	.610	.578	1-3/16	.110	.078		1.609	.141	.070
AN20	1-1/4-12	1.249	1.243	1.815	1.802	.672	.640	1-3/8	.110	.078		1.796	.141	.070

Figure 6-11 (Sheet 1 of 6) Bolt, (AN3 to AN20)

Material: AN-S-9 (SAE 4037), MIL-S-6050 (SAE 8630), MIL-S-6098 (SAE 8735), MIL-S-6049 (SAE 8740), AN-QQ-S-770 Steel Corrosion-resisting. QQ-A-354 Aluminum Alloy (Al 24). Procurement Spec. MIL-B-6812.

Finish: Non-corrosion-resisting bolts: cadmium plated. Aluminum alloy bolts: anodized. Corrosion-resisting bolts: passivate.

Steel Hardness: Rockwell C-26 to C-32, when taken on a smooth, flat prepared surface at any location on the bolt.

Add C before dash number for corrosion-resisting steel bolt.
Add DD before dash number for aluminum alloy bolt.
Add A after dash number for undrilled bolt.
Add H before dash number for bolt with drilled head and shank.
Add H before dash number and A after dash number for bolt with drilled head only.

Examples of Part Nos:

AN3-10 = No.10-32 NF-3A, Steel bolt, 5/8 inch grip, with drilled shank only.

AN4C11 = 1/4-28 UNF-3A, Corr. res. steel bolt, 11/16 inch grip, with drilled shank only.

AN6DD12A = 3/8-24 UNF-3A, Alum. alloy bolt, 11/16 inch grip, undrilled shank and head.

AN9DDH14A = 9/16-18 UNF-3A, Alum. alloy bolt, 3/4 inch grip, with drilled head only.

AN12-16A = 3/4-16 UNF-3A, Steel bolt, 13/16 inch grip, undrilled shank and head.

AN18CH35 = 1-1/8-12 UNF-3A, Corr. res. steel bolt, 2-5/16 inch grip, with drilled head and shank.

AN20DDH47 = 1-1/4-12 UNF-3A, Alum. alloy bolt, 3-3/8 inch grip, with drilled head and shank.

Basic AN Part No.	Rated Strength Pounds					
	Ultimate Tensile At Root Dia.		Yield Tensile At Root Dia.		Single Shear At Full Dia.	
	Steel	AL Alloy	Steel	AL Alloy	Steel	AL Alloy
AN3	2,210	1,100	1,690	710	2,125	990
AN4	4,080	2,030	3,130	1,310	3,680	1,715
AN5	6,500	3,220	4,980	2,080	5,750	2,685
AN6	10,100	5,020	7,740	3,240	8,280	3,870
AN7	13,600	6,750	10,430	4,350	11,250	5,250
AN8	18,500	9,180	14,190	5,920	14,700	6,850
AN9	23,600	11,700	18,100	7,550	18,700	8,700
AN10	30,100	14,900	23,080	9,610	23,000	10,700
AN12	44,000	21,800	33,730	14,100	33,150	15,500
AN14	60,000	29,800	46,000	19,200	45,050	21,050
AN16	80,700	40,000	61,860	25,800	58,900	27,500
AN18	101,800	50,500	78,050	32,600	73,750	34,500
AN20	130,200	64,400	99,820	41,500	91,050	42,500

BOLT LENGTH

To obtain bolt length, add to grip length as follows:

*AN3	13/32
AN4	15/32
AN5	17/32
AN6	41/64
AN7	21/32
AN8	25/32
AN9	29/32
AN10	61/64
AN12	1- 3/32
AN14	1- 1/4
AN16	1- 3/8
AN18	1- 7/16
AN20	1-11/16

Tol: + 1/32 - 1/64

*Except - 3 add 13/32

For grip length see Sheets 3, 4, 5 and 6 of 6.

Figure 6-11 (Sheet 2 of 6) Bolt, (AN3 to AN20)

Dash No.	Grip Length (±1/64)						
	AN3	AN4	AN5	AN6	AN7	AN8	AN9
3	1/16	1/16					
4	1/8	1/16	1/16				
5	1/4	3/16	3/16	1/16	1/16		
6	3/8	5/16	5/16	3/16	3/16	1/16	1/16
7	1/2	7/16	7/16	5/16	5/16	3/16	1/8
10	5/8	9/16	9/16	7/16	7/16	5/16	1/4
11	3/4	11/16	11/16	9/16	9/16	7/16	3/8
12	7/16	13/16	13/16	11/16	11/16	9/16	1/2
13	1	15/16	15/16	13/16	13/16	11/16	5/8
14	1-1/6	1-1/16	1-1/16	15/16	15/16	13/16	3/4
15	1-1/4	1-3/16	1-3/16	1-1/16	1-1/16	15/16	7/8
16	1-3/8	1-5/16	1-5/16	1-3/16	1-3/16	1-1/16	1
17	1-1/2	1-7/16	1-7/16	1-5/16	1-5/16	1-3/16	1-1/8
20	1-5/8	1-9/16	1-9/16	1-7/16	1-7/16	1-5/16	1-1/4
21	1-3/4	1-11/16	1-11/16	1-9/16	1-9/16	1-7/16	1-3/8
22	1-7/8	1-13/16	1-13/16	1-11/16	1-11/16	1-9/16	1-1/2
23	2	1-15/16	1-15/16	1-13/16	1-13/16	1-11/16	1-5/8
24	2-1/8	2-1/16	2-1/16	1-15/16	1-15/16	1-13/16	1-3/4
25	2-1/4	2-3/16	2-3/16	2-1/16	2-1/16	1-15/16	1-7/8
26	2-3/8	2-5/16	2-5/16	2-3/16	2-3/16	2-1/16	2
27	2-1/2	2-7/16	2-7/16	2-5/16	2-5/16	2-3/16	2-1/8
30	2-5/8	2-9/16	2-9/16	2-7/16	2-7/16	2-5/16	2-1/4
31	2-3/4	2-11/16	2-11/16	2-9/16	2-9/16	2-7/16	2-3/8
32	2-7/8	2-13/16	2-13/16	2-11/16	2-11/16	2-9/16	2-1/2
33	3	2-15/16	2-15/16	2-13/16	2-13/16	2-11/16	2-5/8
34	3-1/8	3-1/16	3-1/16	2-15/16	2-15/16	2-13/16	2-3/4
35	3-1/4	3-3/16	3-3/16	3-1/16	3-1/16	2-15/16	2-7/8
36	3-3/8	3-5/16	3-5/16	3-3/16	3-3/16	3-1/16	3
37	3-1/2	3-7/16	3-7/16	3-5/16	3-5/16	3-3/16	3-1/8
40	3-5/8	3-9/16	3-9/16	3-7/16	3-7/16	3-5/16	3-1/4
41	3-3/4	3-11/16	3-11/16	3-9/16	3-9/16	3-7/16	3-3/8
42	3-7/8	3-13/16	3-13/16	3-11/16	3-11/16	3-9/16	3-1/2
43	4	3-15/16	3-15/16	3-13/16	3-13/16	3-11/16	3-5/8
44	4-1/8	4-1/16	4-1/16	3-15/16	3-15/16	3-13/16	3-3/4

Figure 6-11 (Sheet 3 of 6) Bolt, (AN3 to AN20)

Dash No.	Grip Length (±1/64)						
	AN 3	AN 4	AN 5	AN 6	AN 7	AN 8	AN 9
45	4-1/4	4-3/16	4-3/16	4-1/16	4-1/16	3-15/16	3-7/8
46	4-3/8	4-5/16	4-5/16	4-3/16	4-3/16	4-1/16	4
47	4-1/2	4-7/16	4-7/16	4-5/16	4-5/16	4-3/16	4-1/8
50	4-5/8	4-9/16	4-9/16	4-7/16	4-7/16	4-5/16	4-1/4
51	4-3/4	4-11/16	4-11/16	4-9/16	4-9/16	4-7/16	4-3/8
52	4-7/8	4-13/16	4-13/16	4-11/16	4-11/16	4-9/16	4-1/2
53	5	4-15/16	4-15/16	4-13/16	4-13/16	4-11/16	4-5/8
54	5-1/8	5-1/16	5-1/16	4-15/16	4-15/16	4-13/16	4-3/4
55	5-1/4	5-3/16	5-3/16	5-1/16	5-1/16	4-15/16	4-7/8
56	5-3/8	5-5/16	5-5/16	5-3/16	5-3/16	5-1/16	5
57	5-1/2	5-7/16	5-7/16	5-5/16	5-5/16	5-3/16	5-1/8
60	5-5/8	5-9/16	5-9/16	5-7/16	5-7/16	5-5/16	5-1/4
61	5-3/4	5-11/16	5-11/16	5-9/16	5-9/16	5-7/16	5-3/8
62	5-7/8	5-13/16	5-13/16	5-11/16	5-11/16	5-9/16	5-1/2
63	6	5-15/16	5-15/16	5-13/16	5-13/16	5-11/16	5-5/8
64	6-1/8	6-1/16	6-1/16	5-15/16	5-15/16	5-13/16	5-3/4
65	6-1/4	6-3/16	6-3/16	6-1/16	6-1/16	5-15/16	5-7/8
66	6-3/8	6-5/16	6-5/16	6-3/16	6-3/16	6-1/16	6
67	6-1/2	6-7/16	6-7/16	6-5/16	6-5/16	6-3/16	6-1/8
70	6-5/8	6-9/16	6-9/16	6-7/16	6-7/16	6-5/16	6-1/4
71	6-3/4	6-11/16	6-11/16	6-9/16	6-9/16	6-7/16	6-3/8
72	6-7/8	6-13/16	6-13/16	6-11/16	6-11/16	6-9/16	6-1/2
73	7	6-15/16	6-15/16	6-13/16	6-13/16	6-11/16	6-5/8
74	7-1/8	7-1/16	7-1/16	6-15/16	6-15/16	6-13/16	6-3/4
75	7-1/4	7-3/16	7-3/16	7-1/16	7-1/16	6-15/16	6-7/8
76	7-3/8	7-5/16	7-5/16	7-3/16	7-3/16	7-1/16	7
77	7-1/2	7-7/16	7-7/16	7-5/16	7-5/16	7-3/16	7-1/8
80	7-5/8	7-9/16	7-9/16	7-7/16	7-7/16	7-5/16	7-1/4
81			7-11/16			7-7/16	
82						7-9/16	
83						7-11/16	
84						7-13/16	
85				8-1/16		7-15/16	
86						8-1/16	
87						8-3/16	

For bolt length, see Sheet 2 of 6.

Figure 6-11 (Sheet 4 of 6) Bolt, (AN3 to AN20)

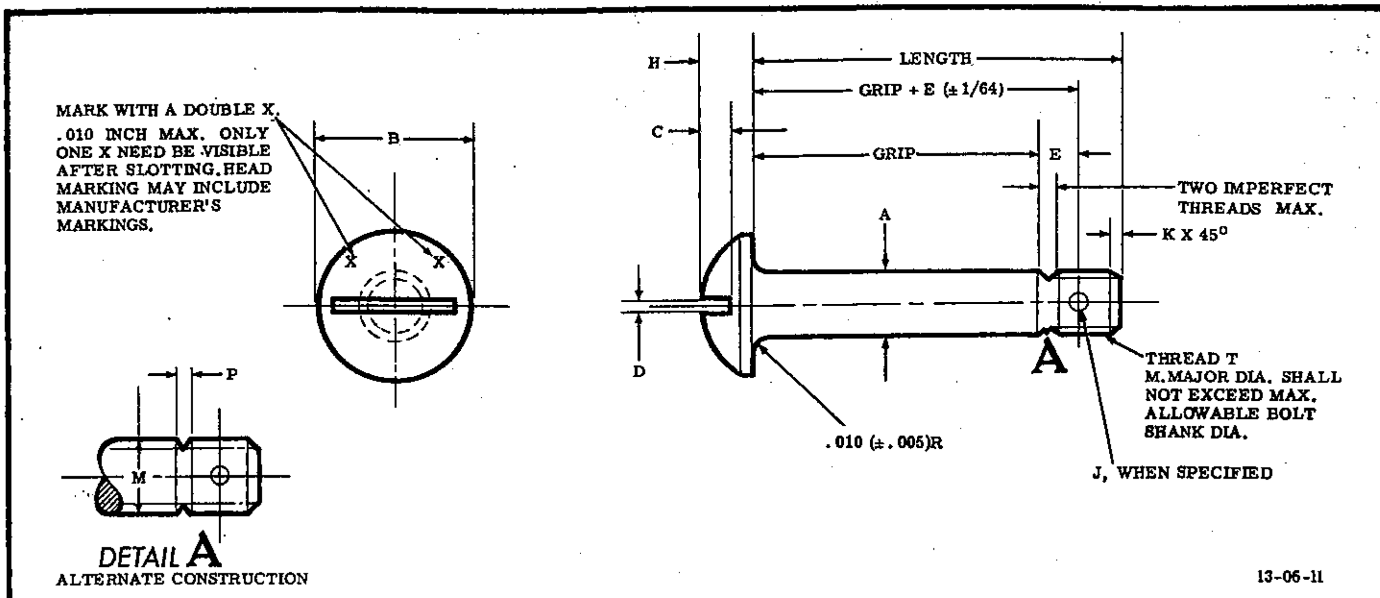
Dash No.	Grip Length (±1/64)					
	AN 10	AN 12	AN 14	AN 16	AN 18	AN 20
7	1/16					
10	3/16	1/16				
11	5/16	3/16	1/16			
12	7/16	5/16	3/16	1/8		
13	9/16	7/16	5/16	1/4	1/16	
14	11/16	9/16	7/16	3/8	3/16	
15	13/16	11/16	9/16	1/2	5/16	1/8
16	15/16	13/16	11/16	5/8	7/16	1/4
17	1-1/16	15/16	13/16	3/4	9/16	3/8
20	1-3/16	1-1/16	15/16	7/8	11/16	1/2
21	1-5/16	1-3/16	1-1/16	1	13/16	5/8
22	1-7/16	1-5/16	1-3/16	1-1/8	15/16	3/4
23	1-9/16	1-7/16	1-5/16	1-1/4	1-1/16	7/8
24	1-11/16	1-9/16	1-7/16	1-3/8	1-3/16	1
25	1-13/16	1-11/16	1-9/16	1-1/2	1-5/16	1-1/8
26	1-15/16	1-13/16	1-11/16	1-5/8	1-7/16	1-1/4
27	2-1/16	1-15/16	1-13/16	1-3/4	1-9/16	1-3/8
30	2-3/16	2-1/16	1-15/16	1-7/8	1-11/16	1-1/2
31	2-5/16	2-3/16	2-1/16	2	1-13/16	1-5/8
32	2-7/16	2-5/16	2-3/16	2-1/8	1-15/16	1-3/4
33	2-9/16	2-7/16	2-5/16	2-1/4	2-1/16	1-7/8
34	2-11/16	2-9/16	2-7/16	2-3/8	2-3/16	2
35	2-13/16	2-11/16	2-9/16	2-1/2	2-5/16	2-1/8
36	2-15/16	2-13/16	2-11/16	2-5/8	2-7/16	2-1/4
37	3-1/16	2-15/16	2-13/16	2-3/4	2-9/16	2-3/8
40	3-3/16	3-1/16	2-15/16	2-7/8	2-11/16	2-1/2
41	3-5/16	3-3/16	3-1/16	3	2-13/16	2-5/8
42	3-7/16	3-5/16	3-3/16	3-1/8	2-15/16	2-3/4
43	3-9/16	3-7/16	3-5/16	3-1/4	3-1/6	2-7/8
44	3-11/16	3-9/16	3-7/16	3-3/8	3-3/16	3
45	3-13/16	3-11/16	3-9/16	3-1/2	3-5/16	3-1/8

Figure 6-11 (Sheet 5 of 6) Bolt, (AN3 to AN20)

Dash No.	Grip Length (±1/64)					
	AN 10	AN 12	AN 14	AN 16	AN 18	AN 20
46	3-15/16	3-13/16	3-11/16	3-5/8	3-7/16	3-1/4
47	4-1/16	3-15/16	3-13/16	3-3/4	3-9/16	3-3/8
50	4-3/16	4-1/16	3-15/16	3-7/8	3-11/16	3-1/2
51	4-5/16	4-3/16	4-1/16	4	3-13/16	3-5/8
52	4-7/16	4-5/16	4-3/16	4-1/8	3-15/16	3-3/4
53	4-9/16	4-7/16	4-5/16	4-1/4	4-1/16	3-7/8
54	4-11/16	4-9/16	4-7/16	4-3/8	4-3/16	4
55	4-13/16	4-11/16	4-9/16	4-1/2	4-5/16	4-1/8
56	4-15/16	4-13/16	4-11/16	4-5/8	4-7/16	4-1/4
57	5-1/16	4-15/16	4-13/16	4-3/4	4-9/16	4-3/8
60	5-3/16	5-1/16	4-15/16	4-7/8	4-11/16	4-1/2
61	5-5/16	5-3/16	5-1/16	5	4-13/16	4-5/8
62	5-7/16	5-5/16	5-3/16	5-1/8	4-15/16	4-3/4
63	5-9/16	5-7/16	5-5/16	5-1/4	5-1/16	4-7/8
64	5-11/16	5-9/16	5-7/16	5-3/8	5-3/16	5
65	5-13/16	5-11/16	5-9/16	5-1/2	5-5/16	5-1/8
66	5-15/16	5-13/16	5-11/16	5-5/8	5-7/16	5-1/4
67	6-1/16	5-15/16	5-13/16	5-3/4	5-9/16	5-3/8
70	6-3/16	6-1/16	5-15/16	5-7/8	5-11/16	5-1/2
71	6-5/16	6-3/16	6-1/16	6	5-13/16	5-5/8
72	6-7/16	6-5/16	6-3/16	6-1/8	5-15/16	5-3/4
73	6-9/16	6-7/16	6-5/16	6-1/4	6-1/16	5-7/8
74	6-11/16	6-9/16	6-7/16	6-3/8	6-3/16	6
75	6-13/16	6-11/16	6-9/16	6-1/2	6-5/16	6-1/8
76	6-15/16	6-13/16	6-11/16	6-5/8	6-7/16	6-1/4
77	7-1/16	6-15/16	6-13/16	6-3/4	6-9/16	6-3/8
80	7-3/16	7-1/16	6-15/16	6-7/8	6-11/16	6-1/2
81				7	6-13/16	6-5/8
82				7-1/8		

For bolt length, see Sheet 2 of 6.

Figure 6-11 (Sheet 6 of 6) Bolt, (AN3 to AN20)



Basic AN Part No.	Thread T 20 NF-3	A +.000 -.002 Dia.	B Dia.	C	D	E Ref	H	J Drill +.010 -.000	K ±.016	M ±.005 Dia.	P	Rated Strength Pounds: Single Shear at Full Dia.	Rated Strength Pounds: Tensile
AN21	6-40	.136	5/16	3/64	1/32	5/32	5/64	.038	.031	.100	1/32	1,060	510
AN22	8-36	.162	3/8	1/16	3/64	5/32	3/32	.070	.031	.120	1/32	1,500	760
AN23	10-32	.186	3/8	1/16	3/64	3/16	3/32	.070	.031	.141	3/64	2,125	1,105
AN24	1/4 -28	.248	1/2	3/32	1/16	3/16	1/8	.076	.031	.196	3/64	3,680	2,040
AN25	5/16-24	.311	5/8	7/64	5/64	3/16	5/32	.076	.047	.250	1/16	5,750	3,250
AN26	3/8 -24	.373	11/16	9/64	3/32	7/32	3/16	.106	.047	.313	1/16	8,280	5,050
AN27	7/16-20	.436	13/16	5/32	3/32	7/32	7/32	.106	.047	.360	1/16	11,250	6,800
AN28	1/2 -20	.497	7/8	11/64	7/64	1/4	1/4	.106	.047	.422	1/16	14,700	9,250
AN29	9/16-18	.560	1	3/16	7/64	5/16	9/32	.141	.062	.482	5/64	18,700	11,800
AN30	5/8 -18	.622	1-1/8	3/16	1/8	5/16	5/16	.141	.062	.545	5/64	23,000	15,050
AN32	3/4 -16	.747	1-5/16	13/64	9/64	3/8	3/8	.141	.062	.660	3/32	33,150	22,000
AN34	7/8 -14	.871	1-1/2	7/32	5/32	7/16	7/16	.141	.078	.773	3/32	45,050	30,000
AN36	1 -14	.996	1-3/4	15/64	11/64	1/2	1/2	.141	.078	.898	3/32	58,900	40,350

Cotter pin hole centre line shall be within .010 inch of bolt centre line for 5/16 diameter bolts and smaller, and within .015 inch for 3/8 diameter bolts and larger. Cotter pin to be normal to bolt centre line within 2°. Rated tensile strengths applicable only when shear nut AN530 or thin nut AN364 is used.

Figure 6-12 (Sheet 1 of 4) Bolt, Clevis (AN21 to AN36)

Material and Finish Specification: Same as AN3 Series Bolts.

Add A after dash number for bolt without cotter pin hole.

Examples of Part Nos:

AN21-14 = No. 6 bolt, 29/32 inch long, with cotter pin hole.

AN21-14A = No. 6 bolt, 29/32 inch long, without cotter pin hole.

Position of slot in head relative to cotter pin hole optional.

Procurement Specification: MIL-B-6812

BOLT LENGTHS

For bolt length, add to grip length as follows:

AN21	9/32
AN22	9/32
AN23	11/32
AN24	11/32
AN25	23/64
AN26	23/64
AN27	27/64
AN28	27/64
AN29	1/2
AN30	1/2
AN32	9/16
AN34	41/64
AN36	45/64

Tol: + 1/32 - 1/64

For grip length, see Sheets 2, 3 and 4 of 4.

Dash No.	Grip Length							
	AN 21,22	AN23, 24	AN25, 26	AN27, 28	AN29, 30	AN32	AN34	AN36
5	1/16							
6	1/8							
7	3/16							
8	1/4	3/16						
9	5/16	1/4	1/4					
10	3/8	5/16	5/16					
11	7/16	3/8	3/8					
12	1/2	7/16	7/16	3/8				
13	9/16	1/2	1/2	7/16				
14	5/8	9/16	9/16	1/2	7/16			
15	11/16	5/8	5/8	9/16	1/2			
16	3/4	11/16	11/16	5/8	9/16	1/2		
17	13/16	3/4	3/4	11/16	5/8	9/16		
18	7/8	13/16	13/16	3/4	11/16	5/8	9/16	
19	15/16	7/8	7/8	13/16	3/4	11/16	5/8	
20	1	15/16	15/16	7/8	13/16	3/4	11/16	5/8

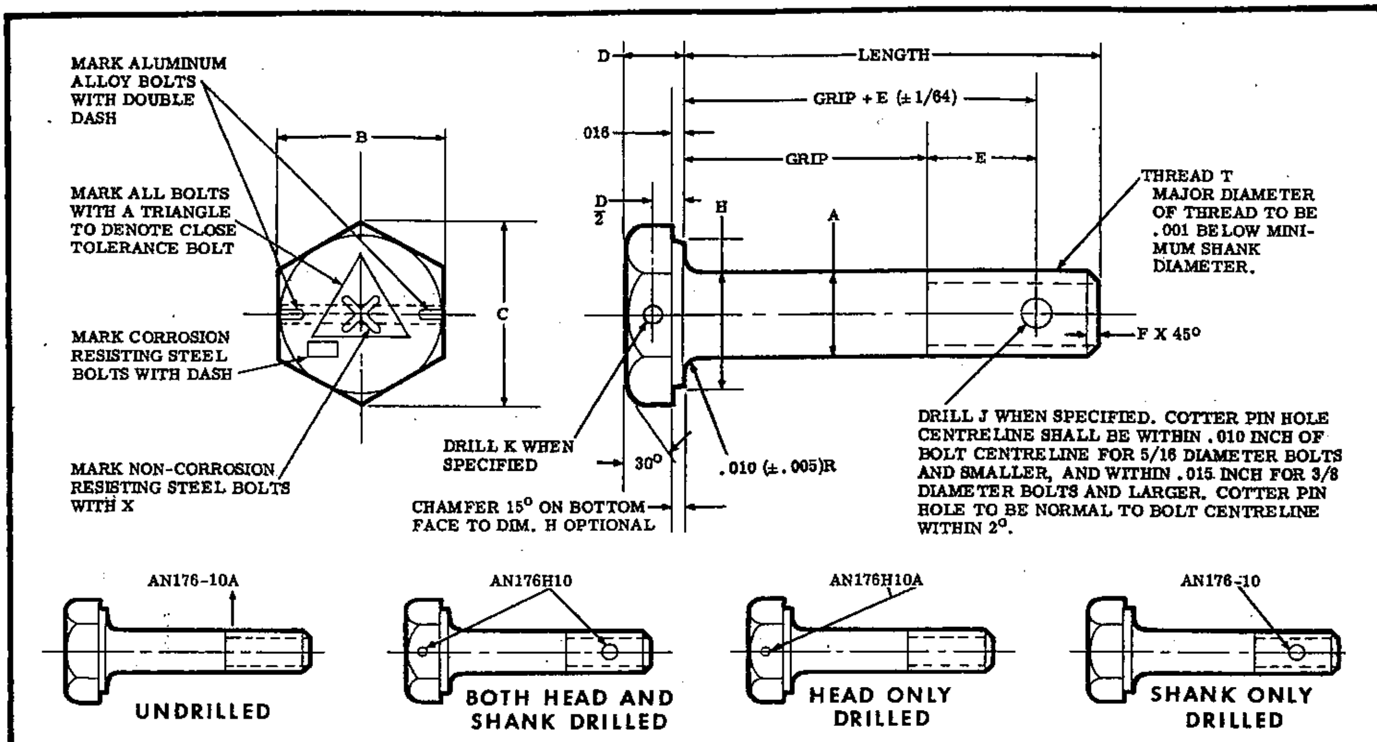
Figure 6-12 (Sheet 2 of 4) Bolt, Clevis (AN21 to AN36)

Dash No.	Grip Length							
	AN21,22	AN23,24	AN25,26	AN27,28	AN29,30	AN32	AN34	AN36
21	1-1/16	1	1	15/16	7/8	13/16	3/4	11/16
22	1-1/8	1-1/16	1-1/16	1	15/16	7/8	13/16	3/4
23	1-3/16	1-1/8	1-1/8	1-1/16	1	15/16	7/8	13/16
24	1-1/4	1-3/16	1-3/16	1-1/8	1-1/16	1	15/16	7/8
25	1-5/16	1-1/4	1-1/4	1-3/16	1-1/8	1-1/16	1	15/16
26	1-3/8	1-5/16	1-5/16	1-1/4	1-3/16	1-1/8	1-1/16	1
27	1-7/16	1-3/8	1-3/8	1-5/16	1-1/4	1-3/16	1-1/8	1-1/16
28	1-1/2	1-7/16	1-7/16	1-3/8	1-5/16	1-1/4	1-3/16	1-1/8
29	1-9/16	1-1/2	1-1/2	1-7/16	1-3/8	1-5/16	1-1/4	1-3/16
30	1-5/8	1-9/16	1-9/16	1-1/2	1-7/16	1-3/8	1-5/16	1-1/4
31	1-11/16	1-5/8	1-5/8	1-9/16	1-1/2	1-7/16	1-3/8	1-5/16
32	1-3/4	1-11/16	1-11/16	1-5/8	1-9/16	1-1/2	1-7/16	1-3/8
34		1-13/16	1-13/16	1-3/4	1-11/16	1-5/8	1-9/16	1-1/2
36		1-15/16	1-15/16	1-7/8	1-13/16	1-3/4	1-11/16	1-5/8
38		2-1/16	2-1/16	2	1-15/16	1-7/8	1-13/16	1-3/4
40		2-3/16	2-3/16	2-1/8	2-1/16	2	1-15/16	1-7/8
42		2-5/16	2-5/16	2-1/4	2-3/16	2-1/8	2-1/16	2
44		2-7/16	2-7/16	2-3/8	2-5/16	2-1/4	2-3/16	2-1/8
46		2-9/16	2-9/16	2-1/2	2-7/16	2-3/8	2-5/16	2-1/4
48		2-11/16	2-11/16	2-5/8	2-9/16	2-1/2	2-7/16	2-3/8
50		2-13/16	2-13/16	2-3/4	2-11/16	2-5/8	2-9/16	2-1/2
52		2-15/16	2-15/16	2-7/8	2-13/16	2-3/4	2-11/16	2-5/8
54		3-1/16	3-1/16	3	2-15/16	2-7/8	2-13/16	2-3/4
56		3-3/16	3-3/16	3-1/8	3-1/16	3	2-15/16	2-7/8
58		3-5/16	3-5/16	3-1/4	3-3/16	3-1/8	3-1/16	3
60		3-7/16	3-7/16	3-3/8	3-5/16	3-1/4	3-3/16	3-1/8

Figure 6-12 (Sheet 3 of 4) Bolt, Clevis (AN21 to AN36)

Dash No.	Grip Length							
	AN21,22	AN23,24	AN25,26	AN27,28	AN29,30	AN32	AN34	AN36
62		3-9/16	3-9/16	3-1/2	3-7/16	3-3/8	3-5/16	3-1/4
64		3-11/16	3-11/16	3-5/8	3-9/16	3-1/2	3-7/16	3-3/8
66		3-13/16		3/3/4	3-11/16	3-5/8	3-9/16	3-1/2
68		3-15/16		3-7/8	3-13/16	3-3/4	3-11/16	3-5/8
70		4-1/16		4	3-15/16	3-7/8	3-13/16	3-3/4
72		4-3/16		4-1/8	4-1/16	4	3-15/16	3-7/8
74				4-1/4	4-3/16	4-1/8	4-1/16	4
76				4-3/8	4-5/16	4-1/4	4-3/16	4-1/8
78				4-1/2	4-7/16	4-3/8	4-5/16	4-1/4
80				4-5/8	4-9/16	4-1/2	4-7/16	4-3/8
82				4-3/4		4-5/8	4-9/16	4-1/2
84				4-7/8		4-3/4	4-11/16	4-5/8
86				5		4-7/8	4-13/16	4-3/4
88				5-1/8		5	4-15/16	4-7/8
90				5-1/4		5-1/8	5-1/16	5
92				5-3/8		5-1/4	5-3/16	5-1/8
94						5-3/8	5-5/16	5-1/4
96							5-7/16	5-3/8
98							5-9/16	5-1/2
100							5-11/16	5-5/8
102							5-13/16	5-3/4
104							5-15/16	5-7/8
106							6-1/16	6
108							6-3/16	6-1/8
110								6-1/4
112								6-3/8

Figure 6-12 (Sheet 4 of 4) Bolt, Clevis (AN21 to AN36)



DRILLED AND UNDRILLED BOLTS AND PART NUMBERS

Basic AN Part No.	*Thread	A Dia. Max.	A Dia. Min.	B Max.	B Min.	D Max.	D Min.	E Ref.	F Max.	F Min.	H Dia. Max.	H Dia. Min.	J Drill Dia. ±.010 -.000	K Drill Dia. ±.010 -.000
AN173	10-32	.189	.189	.377	.365	.141	.109	17/64	.047	.015	Maximum not to exceed B diameter	.359	.070	.046
AN174	1/4-28	.249	.249	.440	.428	.172	.140	5/16	.047	.015		.422	.076	.046
AN175	5/16-24	.312	.311	.502	.490	.204	.172	23/64	.063	.031		.484	.076	.070
AN176	3/8-24	.374	.374	.565	.553	.235	.203	7/16	.063	.031		.547	.106	.070
AN177	7/16-20	.437	.436	.627	.615	.266	.234	31/64	.063	.031		.609	.106	.070
AN178	1/2-20	.499	.499	.752	.740	.297	.265	39/64	.063	.031		.734	.106	.070
AN179	9/16-18	.562	.561	.877	.865	.328	.296	21/32	.078	.046		.859	.141	.070
AN180	5/8-18	.624	.623	.940	.928	.360	.328	47/64	.078	.046		.922	.141	.070
AN182	3/4-16	.749	.748	1.066	1.053	.422	.390	7/8	.078	.046		1.047	.141	.070
AN184	7/8-14	.874	.873	1.253	1.240	.485	.453	63/64	.094	.062		1.234	.141	.070
AN186	1 -14	.999	.998	1.441	1.428	.547	.515	1-3/32	.094	.062		1.422	.141	.070

Material and Finish: Same as AN3 series bolts except as noted on Sheet 2 of 6.
*10-32 NF-3A, 1-14 NF-3A, all others UNF-3A

Figure 6-13 (Sheet 1 of 6) Bolts, Close Tolerance, (AN173 to AN186)

Plating may be ground off shank or underside of head. Unplated surfaces shall be coated with compound, Specification MIL-C-6708. Surface roughness in RMS micro-inches before plating shall be: 63 max. for shank and underside of head, 125 max. for threads (visual comparison only), 250 max. for all other areas (visual comparison only).

Add C before dash number for corrosion resisting steel bolt. Inactive for design after 1952.

Add DD before dash number for aluminum bolt. Inactive for design after 1952.

Add A after dash number for undrilled bolt.

Add H before dash number for bolt with drilled head and shank.

Add H before dash number and A after dash number for bolt with drilled head only.

Examples of Part Nos:

AN176-10= 3/8 non-corrosion resisting steel bolt 1-5/64 long, 7/16 grip with drilled shank only.

AN176C10= 3/8 corrosion resisting steel bolt 1-5/64 long, 7/16 grip with drilled shank only.

AN176DD10= 3/8 aluminum alloy bolt 1-5/64 long, 7/16 grip with drilled shank only.

AN176DD10A= 3/8 aluminum alloy bolt 1-5/64 long, 7/16 grip, undrilled shank and head.

AN176DDH10=3/8 aluminum alloy bolt 1-5/64 long, 7/16 grip with drilled head and shank.

AN176DDH10A=3/8 aluminum alloy bolt 1-5/64 long, 7/16 grip with drilled head only.

NF-3A, 10-32 NF-3A, 1-14 All others UNF-3A	Rated Strength Pounds					
	Ultimate Tensile At Root Dia.		Yield Tensile At Root Dia.		Single Shear At Full Dia.	
	Steel	Al Alloy	Steel	Al Alloy	Steel	Al Alloy
AN173	2,210	1,100	1,690	710	2,125	990
AN174	4,080	2,030	3,130	1,310	3,680	1,715
AN175	6,500	3,220	4,980	2,080	5,750	2,685
AN176	10,100	5,020	7,740	3,240	8,280	3,870
AN177	13,600	6,750	10,430	4,350	11,250	5,250
AN178	18,500	9,180	14,190	5,920	14,700	6,850
AN179	23,600	11,700	18,100	7,550	18,700	8,700
AN180	30,100	14,900	23,080	9,610	23,000	10,750
AN182	44,000	21,800	33,730	14,100	33,150	15,500
AN184	60,000	29,800	46,000	19,200	45,050	21,050
AN186	80,700	40,000	61,870	25,800	58,900	27,500

BOLT LENGTHS

To obtain bolt length, add to grip length as follows:

AN173	13/32
*AN174	15/32
AN175	17/32
AN176	41/64
AN177	21/32
AN178	25/32
AN179	29/32
AN180	61/64
AN182	1-3/32
AN184	1-1/4
AN186	1-3/8

Tol: + 1/32 - 1/64

*Except -3 add 13/32

For grip length see Sheets 3, 4, 5 and 6 of 6.

Figure 6-13 (Sheet 2 of 6) Bolts, Close Tolerance, (AN173 to AN186)

Dash No.	Grip Length (±1/64)				
	AN173	AN174	AN175	AN176	AN177
3	1/16	1/16			
4	1/8	1/16	1/16		
5	1/4	3/16	3/16	1/16	1/16
6	3/8	5/16	5/16	3/16	3/16
7	1/2	7/16	7/16	5/16	5/16
10	5/8	9/16	9/16	7/16	7/16
11	3/4	11/16	11/16	9/16	9/16
12	7/8	13/16	13/16	11/16	11/16
13	1	15/16	15/16	13/16	13/16
14	1-1/8	1-1/16	1-1/16	15/16	15/16
15	1-1/4	1-3/16	1-3/16	1-1/16	1-1/16
16	1-3/8	1-5/16	1-5/16	1-3/16	1-3/16
17	1-1/2	1-7/16	1-7/16	1-5/16	1-5/16
20	1-5/8	1-9/16	1-9/16	1-7/16	1-7/16
21	1-3/4	1-11/16	1-11/16	1-9/16	1-9/16
22	1-7/8	1-13/16	1-13/16	1-11/16	1-11/16
23	2	1-15/16	1-15/16	1-13/16	1-13/16
24	2-1/8	2-1/16	2-1/16	1-15/16	1-15/16
25	2-1/4	2-3/16	2-3/16	2-1/16	2-1/16
26	2-3/8	2-5/16	2-5/16	2-3/16	2-3/16
27	2-1/2	2-7/16	2-7/16	2-5/16	2-5/16
30	2-5/8	2-9/16	2-9/16	2-7/16	2-7/16
31	2-3/4	2-11/16	2-11/16	2-9/16	2-9/16
32	2-7/8	2-13/16	2-13/16	2-11/16	2-11/16
33	3	2-15/16	2-15/16	2-13/16	2-13/16
34	3-1/8	3-1/16	3-1/16	2-15/16	2-15/16
35	3-1/4	3-3/16	3-3/16	3-1/16	3-1/16
36	3-3/8	3-5/16	3-5/16	3-3/16	3-3/16
37	3-1/2	3-7/16	3-7/16	3-5/16	3-5/16
40	3-5/8	3-9/16	3-9/16	3-7/16	3-7/16
41	3-3/4	3-11/16	3-11/16	3-9/16	3-9/16
42	3-7/8	3-13/16	3-13/16	3-11/16	3-11/16

Figure 6-13 (Sheet 3 of 6) Bolts, Close Tolerance, (AN173 to AN186)

Dash No.	Grip Length (±1/64)				
	AN173	AN174	AN175	AN176	AN177
43	4	3-15/16	3-15/16	3-13/16	3-13/16
44	4-1/8	4-1/16	4-1/16	3-15/16	3-15/16
45	4-1/4	4-3/16	4-3/16	4-1/16	4-1/16
46	4-3/8	4-5/16	4-5/16	4-3/16	4-3/16
47	4-1/2	4-7/16	4-7/16	4-5/16	4-5/16
50	4-5/8	4-9/16	4-9/16	4-7/16	4-7/16
51	4-3/4	4-11/16	4-11/16	4-9/16	4-9/16
52	4-7/8	4-13/16	4-13/16	4-11/16	4-11/16
53	5	4-15/16	4-15/16	4-13/16	4-13/16
54	5-1/8	5-1/16	5-1/16	4-15/16	4-15/16
55	5-1/4	5-3/16	5-3/16	5-1/16	5-1/16
56	5-3/8	5-5/16	5-5/16	5-3/16	5-3/16
57	5-1/2	5-7/16	5-7/16	5-5/16	5-5/16
60	5-5/8	5-9/16	5-9/16	5-7/16	5-7/16
61	5-3/4	5-11/16	5-11/16	5-9/16	5-9/16
62	5-7/8	5-13/16	5-13/16	5-11/16	5-11/16
63	6	5-15/16	5-15/16	5-13/16	5-13/16
64	6-1/8	6-1/16	6-1/16	5-15/16	5-15/16
65	6-1/4	6-3/16	6-3/16	6-1/16	6-1/16
66	6-3/8	6-5/16	6-5/16	6-3/16	6-3/16
67	6-1/2	6-7/16	6-7/16	6-5/16	6-5/16
70	6-5/8	6-9/16	6-9/16	6-7/16	6-7/16
71	6-3/4	6-11/16	6-11/16	6-9/16	6-9/16
72	6-7/8	6-13/16	6-13/16	6-11/16	6-11/16
73	7	6-15/16	6-15/16	6-13/16	6-13/16
74	7-1/8	7-1/16	7-1/16	6-15/16	6-15/16
75	7-1/4	7-3/16	7-3/16	7-1/16	7-1/16
76	7-3/8	7-5/16	7-5/16	7-3/16	7-3/16
77	7-1/2	7-7/16	7-7/16	7-5/16	7-5/16
80	7-5/8	7-9/16	7-9/16	7-7/16	7-7/16
81	For bolt length, see Sheet 2 of 6.		7-11/16		
85				8-1/16	

Figure 6-13 (Sheet 4 of 6) Bolts, Close Tolerance, (AN173 to AN186)

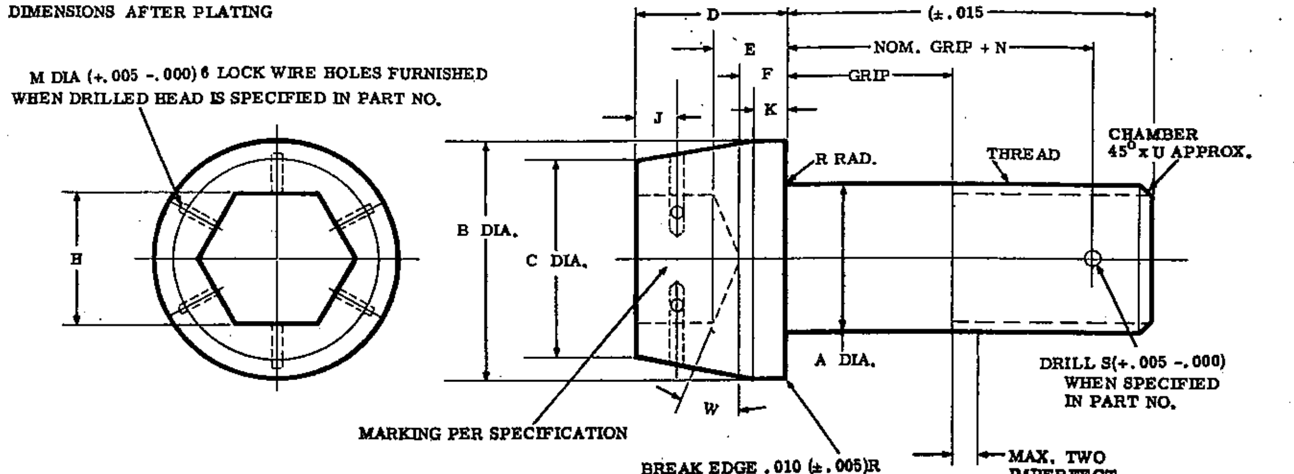
Dash No.	Grip Length (±1/64)					
	AN178	AN179	AN180	AN182	AN184	AN186
6	1/16	1/16				
7	3/16	1/8	1/16			
10	5/16	1/4	3/16	1/16		
11	7/16	3/8	5/16	3/16	1/16	
12	9/16	1/2	7/16	5/16	3/16	1/8
13	11/16	5/8	9/16	7/16	5/16	1/4
14	13/16	3/4	11/16	9/16	7/16	3/8
15	15/16	7/8	13/16	11/16	9/16	1/2
16	1-1/16	1	15/16	13/16	11/16	5/8
17	1-3/16	1-1/8	1-1/16	15/16	13/16	3/4
20	1-5/16	1-1/4	1-3/16	1-1/16	15/16	7/8
21	1-7/16	1-3/8	1-5/16	1-3/16	1-1/16	1
22	1-9/16	1-1/2	1-7/16	1-5/16	1-3/16	1-1/8
23	1-11/16	1-5/8	1-9/16	1-7/16	1-5/16	1-1/4
24	1-13/16	1-3/4	1-11/16	1-9/16	1-7/16	1-3/8
25	1-15/16	1-7/8	1-13/16	1-11/16	1-9/16	1-1/2
26	2-1/16	2	1-15/16	1-13/16	1-11/16	1-5/8
27	2-3/16	2-1/8	2-1/16	1-15/16	1-13/16	1-3/4
30	2-5/16	2-1/4	2-3/16	2-1/16	1-15/16	1-7/8
31	2-7/16	2-3/8	2-5/16	2-3/16	2-1/16	2
32	2-9/16	2-1/2	2-7/16	2-5/16	2-3/16	2-1/8
33	2-11/16	2-5/8	2-9/16	2-7/16	2-5/16	2-1/4
34	2-13/16	2-3/4	2-11/16	2-9/16	2-7/16	2-3/8
35	2-15/16	2-7/8	2-13/16	2-11/16	2-9/16	2-1/2
36	3-1/16	3	2-15/16	2-13/16	2-11/16	2-5/8
37	3-3/16	3-1/8	3-1/16	2-15/16	2-13/16	2-3/4
40	3-5/16	3-1/4	3-3/16	3-1/16	2-15/16	2-7/8
41	3-7/16	3-3/8	3-5/16	3-3/16	3-1/16	3
42	3-9/16	3-1/2	3-7/16	3-5/16	3-3/16	3-1/8
43	3-11/16	3-5/8	3-9/16	3-7/16	3-5/16	3-1/4
44	3-13/16	3-3/4	3-11/16	3-9/16	3-7/16	3-3/8
45	3-15/16	3-7/8	3-13/16	3-11/16	3-9/16	3-1/2
46	4-1/16	4	3-15/16	3-13/16	3-11/16	3-5/8

Figure 6-13 (Sheet 5 of 6) Bolts, Close Tolerance, (AN173 to AN186)

Dash No.	Grip Length (±1/64)					
	AN178	AN179	AN180	AN182	AN184	AN186
47	4-3/16	4-1/8	4-1/16	3-15/16	3-13/16	3-3/4
50	4-5/16	4-1/4	4-3/16	4-1/16	3-15/16	3-7/8
51	4-7/16	4-3/8	4-5/16	4-3/16	4-1/16	4
52	4-9/16	4-1/2	4-7/16	4-5/16	4-3/16	4-1/8
53	4-11/16	4-5/8	4-9/16	4-7/16	4-5/16	4-1/4
54	4-13/16	4-3/4	4-11/16	4-9/16	4-7/16	4-3/8
55	4-15/16	4-7/8	4-13/16	4-11/16	4-9/16	4-1/2
56	5-1/16	5	4-15/16	4-13/16	4-11/16	4-5/8
57	5-3/16	5-1/8	5-1/16	4-15/16	4-13/16	4-3/4
60	5-5/16	5-1/4	5-3/16	5-1/16	4-15/16	4-7/8
61	5-7/16	5-3/8	5-5/16	5-3/16	5-1/16	5
62	5-9/16	5-1/2	5-7/16	5-5/16	5-3/16	5-1/8
63	5-11/16	5-5/8	5-9/16	5-7/16	5-5/16	5-1/4
64	5-13/16	5-3/4	5-11/16	5-9/16	5-7/16	5-3/8
65	5-15/16	5-7/8	5-13/16	5-11/16	5-9/16	5-1/2
66	6-1/16	6	5-15/16	5-13/16	5-11/16	5-5/8
67	6-3/16	6-1/8	6-1/16	5-15/16	5-13/16	5-3/4
70	6-5/16	6-1/4	6-3/16	6-1/16	5-15/16	5-7/8
71	6-7/16	6-3/8	6-5/16	6-3/16	6-1/16	6
72	6-9/16	6-1/2	6-7/16	6-5/16	6-3/16	6-1/8
73	6-11/16	6-5/8	6-9/16	6-7/16	6-5/16	6-1/4
74	6-13/16	6-3/4	6-11/16	6-9/16	6-7/16	6-3/8
75	6-15/16	6-7/8	6-13/16	6-11/16	6-9/16	6-1/2
76	7-1/16	7	6-15/16	6-13/16	6-11/16	6-5/8
77	7-3/16	7-1/8	7-1/16	6-15/16	6-13/16	6-3/4
80	7-5/16	7-1/4	7-3/16	7-1/16	6-15/16	6-7/8
81	7-7/16					7
82	7-9/16					7-1/8
83	7-11/16					
84	7-13/16					
85	7-15/16					
86	8-1/16					
87	8-3/16					

For bolt length, see Sheet 2 of 6.

Figure 6-13 (Sheet 6 of 6) Bolts, Close Tolerance, (AN173 to AN186)



LOCK WIRE HOLES MUST BE FREE FROM BURRS AND SHARP EDGES.
LETTER R ON BOLT DESIGNATES THAT THREADS HAVE BEEN ROLLED AFTER HEAT TREATMENT.

Basic NAS Part No.	* Thread	A	B	C	D	E	F Min.	H	J	K
144	1/4-28	.2490 .2460	.438 .430	.381	.226	.122	.072	.2210 .2190	.063	.063
145	5/16-24	.3115 .3085	.531 .523	.501	.276	.142	.075	.3150 .3130	.063	.063
146	3/8-24	.3740 .3710	.625 .615	.583	.343	.170	.091	.3785 .3755	.094	.063
147	7/16-20	.4365 .4330	.750 .740	.594	.407	.209	.130	.3785 .3755	.094	.063
148	1/2-20	.4990 .4955	.813 .802	.751	.460	.223	.130	.5035 .5005	.094	.063
149	9/16-18	.5615 .5575	.938 .927	.775	.529	.261	.160	.5035 .5005	.125	.094
150	5/8-18	.6240 .6200	1.000 .988	.850	.595	.288	.175	.5660 .5630	.188	.094
152	3/4-16	.7490 .7445	1.188 1.175	.938	.732	.357	.232	.6297 .6257	.188	.094
154	7/8-14	.8740 .8690	1.438 1.424	1.098	.846	.406	.259	.7547 .7507	.188	.094
156	1-14	.9990 .9935	1.625 1.609	1.405	.952	.434	.259	1.0050 1.0010	.188	.094
158	1-1/8-12	1.1240 1.1180	1.875 1.857	1.423	1.091	.512	.320	1.0050 1.0010	.188	.094

*Thread NAS156 1-14 NF-3A. All others UNF-3A

Figure 6-14 (Sheet 1 of 6) Bolt, Internal Wrenching (NAS144 to NAS158)

Material: AN-QQ-S-687 (SAE 6150), AN-QQ-S-690 (SAE 3140), AN-QQ-S-756 (SAE 4340), MIL-S-6049 (SAE 8740).

Heat Treat: 160,000 to 180,000 psi tensile strength.

Finish: Cadmium plate. See Part 20. Bake after plating.

Code: Add DH to part number to designate drilled head. Add A to part number to designate drilled shank. For suffix dash number to designate grip and length, see Figure 6-14, Sheets 3, 4, 5 and 6 of 6.

Examples of Part Nos: NAS144-25 = 1/4-28 bolt, Int. Wr. 1-9/16 long, undrilled, NAS144DH-25=1/4-28 bolt, Int. Wr. 1-9/16 long, drilled head, NAS144ADH-25=1/4-28 bolt, Int. Wr. 1-9/16 long, drilled head, drilled shank.

Basic NAS Part No.	Thread NAS156 1-14 NF-3A All others UNF-3A	M	N	R	S	U	W Max.	Strength	
								Double Shear	Ultimate Tensile
144	1/4-28	.046	11/32	.041 .026	.076	.03	20°	9,300	5,000
145	5/16-24	.070	25/64	.041 .026	.076	.05	20°	14,600	8,200
146	3/8-24	.070	15/32	.057 .042	.106	.05	20°	21,000	12,700
147	7/16-20	.070	33/64	.057 .042	.106	.05	20°	28,600	17,100
148	1/2-20	.070	5/8	.057 .042	.106	.05	18°	37,300	23,400
149	9/16-18	.070	43/64	.057 .042	.141	.06	20°	47,200	28,900
150	5/8-18	.070	3/4	.073 .058	.141	.06	20°	58,300	38,000
152	3/4-16	.070	7/8	.073 .058	.141	.06	20°	83,900	55,600
154	7/8-14	.070	31/32	.073 .058	.141	.08	20°	114,000	76,200
156	1-14	.070	1-1/8	.073 .058	.141	.08	18.5°	149,200	102,500
158	1-1/8-12	.070	1-3/16	.073 .058	.141	.09	20°	188,900	128,800

For 1-1/4, 1-3/8 and 1-1/2 dia. bolts, see NAS172, NAS174 and NAS176.

Figure 6-14 (Sheet 2 of 6) Bolt, Internal Wrenching (NAS144 to NAS158)

Dash No.	Length All Sizes	Grip Length										
		1/4 -28	5/16 -24	3/8 -24	7/16 -20	1/2 -20	9/16 -18	5/8 -18	3/4 -16	7/8 -14	1 -14	1-1/3 -12
9	0.562	0.062										
10	0.625	0.125	0.062									
11	0.687	0.187	0.125									
12	0.750	0.250	0.187	0.062								
13	0.812	0.312	0.250	0.125								
14	0.875	0.375	0.312	0.187	0.062	0.062						
15	0.937	0.438	0.375	0.250	0.125	0.125	0.062					
16	1.000	0.500	0.438	0.312	0.187	0.187	0.125	0.062				
17	1.062	0.562	0.500	0.375	0.125	0.125	0.187	0.125				
18	1.125	0.625	0.562	0.438	0.312	0.312	0.250	0.187	0.062			
19	1.187	0.687	0.625	0.500	0.375	0.375	0.312	0.250	0.125			
20	1.250	0.750	0.687	0.562	0.438	0.438	0.375	0.312	0.187	0.062		
21	1.312	0.812	0.750	0.625	0.500	0.500	0.438	0.375	0.250	0.125		
22	1.375	0.875	0.812	0.687	0.562	0.562	0.500	0.438	0.312	0.187	0.062	
23	1.438	0.937	0.875	0.750	0.625	0.625	0.562	0.500	0.375	0.250	0.062	
24	1.500	1.000	0.937	0.812	0.687	0.687	0.625	0.562	0.438	0.312	0.187	
25	1.562	1.062	1.000	0.875	0.750	0.750	0.687	0.625	0.500	0.375	0.250	0.062
26	1.625	1.125	1.062	0.937	0.812	0.812	0.750	0.687	0.562	0.438	0.312	0.125
27	1.687	1.187	1.125	1.000	0.875	0.875	0.812	0.750	0.625	0.500	0.375	0.187
28	1.750	1.250	1.187	1.062	0.937	0.937	0.875	0.812	0.687	0.562	0.438	0.250
29	1.812	1.312	1.250	1.125	1.000	1.000	0.937	0.875	0.750	0.625	0.500	0.312
30	1.875	1.375	1.312	1.187	1.062	1.062	1.000	0.937	0.812	0.687	0.562	0.375
31	1.937	1.438	1.375	1.250	1.125	1.125	1.062	1.000	0.875	0.750	0.625	0.438
32	2.000	1.500	1.438	1.312	1.187	1.187	1.125	1.062	0.937	0.812	0.687	0.500
33	2.062	1.562	1.500	1.375	1.250	1.250	1.187	1.125	1.000	0.875	0.750	0.562
34	2.125	1.625	1.562	1.438	1.312	1.312	1.250	1.187	1.062	0.937	0.812	0.625
35	2.187	1.687	1.625	1.500	1.375	1.375	1.312	1.250	1.125	1.000	0.875	0.687
36	2.250	1.750	1.687	1.562	1.438	1.438	1.375	1.312	1.187	1.062	0.937	0.750
37	2.312	1.812	1.750	1.625	1.500	1.500	1.438	1.375	1.250	1.125	1.000	0.812
38	2.375	1.875	1.812	1.687	1.562	1.562	1.500	1.438	1.312	1.187	1.062	0.875

Figure 6-14 (Sheet 3 of 6) Bolt, Internal Wrenching (NAS144 to NAS158)

Dash No.	Length All Sizes	Grip Length										
		1/4 -28	5/16 -24	3/8 -24	7/16 -20	1/2 -20	9/16 -18	5/8 -18	3/4 -16	7/8 -14	1 -14	1-1/3 -12
39	2.438	1.937	1.875	1.750	1.625	1.625	1.562	1.500	1.375	1.250	1.125	0.937
40	2.500	2.000	1.937	1.812	1.687	1.687	1.625	1.562	1.438	1.312	1.187	1.000
41	2.562	2.062	2.000	1.875	1.750	1.750	1.687	1.625	1.500	1.375	1.250	1.062
42	2.625	2.125	2.062	1.937	1.812	1.812	1.750	1.687	1.562	1.438	1.312	1.125
43	2.687	2.187	2.125	2.000	1.875	1.875	1.812	1.750	1.625	1.500	1.375	1.187
44	2.750	2.250	2.187	2.062	1.937	1.937	1.875	1.812	1.687	1.562	1.438	1.250
45	2.812	2.312	2.250	2.125	2.000	2.000	1.937	1.875	1.750	1.625	1.500	1.312
46	2.875	2.375	2.312	2.187	2.062	2.062	2.000	1.937	1.812	1.687	1.562	1.375
47	2.937	2.438	2.375	2.250	2.125	2.125	2.062	2.000	1.875	1.750	1.625	1.438
48	3.000	2.500	2.438	2.312	2.187	2.187	2.125	2.062	1.937	1.812	1.687	1.500
49	3.062	2.562	2.500	2.375	2.250	2.250	2.187	2.125	2.000	1.875	1.750	1.562
50	3.125	2.625	2.562	2.438	2.312	2.312	2.250	2.187	2.062	1.937	1.812	1.625
51	3.187	2.687	2.625	2.500	2.375	2.375	2.312	2.250	2.125	2.000	1.875	1.687
52	3.250	2.750	2.687	2.562	2.438	2.438	2.375	2.312	2.187	2.062	1.937	1.750
53	3.312	2.812	2.750	2.625	2.500	2.500	2.438	2.375	2.250	2.125	2.000	1.812
54	3.375	2.875	2.812	2.687	2.562	2.562	2.500	2.438	2.312	2.187	2.062	1.875
55	3.438	2.937	2.875	2.750	2.625	2.625	2.562	2.500	2.375	2.250	2.125	1.937
56	3.500	3.000	2.937	2.812	2.687	2.687	2.625	2.562	2.438	2.312	2.187	2.000
57	3.562	3.062	3.000	2.875	2.750	2.750	2.687	2.625	2.500	2.375	2.250	2.062
58	3.625	3.125	3.062	2.937	2.812	2.812	2.750	2.687	2.562	2.438	2.312	2.125
59	3.687	3.187	3.125	3.000	2.875	2.875	2.812	2.750	2.625	2.500	2.375	2.187
60	3.750	3.250	3.187	3.062	2.937	2.937	2.875	2.812	2.687	2.562	2.438	2.250
61	3.812	3.312	3.250	3.125	3.000	3.000	2.937	2.875	2.750	2.625	2.500	2.312
62	3.875	3.375	3.312	3.187	3.062	3.062	3.000	2.937	2.812	2.687	2.562	2.375
63	3.937	3.438	3.375	3.250	3.125	3.125	3.062	3.000	2.875	2.750	2.625	2.438
64	4.000	3.500	3.438	3.312	3.187	3.187	3.125	3.062	2.937	2.812	2.687	2.500
65	4.062	3.562	3.500	3.375	3.250	3.250	3.187	3.125	3.000	2.875	2.750	2.562
66	4.125	3.625	3.562	3.438	3.312	3.312	3.250	3.187	3.062	2.937	2.812	2.625
67	4.187	3.687	3.625	3.500	3.375	3.375	3.312	3.250	3.125	3.000	2.875	2.687
68	4.250	3.750	3.687	3.562	3.438	3.438	3.375	3.312	3.187	3.062	2.937	2.750

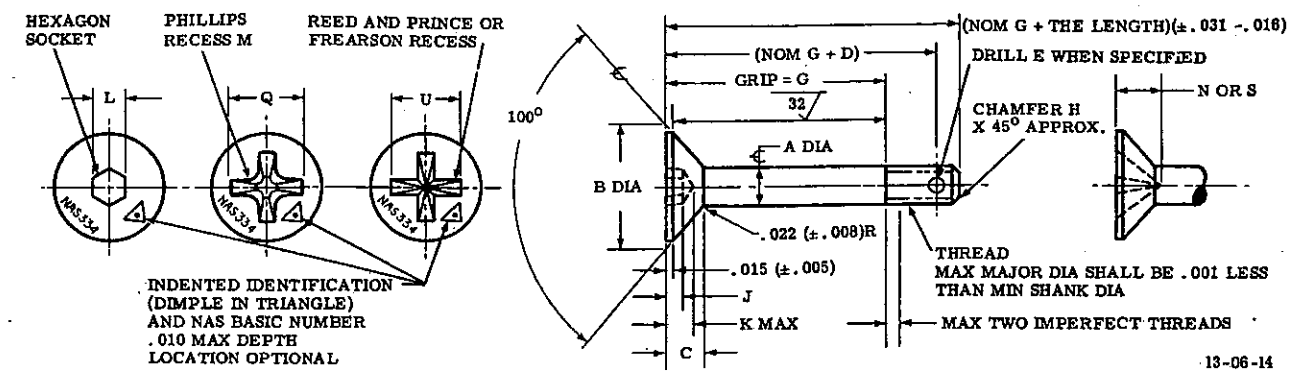
Figure 6-14 (Sheet 4 of 6) Bolt, Internal Wrenching (NAS144 to NAS158)

Dash No.	Length All Sizes	Grip Length 1/4 -28	5/16 -24	3/8 -24	7/16 -20	1/2 -20	9/16 -18	5/8 -18	3/4 -16	7/8 -14	1 -14	1-1/3 -12
69	4.312	3.812	3.750	3.625	3.500	3.500	3.438	3.375	3.250	3.125	3.000	2.812
70	4.375	3.875	3.812	3.687	3.562	3.562	3.500	3.438	3.312	3.187	3.062	2.875
71	4.438	3.937	3.875	3.750	3.625	3.625	3.562	3.500	3.375	3.250	3.125	2.937
72	4.500	4.000	3.937	3.812	3.687	3.687	3.625	3.562	3.438	3.312	3.187	3.000
73	4.562	4.062	4.000	3.875	3.750	3.750	3.687	3.625	3.500	3.375	3.250	3.062
74	4.625	4.125	4.062	3.937	3.812	3.812	3.750	3.687	3.562	3.438	3.312	3.125
75	4.687	4.187	4.125	4.000	3.875	3.875	3.812	3.750	3.625	3.500	3.375	3.187
76	4.750	4.250	4.187	4.062	3.937	3.937	3.875	3.812	3.687	3.562	3.438	3.250
77	4.812	4.312	4.250	4.125	4.000	4.000	3.937	3.875	3.750	3.625	3.500	3.312
78	4.875	4.375	4.312	4.187	4.062	4.062	4.000	3.937	3.812	3.687	3.562	3.375
79	4.937	4.438	4.375	4.250	4.125	4.125	4.062	4.000	3.875	3.750	3.625	3.438
80	5.000	4.500	4.438	4.312	4.187	4.187	4.125	4.062	3.937	3.812	3.687	3.500
81	5.062	4.562	4.500	4.375	4.250	4.250	4.187	4.125	4.000	3.875	3.750	3.562
82	5.125	4.625	4.562	4.438	4.312	4.312	4.250	4.187	4.062	3.937	3.812	3.625
83	5.187	4.687	4.625	4.500	4.375	4.375	4.312	4.250	4.125	4.000	3.875	3.687
84	5.250	4.750	4.687	4.562	4.438	4.438	4.375	4.312	4.187	4.062	3.937	3.750
85	5.312	4.812	4.750	4.625	4.500	4.500	4.438	4.375	4.250	4.125	4.000	3.812
86	5.375	4.875	4.812	4.687	4.562	4.562	4.500	4.438	4.312	4.187	4.062	3.875
87	5.438	4.937	4.875	4.750	4.625	4.625	4.562	4.500	4.375	4.250	4.125	3.937
88	5.500	5.000	4.937	4.812	4.687	4.687	4.625	4.562	4.438	4.312	4.187	4.000
89	5.562	5.062	5.000	4.875	4.750	4.750	4.687	4.625	4.500	4.375	4.250	4.062
90	5.625	5.125	5.062	4.937	4.812	4.812	4.750	4.687	4.562	4.438	4.312	4.125
91	5.687	5.187	5.125	5.000	4.875	4.875	4.812	4.750	4.625	4.500	4.375	4.187
92	5.750	5.250	5.187	5.062	4.937	4.937	4.875	4.812	4.687	4.562	4.438	4.250
93	5.812	5.312	5.250	5.125	5.000	5.000	4.937	4.875	4.750	4.625	4.500	4.312
94	5.875	5.375	5.312	5.187	5.062	5.062	5.000	4.937	4.812	4.687	4.562	4.375
95	5.937	5.438	5.375	5.250	5.125	5.125	5.062	5.000	4.875	4.750	4.625	4.438
96	6.000	5.500	5.438	5.312	5.187	5.187	5.125	5.062	4.937	4.812	4.687	4.500
97	6.062	5.562	5.500	5.375	5.250	5.250	5.187	5.125	5.000	4.875	4.750	4.562
98	6.125	5.625	5.562	5.438	5.312	5.312	5.250	5.187	5.062	4.937	4.812	4.625

Figure 6-14 (Sheet 5 of 6) Bolt, Internal Wrenching (NAS144 to NAS158)

Dash No.	Length All Sizes	Grip Length										
		1/4 -28	5/16 -24	3/8 -24	7/16 -20	1/2 -20	9/16 -18	5/8 -18	3/4 -16	7/8 -14	1 -14	1-1/3 -12
99	6.187	5.687	5.625	5.500	5.375	5.375	5.312	5.250	5.125	5.000	4.875	4.687
100	6.250	5.750	5.687	5.562	5.438	5.438	5.375	5.312	5.187	5.062	4.937	4.750
101	6.312	5.812	5.750	5.625	5.500	5.500	5.438	5.375	5.250	5.125	5.000	4.812
102	6.375	5.875	5.812	5.687	5.562	5.562	5.500	5.438	5.312	5.187	5.062	4.875
103	6.438	5.937	5.875	5.750	5.625	5.625	5.562	5.500	5.375	5.250	5.125	4.937
104	6.500	6.000	5.937	5.812	5.687	5.687	5.625	5.562	5.438	5.312	5.187	5.000
105	6.562	6.062	6.000	5.875	5.750	5.750	5.687	5.625	5.500	5.375	5.250	5.062
106	6.625	6.125	6.062	5.937	5.812	5.812	5.750	5.687	5.562	5.438	5.312	5.125
107	6.687	6.187	6.125	6.000	5.875	5.875	5.812	5.750	5.625	5.500	5.375	5.187
108	6.750	6.250	6.187	6.062	5.937	5.937	5.875	5.812	5.687	5.562	5.438	5.250
109	6.812	6.312	6.250	6.125	6.000	6.000	5.937	5.875	5.750	5.625	5.500	5.312
110	6.875	6.375	6.312	6.187	6.062	6.062	6.000	5.937	5.812	5.687	5.562	5.375
111	6.937	6.438	6.375	6.250	6.125	6.125	6.062	6.000	5.875	5.750	5.625	5.438
112	7.000	6.500	6.438	6.312	6.187	6.187	6.125	6.062	5.937	5.812	5.687	5.500
113	7.062	6.562	6.500	6.375	6.250	6.250	6.187	6.125	6.000	5.875	5.750	5.562
114	7.125	6.625	6.562	6.438	6.312	6.312	6.250	6.187	6.062	5.937	5.812	5.625
115	7.187	6.687	6.625	6.500	6.375	6.375	6.312	6.250	6.125	6.000	5.875	5.687
116	7.250	6.750	6.687	6.562	6.438	6.438	6.375	6.312	6.187	6.062	5.937	5.750
117	7.312	6.812	6.750	6.625	6.500	6.500	6.438	6.375	6.250	6.125	6.000	5.812
118	7.375	6.875	6.812	6.687	6.562	6.562	6.500	6.438	6.312	6.187	6.062	5.875
119	7.438	6.937	6.875	6.750	6.625	6.625	6.562	6.500	6.375	6.250	6.125	5.937
120	7.500	7.000	6.937	6.812	6.687	6.687	6.625	6.562	6.438	6.312	6.187	6.000
121	7.562	7.062	7.000	6.875	6.750	6.750	6.687	6.625	6.500	6.375	6.250	6.062
122	7.625	7.125	7.062	9.937	6.812	6.812	6.750	6.687	6.562	6.438	6.312	6.125
123	7.687	7.187	7.125	7.000	6.875	6.875	6.812	6.750	6.625	6.500	6.375	6.187
124	7.750	7.250	7.187	7.062	6.937	6.937	6.875	6.812	6.687	6.562	6.438	6.250
125	7.812	7.312	7.250	7.125	7.000	7.000	6.937	6.875	6.750	6.625	6.500	6.312
126	2.875	7.375	7.312	7.187	7.062	7.062	7.000	6.937	6.812	6.687	6.562	6.375
127	7.937	7.438	7.375	7.250	7.125	7.125	7.062	7.000	6.875	6.750	6.625	6.438
128	8.000	7.500	7.438	7.312	7.187	7.187	7.125	7.062	6.937	6.812	6.687	6.500

Figure 6-14 (Sheet 6 of 6) Bolt, Internal Wrenching (NAS144 to NAS158)



Basic No. NAS	Thread Class 3A (UNF)	Thread Length	A Dia.	B Dia.	C Head Height (Ref)	D	E	H
333	10-32	.406	.1894 .1889	.385 .376	.080	.267	No.50(.070)	.031
334	.250-28	.469	.2492 .2487	.507 .497	.106	.312	No.48(.076)	.031
335	.312-24	.531	.3117 .3112	.635 .625	.133	.359	No.48(.076)	.047
336	.375-24	.641	.3742 .3737	.762 .752	.160	.438	No.36(.106)	.047
337	.438-20	.656	.4367 .4362	.890 .880	.188	.484	No.36(.106)	.047
338	.500-20	.781	.4991 .4986	1.017 1.007	.215	.609	No.36(.106)	.047
339	.562-18	.906	.5616 .5611	1.145 1.135	.242	.656	No.28(.141)	.062
340	.625-18	.953	.6240 .6234	1.272 1.262	.270	.734	No.28(.141)	.062

Basic No. NAS	J Hex Socket Depth	K Hex Depth Max.	L Hex Socket Width	M Phillips Recess	N Phillips Recess Depth	Q Phillips Recess Width	S Frearson Recess Depth	U Frearson Recess Width	Double Shear Strength Min. (lbs)
333				No.2	.113 .103	.181 .171	.156 .146	.244 .231	
334	.063	.095	.1592 .1572	No.3	.132 .122	.244 .234	.180 .170	.325 .307	9,300
335	.078	.110	.1905 .1885	No.4	.165 .155	.314 .304	.253 .243	.406 .382	14,600
336	.094	.140	.2217 .2197	No.4	.190 .180	.339 .329	.302 .292	.485 .457	21,000
337	.094	.155	.3165 .3135	No.4	.215 .205	.363 .353	.346 .336	.552 .524	28,600
338	.094	.162	.3790 .3760	No.4	.243 .233	.391 .381	.379 .369	.578 .564	37,300
339	.094	.164	.3790 .3760	No.4	.273 .263	.421 .411	.439 .429	.673 .659	47,200
340	.094	.182	.5040 .5010						

Figure 6-15 (Sheet 1 of 4)
Bolt, Close Tolerance High Strength Countersunk (NAS333 to NAS340)

Material:
MIL-S-6098 (SAE 8735), MIL-S-6049 (SAE 8740), MIL-S-8503 (SAE 6150), AN-QQ-S-690 (SAE 3140), MIL-S-5626 (SAE 4140), MIL-S-5000 (SAE 4340), AN-S-9 (SAE 4037) (Diameters 7/16 and smaller).

Finish:
Land, Head Flat and Threads, cadmium plate.

Hardness:
Rockwell C-36 to C-40, taken on end of the bolt, prior to plating.

Code:
Add -5 after last dash number to designate bolt with grip and length .062 longer than designated by length dash number alone.

Add C to basic part number to designate bolt with cadmium plated shank.
Add P after basic part number to designate bolt with Phillips recess.
Add F after basic part number to designate bolt with Frearson recess. No letter indicates hexagon socket.
Add A after basic part number to designate bolt without cotter pin hole.

Example of Part Nos:
NAS334-10 = 1/4-28 steel bolt, .562 grip, unplated shank, hexagon socket, with cotter pin hole.
NAS334CPA24 = 1/4-28 steel bolt, 2.062 grip, plated shank, Phillips recess, without cotter pin hole.
NAS334CFA24 = 1/4-28 steel bolt, 2.062 grip, plated shank, Frearson recess, without cotter pin hole.
NAS334CA24-5 = 1/4-28 steel bolt, 2.124 grip, (-5 indicates .062 over tabulated -24 grip and length), plated shank, hexagon socket, without cotter pin hole.

Notes:
1. All diameters marked ∈ to be concentric within .003 total indicator reading.

2. Dimensions A and thread pitch diameter shall be concentric with each other within the following total indicator reading values, .0045 for sizes No.10 to 3/8, .0060 for sizes 7/16 to 5/8.

3. Dia. B is taken to theoretical sharp edge of head.

4. √ surface roughness per NAS30. See Part 20, following.

5. Hexagonal socket in head is for holding bolt when installing nut. It is not intended to be used for tightening. To torque from head side use recessed head bolts.

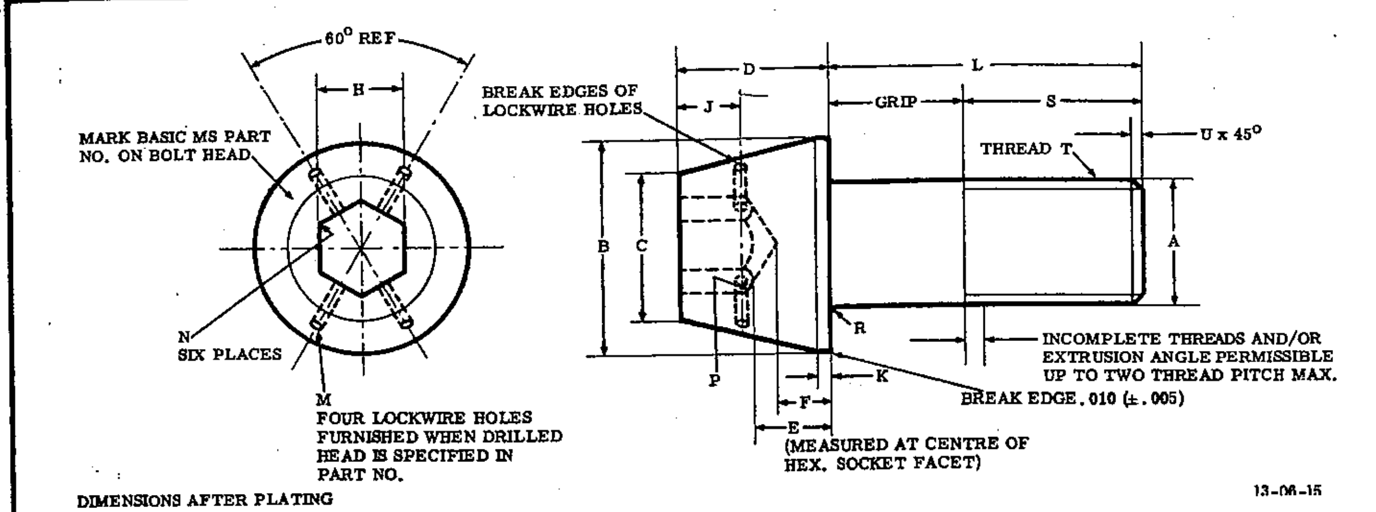
Figure 6-15 (Sheet 2 of 4)
Bolt, Close Tolerance High Strength Countersunk (NAS333 to NAS340)

Dash No.	Grip Length							
	NAS333	NAS334	NAS335	NAS336	NAS337	NAS338	NAS339	NAS340
4	.125							
5	.250	.188	.188					
6	.375	.312	.312	.188				
7	.500	.438	.438	.312	.312			
10	.625	.562	.562	.438	.438	.312	.250	
11	.750	.688	.688	.562	.562	.438	.375	.312
12	.875	.812	.812	.688	.688	.562	.500	.438
13	1.000	.938	.938	.812	.812	.688	.625	.562
14	1.125	1.062	1.062	.938	.938	.812	.750	.688
15	1.250	1.188	1.188	1.062	1.062	.938	.875	.812
16	1.375	1.312	1.312	1.188	1.188	1.062	1.000	.938
17	1.500	1.438	1.438	1.312	1.312	1.188	1.125	1.062
20	1.625	1.562	1.562	1.438	1.438	1.312	1.250	1.188
21	1.750	1.688	1.688	1.562	1.562	1.438	1.375	1.312
22	1.875	1.812	1.812	1.688	1.688	1.562	1.500	1.438
23	2.000	1.938	1.938	1.812	1.812	1.688	1.625	1.562
24	2.125	2.062	2.062	1.938	1.938	1.812	1.750	1.688
25	2.250	2.188	2.188	2.062	2.062	1.938	1.875	1.812
26	2.375	2.312	2.312	2.188	2.188	2.062	2.000	1.938
27	2.500	2.438	2.438	2.312	2.312	2.188	2.125	2.062
30	2.625	2.562	2.562	2.438	2.438	2.312	2.250	2.188
31	2.750	2.688	2.688	2.562	2.562	2.438	2.375	2.312
32	2.875	2.812	2.812	2.688	2.688	2.562	2.500	2.438
33	3.000	2.938	2.938	2.812	2.812	2.688	2.625	2.562
34	3.125	3.062	3.062	2.938	2.938	2.812	2.750	2.688
35	3.250	3.188	3.188	3.062	3.062	2.938	2.875	2.812
36	3.375	3.312	3.312	3.188	3.188	3.062	3.000	2.938
37	3.500	3.438	3.438	3.312	3.312	3.188	3.125	3.062
40	3.625	3.562	3.562	3.438	3.438	3.312	3.250	3.188
41	3.750	3.688	3.688	3.562	3.562	3.438	3.375	3.312
42	3.875	3.812	3.812	3.688	3.688	3.562	3.500	3.438

Figure 6-15 (Sheet 3 of 4)
Bolt, Close Tolerance High Strength Countersunk (NAS333 to NAS340)

Dash No.	Grip Length							
	NAS333	NAS334	NAS335	NAS336	NAS337	NAS338	NAS339	NAS340
43	4.000	3.938	3.938	3.812	3.812	3.688	3.625	3.562
44	4.125	4.062	4.062	3.938	3.938	3.812	3.750	3.688
45	4.250	4.188	4.188	4.062	4.062	3.938	3.875	3.812
46	4.375	4.312	4.312	4.188	4.188	4.062	4.000	3.938
47	4.500	4.438	4.438	4.312	4.312	4.188	4.125	4.062
50	4.625	4.562	4.562	4.438	4.438	4.312	4.250	4.188
51	4.750	4.688	4.688	4.562	4.562	4.438	4.375	4.312
52	4.875	4.812	4.812	4.688	4.688	4.562	4.500	4.438
53	5.000	4.938	4.938	4.812	4.812	4.688	4.625	4.562
54	5.125	5.062	5.062	4.938	4.938	4.812	4.750	4.688
55	5.250	5.188	5.188	5.062	5.062	4.938	4.875	4.812
56	5.375	5.312	5.312	5.188	5.188	5.062	5.000	4.938
57	5.500	5.438	5.438	5.312	5.312	5.188	5.125	5.062
60	5.625	5.562	5.562	5.438	5.438	5.312	5.250	5.188
61	5.750	5.688	5.688	5.562	5.562	5.438	5.375	5.312
62	5.875	5.812	5.812	5.688	5.688	5.562	5.500	5.438
63	6.000	5.938	5.938	5.812	5.812	5.688	5.625	5.562
64	6.125	6.062	6.062	5.938	5.938	5.812	5.750	5.688
65	6.250	6.188	6.188	6.062	6.062	5.938	5.875	5.812
66	6.375	6.312	6.312	6.188	6.188	6.062	6.000	5.938
67	6.500	6.438	6.438	6.312	6.312	6.188	6.125	6.062
70	6.625	6.562	6.562	6.438	6.438	6.312	6.250	6.188
71	6.750	6.688	6.688	6.562	6.562	6.438	6.375	6.312
72	6.875	6.812	6.812	6.688	6.688	6.562	6.500	6.438
73	7.000	6.938	6.938	6.812	6.812	6.688	6.625	6.562
74	7.125	7.062	7.062	6.938	6.938	6.812	6.750	6.688
75	7.250	7.188	7.188	7.062	7.062	6.938	6.875	6.812
76	7.375	7.312	7.312	7.188	7.188	7.062	7.000	6.938
77	7.500	7.438	7.438	7.312	7.312	7.188	7.125	7.062
80	7.625	7.562	7.562	7.438	7.438	7.312	7.250	7.188

Figure 6-15 (Sheet 4 to 4)
Bolt, Close Tolerance High Strength Countersunk (NAS333 to NAS340)



Basic MS Part No	Thread MS20016 1-14NF-3A All others UNF-3A	A Dia.	B Dia.	C Dia.	D	E	F Min.	H	J	K	M +.005 -.000 Dia.
20004	1/4-28	.2492 .2477	.438 .428	.342	.250	.112	.068	.1900 .1880	.078	.063	.037
20005	5/16-24	.3117 .3102	.531 .521	.394	.312	.144	.094	.2210 .2190	.094	.063	.055
20006	3/8-24	.3742 .3727	.649 .639	.520	.375	.183	.116	.3150 .3130	.125	.063	.055
20007	7/16-20	.4367 .5347	.750 .740	.534	.438	.208	.141	.3150 .3130	.156	.063	.055
20008	1/2-20	.4991 .4971	.828 .818	.625	.500	.247	.169	.3785 .3755	.172	.063	.055
20009	9/16-18	.5616 .5596	.938 .928	.723	.562	.279	.190	.4410 .4380	.203	.094	.055
20010	5/8-18	.6240 .6228	1.050 1.040	.826	.625	.317	.216	.5035 .5005	.234	.094	.055
20012	3/4-16	.7488 .7468	1.230 1.220	.921	.750	.385	.273	.5660 .5630	.281	.094	.055
20014	7/8-14	.8737 .8707	1.438 1.428	1.083	.875	.450	.327	.6295 .6257	.344	.094	.055
20016	1 -14	.9985 .9955	1.625 1.615	1.249	1.000	.527	.381	.7547 .7507	.391	.094	.055
20018	1-1/8-12	1.124 1.121	1.875 1.865	1.275	1.125	.589	.443	.7549 .7509	.453	.094	.055
20020	1-1/4-12	1.249 1.246	2.125 2.115	1.598	1.250	.667	.475	1.005 1.001	.500	.125	.055
20022	1-3/8-12	1.374 1.370	2.313 2.303	1.768	1.375	.746	.531	1.131 1.126	.547	.125	.055
20024	1-1/2-12	1.499 1.495	2.500 2.490	1.931	1.500	.823	.586	1.256 1.251	.594	.156	.055

Figure 6-16 (Sheet 1 of 6) Bolt, Internal Wrenching 160,000 psi (MS20004 to MS20024)

Material: MIL-S-5000 Steel (SAE 4340), MIL-S-5625 Steel (SAE 4140), MIL-S-6049 Steel (SAE 8740), MIL-S-6098 Steel (SAE 8735), AN-QQ-S-687 Steel (SAE 6150) AN-QQ-S-690 Steel (SAE 3140).
Finish: Cadmium Plate.
Heat Treat: See mechanical properties.
Hardness: Rockwell C-36 to C-40 inclusive.
Dimensions A, B and C shall be concentric to each other within values specified for X total indicator reading. Dimensions H and C shall be concentric to each other within values specified for Y total indicator reading. Dimensions A and thread pitch diameter shall be concentric to each other within values specified for Z total indicator reading.

Examples of Part Nos:
MS20004-8 = 1/4-28 bolt, 1.000 inch long, .500 inch grip, undrilled head. MS20004H8 = 1/4-28 bolt, 1.000 inch long, .500 inch grip, drilled head. MS20004-9 = 1/4-29 bolt, 1.062 inch long, .562 inch grip, undrilled head. MS20004H9 = 1/4-28 bolt, 1.062 inch long, .562 inch grip, drilled head.

1. Stress areas used for the calculation of ultimate tensile load values are based on pitch diameter of external thread.
2. The formula used in the calculation of the double shear strengths is as follows:
   Double Shear Strength = SA
   where: S = 160,000 x 2 x 60%.
   A = Cross-sectional area of the bolt shank at full diameter.

Basic MS Part No	Thread MS20016 1-14NF-3A All others UNF-3A	N Max. Rad	P Rad	R Rad	S Ref	U (±.016)	Concentricity			1 Ultimate Tensile Load	2 Double Shear Strength
							X	Y	Z	Lbs. Min.	
20004	1/4-28	.010	.020 .010	.041 .031	.500	.031	.005	.007	.0045	6,190	9,300
20005	5/16-24	.010	.020 .010	.041 .031	.562	.047	.006	.008	.0045	9,820	14,600
20006	3/8-24	.011	.020 .010	.057 .047	.688	.047	.008	.010	.0045	15,200	21,000
20007	7/16-20	.011	.020 .010	.057 .047	.812	.047	.009	.011	.006	20,600	28,600
20008	1/2-20	.011	.020 .010	.057 .047	.812	.047	.010	.012	.006	27,400	37,300
20009	9/16-18	.011	.020 .010	.057 .047	.875	.062	.011	.014	.006	34,800	47,200
20010	5/8-18	.019	.020 .010	.073 .063	.938	.062	.012	.016	.006	43,600	58,300
20012	3/4-16	.022	.030 .015	.073 .063	1.062	.062	.015	.018	.006	63,200	83,900
20014	7/8-14	.022	.030 .015	.073 .063	1.188	.078	.018	.022	.009	86,100	114,200
20016	1 -14	.022	.030 .015	.073 .063	1.312	.078	.020	.025	.009	114,000	149,200
20018	1-1/8-12	.022	.030 .015	.073 .063	1.500	.094	.022	.026	.009	144,000	188,900
20020	1-1/4-12	.022	.030 .015	.089 .077	1.625	.094	.025	.032	.009	180,000	233,200
20022	1-3/8-12	.022	.030 .015	.089 .077	1.750	.094	.028	.035	.012	219,000	282,100
20024	1-1/2-12	.022	.030 .015	.089 .077	1.875	.094	.030	.039	.012	263,000	335,800

Figure 6-16 (Sheet 2 of 6) Bolt, Internal Wrenching 160,000 psi (MS20004 to MS20024)

Dash No.	Grip (±.010)	Grip Length (±.015)						
		MS20004	MS20005	MS20006	MS20007	MS20008	MS20009	MS20010
		1/4	5/16	3/8	7/16	1/2	9/16	5/8
4	.250	.750						
6	.375	.875	.938	1.062				
8	.500	1.000	1.062	1.188	1.312	1.312		
10	.625	1.125	1.188	1.312	1.438	1.438	1.500	1.562
12	.750	1.250	1.312	1.438	1.562	1.562	1.625	1.688
14	.875	1.375	1.438	1.562	1.688	1.688	1.750	1.812
16	1.000	1.500	1.562	1.688	1.812	1.812	1.875	1.938
18	1.125	1.625	1.688	1.812	1.938	1.938	2.000	2.062
20	1.250	1.750	1.812	1.938	2.062	2.062	2.125	2.188
22	1.375	1.875	1.938	2.062	2.188	2.188	2.250	2.312
24	1.500	2.000	2.062	2.188	2.312	2.312	2.375	2.438
26	1.625	2.125	2.188	2.312	2.438	2.438	2.500	2.562
28	1.750	2.250	2.312	2.438	2.562	2.562	2.625	2.688
30	1.857	2.357	2.438	2.562	2.688	2.688	2.750	2.812
32	2.000	2.500	2.562	2.688	2.812	2.812	2.875	2.938
34	2.125	2.625	2.688	2.812	2.938	2.938	3.000	3.062
36	2.250	2.750	2.812	2.938	3.062	3.062	3.125	3.188
38	2.375	2.875	2.938	3.062	3.188	3.188	2.250	3.312
40	2.500	3.000	3.062	3.188	3.312	3.312	3.375	3.438
42	2.625	3.125	3.188	3.312	3.438	3.438	3.500	3.562
44	2.750	3.250	3.312	3.438	3.562	3.562	3.625	3.688
46	2.875	3.375	3.438	3.562	3.688	3.688	3.750	3.812
48	3.000	3.500	3.562	3.688	3.812	3.812	3.875	3.938
50	3.125	3.625	3.688	3.812	3.938	3.938	4.000	4.062
52	3.250	3.750	3.812	3.938	4.062	4.062	4.125	4.188
54	3.375	3.875	3.938	4.062	4.188	4.188	4.250	4.312
56	3.500	4.000	4.062	4.188	4.312	4.312	4.375	4.438
58	3.625	4.125	4.188	4.312	4.438	4.438	4.500	4.562
60	3.750	4.250	4.312	4.438	4.562	4.562	4.625	4.688
62	3.875	4.375	4.438	4.562	4.688	4.688	4.750	4.812
64	4.000	4.500	4.562	4.688	4.812	4.812	4.875	4.938
66	4.125	4.625	4.688	4.812	4.938	4.938	5.000	5.062

Figure 6-16 (Sheet 3 of 6) Bolt, Internal Wrenching 160, 000 psi (MS20004 to MS20024)

Dash No.	Grip (±.010)	Grip Length (±.015)						
		MS20012	MS20014	MS20016	MS20018	MS20020	MS20022	MS20024
		3/4	7/8	1	1-1/8	1-1/4	1-3/8	4-1/2
4	.250							
6	.375							
8	.500							
10	.625							
12	.750	1.812						
14	.875	1.938	2.062					
16	1.000	2.062	2.188	2.312				
18	1.125	2.188	2.312	2.438	2.625			
20	1.250	2.312	2.438	2.562	2.750	2.875		
22	1.375	2.438	2.562	2.688	2.875	3.000	3.125	
24	1.500	2.562	2.688	2.812	3.000	3.125	3.250	3.375
26	1.625	2.688	2.812	2.938	3.125	3.250	3.375	3.500
28	1.750	2.812	2.938	3.062	3.250	3.375	3.500	1.625
30	1.875	2.938	3.062	2.188	3.375	3.500	3.625	3.750
32	2.000	3.062	3.188	3.312	3.500	3.625	3.750	3.875
34	2.125	3.188	3.312	3.438	3.625	3.750	3.875	4.000
36	2.250	3.312	3.438	3.562	3.750	3.875	4.000	4.125
38	2.375	3.438	3.562	3.688	3.875	4.000	4.125	4.250
40	2.500	3.562	3.688	3.812	4.000	4.125	4.250	4.375
42	2.625	3.688	3.812	3.938	4.125	4.250	4.375	4.500
44	2.750	3.812	3.938	4.062	4.250	4.375	4.500	4.625
46	2.875	3.938	4.062	4.188	4.375	4.500	4.625	4.750
48	3.000	4.062	4.188	4.312	4.500	4.625	4.750	4.875
50	3.125	4.188	4.312	4.438	4.625	4.750	4.875	5.000
52	3.250	4.312	4.438	4.562	4.750	4.875	5.000	5.125
54	3.375	4.438	4.562	4.688	4.875	5.000	5.125	5.250
56	3.500	4.562	4.688	4.812	5.000	5.125	5.250	5.375
58	3.625	4.688	4.812	4.938	5.125	5.250	5.375	5.500
60	3.750	4.812	4.938	5.062	5.250	5.375	5.500	5.625
62	3.875	4.938	5.062	5.188	5.375	5.500	5.625	5.750
64	4.000	5.062	5.188	5.312	5.500	5.625	5.750	5.875
66	4.125	5.188	5.312	5.438	5.625	5.750	5.875	6.000

For intermediate dash numbers see note on Sheet 5 of 6

Figure 6-16 (Sheet 4 of 6) Bolt, Internal Wrenching 160,000 psi (MS20004 to MS20024)

Dash No.	Grip (±.010)	Grip Length (±.015)						
		MS20004	MS20005	MS20006	MS20007	MS20008	MS20009	MS20010
		1/4	5/16	3/8	7/16	1/2	9/16	5/8
68	4.250	4.750	4.812	4.938	5.062	5.062	5.125	5.188
70	4.375	4.875	4.938	5.062	5.188	5.188	5.250	5.312
72	4.500	5.000	5.062	5.188	5.312	5.312	5.375	5.438
74	4.625	5.125	5.188	5.312	5.438	5.438	5.500	5.562
76	4.750	5.250	5.312	5.438	5.562	5.562	5.625	5.688
78	4.875	5.375	5.438	5.562	5.688	5.688	5.750	5.812
80	5.000	5.500	5.562	5.688	5.812	5.812	5.875	5.938
82	5.125	5.625	5.688	5.812	5.938	5.938	6.000	6.062
84	5.250	5.750	5.812	5.938	6.062	6.062	6.125	6.188
86	5.375	5.875	5.938	6.062	6.188	6.188	6.250	6.312
88	5.500	6.000	6.062	6.188	6.312	6.312	6.375	6.438
90	5.625	6.125	6.188	6.312	6.438	6.438	6.500	6.562
92	5.750	6.250	6.312	6.438	6.562	6.562	6.625	6.688
94	5.875	6.375	6.438	6.562	6.688	6.688	6.750	6.812
96	6.000	6.500	6.562	6.688	6.812	6.812	6.875	6.938
98	6.125						7.000	7.062
100	6.250						7.125	7.188
102	6.375						7.250	7.312
104	6.500						7.375	7.438
106	6.625						7.500	7.562
108	6.750						7.625	7.688
110	6.875						7.750	7.812
112	7.000						7.875	7.938
114	7.125							
116	7.250							
118	7.375							
120	7.500							
122	7.625							
124	7.750							
126	7.875							
128	8.000							

NOTE

Dash numbers indicate preferred grip lengths in .125 inch increments. Grip lengths in addition to those tabulated are available in .125 inch increments by the use of significant dash numbers. Intermediate grip lengths in .062 inch increments may be obtained by specifying intermediate dash numbers. Length and grip of a bolt with an odd number for the dash number will be .062 inch greater than shown for the bolt with the preceding even dash number.

Figure 6-16 (Sheet 5 of 6) Bolt, Internal Wrenching 160,000 psi (MS20004 to MS20024)

Dash No.	Grip (±.010)	Grip Length (±.015)						
		MS20012	MS20014	MS20016	MS20018	MS20020	MS20022	MS20024
		3/4	7/8	1	1-1/8	1-1/4	1-3/8	4-1/2
68	4.250	5.312	5.438	5.562	5.750	5.875	6.000	6.125
70	4.375	5.438	5.562	5.688	5.875	6.000	6.125	6.250
72	4.500	5.562	5.688	5.812	6.000	6.125	6.250	6.375
74	4.625	5.688	5.812	5.938	6.125	6.250	6.375	6.500
76	4.750	5.812	5.938	6.062	6.250	6.375	6.500	6.625
78	4.875	5.938	6.062	6.188	6.375	6.500	6.625	6.750
80	5.000	6.062	6.188	6.312	6.500	6.625	6.750	6.875
82	5.125	6.188	6.312	6.438	6.625	6.750	6.875	7.000
84	5.250	6.312	6.438	6.562	6.750	6.875	7.000	7.125
86	5.375	6.438	6.562	6.688	6.875	7.000	7.125	7.250
88	5.500	6.562	6.688	6.812	7.000	7.125	7.250	7.375
90	5.625	6.688	6.812	6.938	7.125	7.250	7.375	7.500
92	5.750	6.812	6.938	7.062	7.250	7.375	7.500	7.625
94	5.875	6.938	7.062	7.188	7.375	7.500	7.625	7.750
96	6.000	7.062	7.188	7.312	7.500	7.625	7.750	7.875
98	6.125	7.188	7.312	7.438	7.625	7.750	7.875	8.000
100	6.250	7.312	7.438	7.562	7.750	7.875	8.000	8.125
102	6.375	7.438	7.562	7.688	7.875	8.000	8.125	8.250
104	6.500	7.562	7.688	7.812	8.000	8.125	8.250	8.375
106	6.625	7.688	7.812	7.938	8.125	8.250	8.375	8.500
108	6.750	7.812	7.938	8.062	8.250	8.375	8.500	8.625
110	6.875	7.938	8.062	8.188	8.375	8.500	8.625	8.750
112	7.000	8.062	8.188	8.312	8.500	8.625	8.750	8.875
114	7.125				8.625	8.750	8.875	9.000
116	7.250				8.750	8.875	9.000	9.125
118	7.375				8.875	9.000	9.125	9.250
120	7.500				9.000	9.125	9.250	9.375
122	7.625				9.125	9.250	9.375	9.500
124	7.750				9.250	9.375	9.500	9.625
126	7.875				9.375	9.500	9.625	9.750
128	8.000				9.500	9.625	9.750	9.875

Figure 6-16 (Sheet 6 of 6) Bolt, Internal Wrenching 160,000 psi (MS20004 to MS20024)

(AN42 to AN49) Bolt, Eye

Material and properties the same as AN3 series, but not made in aluminum alloy. Grip, length and Part No. Coding similar to AN3 series.

Grip Length: 1/16 inch to 8-1/16 inches.

Part No.	Bolt Dia.	Pin Size	Corresponding to
AN42B	No. 10	3/16	AN3
AN43B	1/4	3/16	AN4
AN44	5/16	1/4	AN5
AN45	5/16	5/16	AN5
AN46	3/8	3/8	AN6
AN47	7/16	3/8	AN7
AN48	1/2	7/16	AN8
AN49	9/16	1/2	AN9

Part No. Coding: AN46-10 = 3/8-24, 7/16 inch grip, drilled hole in shank, non-corrosion-resistant steel.

AN46-C10 = 3/8-24, 7/16 inch grip, drilled hole in shank, corrosion-resistant steel.

AN49-C10A = 9/16-18, 9/16 inch grip, no hole in shank, corrosion-resistant steel.

(AN73 to AN81) Bolt, Drilled Head

Material: Steel only. Properties the same as AN3 series.

Size Range: 10-32 to 3/4-16.

Fine thread: AN73, AN74, AN75, AN76, AN77B, AN78, AN79, AN80B, AN81B.

Coarse thread: AN73A, AN74A, AN75A, AN76A, AN77H, AN78A, AN79A, AN80H, AN81H.

Grip Length: 1/16 inch to 5-1/2 inches.

Part No. Coding: AN75-6 = 5/16-24, 1/4 inch grip.

AN75A-6 = 5/16-18, 1/4 inch grip.

AN79-24 = 9/16-15, 1-11/16 grip.

Figure 6-17 (Sheet 1 of 3) Bolt Specifications

(NAS172, NAS174, NAS176) Bolt, Internal Wrenching

Material and properties the same as NAS144.

Size Range: NAS172 1-1/4 inch, NAS174 1-3/8 inch, NAS176 1-1/2 inch. All threads UNF-3A, 12 per inch.

Grip Length: NAS172, 1/8 inch (Dash No.28) to 6-3/8 inches (Dash No.128)
NAS174, 1/8 inch (Dash No.30) to 6-1/4 inches (Dash No.128)
NAS176, 1/8 inch (Dash No.32) to 6-1/8 inches (Dash No.128)

Part No. Coding: NAS172DH32 = 1-1/4 - 12, drilled head bolt, 2 inches long, 3/8 inch grip.
NAS174-63 = 1-3/8 - 12, undrilled head bolt, 3-15/16 inches long, 2-3/16 inch grip.

(NAS464) Bolt, Shear, Close Tolerance

Material: Steel, properties the same as NAS333 to NAS340 series.

Size Range: 10-32 (Dash No.3) to 1-14 (Dash No.16)

Grip Length: 3/16 inch (Second Dash No.3) to 6-3/8 inches (Second Dash No.102)

Part No. Coding: NAS464-3-12 = 10-32, bolt with cotter-pin hole, 3/4 inch grip.
NAS464P4-15 = 1/4-28, bolt with cotter-pin hole, plated shank, 15/16 inch grip.
NAS464-12A18 = 3/4-16, bolt without cotter-pin hole, unplated shank, 1-1/8 inch grip.
NAS464P14A51 = 7/8-14, bolt without cotter-pin hole, plated shank, 3-3/16 inch grip.

(NAS495) Bolt, Internal Wrenching

Material: Alloy steel, cadmium plated. Properties the same as NAS333 to NAS340 series.

Size Range: 1/4-28 (Dash No.4) to 1-1/2-12 (Dash No.24)

Grip Length: 1/4 inch (Second Dash No.4) to 8 inches (Second Dash No. 128) (Increments in 1/8 inch for even dash Nos.)

Part No. Coding: NAS495H8-13 = 1/2-20, bolt with drilled head, 13/16 inch grip.
NAS495-4-8 = 1/4-28, bolt with undrilled head, 1/2 inch grip.

Figure 6-17 (Sheet 2 of 3) Bolt Specifications

(NAS501) Bolt, Stabilized, Non-magnetic

Material: Corrosion resistant steel.

Size Range: 10-32 (Dash No.3) to 1-1/4 - 12 (Dash No.20)

Grip Length: 1/16 inch to 8-3/16 inches.

Part No. Coding: NAS501-3-10A= 10-32, bolt undrilled, 5/8 inch grip.
NAS501-4H14A= 1/4-28 bolt with head only drilled, 1-1/16 inch grip.
NAS501-20-24 = 1-1/4-12 bolt with shank only drilled, 1 inch grip.

(NAS467) Bolt, Brass, Hex Head

Material: Brass, tin plated.

Size Range: NAS467-4, 1/4-28; NAS467-5, 5/16-24; NAS467-6, 3/8-24; NAS467-8, 1/2-20;

Grip Length: 3/8 inch (Second Dash No.6) to 6 inches (Second Dash No.96)

Part No. Coding: NAS467-4-18 = 1/4-28 bolt, 1-1/8 inch long.
NAS467-6-32 = 3/8-24 bolt, 2 inches long.

Figure 6-17 (Sheet 3 of 3) Bolt Specifications

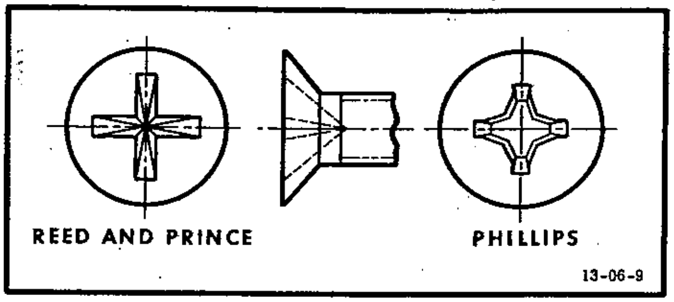
PART 6 SECTION 3

SCREWS, NUTS AND WASHERS

SCREWS

General

1 The distinction between bolts and screws is that wrenches are used for turning or holding bolts while screwdrivers are used on screws. The terms are used very loosely. Where recessed heads are used, both Reed and Prince (Frearson) and Phillips are usually available. The screwdrivers are similar in appearance, but are not interchangeable.



2 Aircraft screws fall into two principal classes:

(a) Structural, such as AN509, which have mechanical characteristics of an AN3 series bolts, or better.

(b) Non-structural, such as AN507, usually of carbon steel, frequently threaded full length. These screws are unsuitable for plate bearing load, but are used for fairing attachment, electrical installations, etc. Included in this group are the self-tapping screws such as AN504 and AN530.

3 Screw size coding: No. 0 is .060 inch. For each additional size, add .013 inch. Thus, screw size No. 10 is .060 plus (10 x .013) = .190 inch.

Hole Sizes and Dimpling

4 For hole sizes and dimpling, see Figure 6-18. (Refer to Part 25, following.)

Sheet Metal Screws (AN530 and AN531)

5 These screws correspond to the Parker-Kalon type Z sheet metal screw, and are used in the temporary attachment of sheet metal for rivetting and for the permanent assembly of non-structural assemblies where the ability to insert the screws in blind applications is required. For table of hole sizes, see Figure 6-19.

Self-tapping Screws

6 Self-tapping screws are made of carbon steel, case hardened, or of corrosion-resistant steel, type 410, hardened, and are used for attaching removable parts of non-structural importance, such as floor boards, inside fairing, covers and the like. There are two head styles of self-tapping screws; round head and flush 82° countersunk head.

Restrictions

7 The following restrictions apply to the use of self-tapping screws:

(a) Self-tapping screws must not be used in the primary aircraft structure, or on the attachment of the superstructure and accessories where their failure would interfere with the safe operation of the aircraft.

(b) They must not be used where their loss permits the opening of a joint by air flow.

(c) Self-tapping screws must never be used to replace bolts, screws, or rivets.

(d) Self-tapping screws must be installed in holes of the proper size, (see Figure 6-20).

Approved Self-tapping Screws

8 Trade names of presently approved self-tapping screws and nuts are shown in Figure 6-21. The use of these screws is subject to the general restrictions outlined in Paragraph 7, preceding. If further applications of self-tapping screws are desirable, approval must be obtained from engineering authority.

Screw Size	A Min. Edge Distance for Dimpled Joints	B Min. Spacing for Dimpled Joints	C Min. Thickness for Countersinking	D Min. Thickness for Sub-countersinking	E Thickness for Dimpling — Minimum — Al. Alloy	E Minimum — Milled Al. Alloy Clad on Top	E Minimum — Titanium — Pure 80,000 psi	E Minimum — Titanium — Alloy 120,000 psi	E Maximum — Stationary Squeezer — Al. Alloy	E Maximum — Stationary Squeezer — Titanium — Pure 80,000 psi	E Maximum — Stationary Squeezer — Titanium — Alloy 20,000 psi	E Maximum — Stationary Squeezer — C.R. Steel — Anld	E Maximum — Stationary Squeezer — C.R. Steel — 1/2H
No.4	9/32	9/16	.032	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
No.6	11/32	11/16	.040	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
No.8	3/8	3/4	.050	.072	.032	.050	.025	.032	.081	.100	.100	.080	.063
No.10	7/16	7/8	.090	.090	.020	.050	.025	.032	.091	.063	.063	.080	.063
1/4	9/16	1-1/8	.112	.125	.040	.050	.025	.032	.091	.063	.063	.050	.045
5/16	23/32	1-7/16	.140	.156	.051	(3)	(3)	.032	.081	(3)	.056	.045	.045
3/8	27/32	1-11/16	.170	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
7/16	1	2	.200	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

Screw Size	E Thickness for Dimpling — Portable Squeezer — Al. Alloy	E Portable Squeezer — C.R. Steel — Anld	E Portable Squeezer — C.R. Steel — 1/2H	F Clearance Diameter — Cold Dimpling	F Clearance Diameter — Hot Dimpling	G Drill Size for Machined Parts	H Countersink Diameter	Sub-countersink Dia.
No.4	(1)	(1)	(1)	(1)	(1)	No.31(.120)	.210	(1)
No.6	(1)	(1)	(1)	(1)	(1)	No.27(.144)	.262	(1)
No.8	.040	.050	.036	3/4	1	No.19(.166)	.323	.337
No.10	.032	.032	.025	3/4	1	No.12(.189)	.376	.404
1/4	(1)	(1)	(1)	(2)	1	1/4 (.250)	.496	.520
5/16	(1)	(1)	(1)	1-1/8	1-1/8	5/16 (.312)	.621	.645
3/8	(1)	(1)	(1)	(1)	(1)	3/8 (.375)	.747	(1)
7/16	(1)	(1)	(1)	(1)	(1)	7/16 (.437)	.873	(1)

Notes

(1) Approved dimpling tools are not available.

(2) Values are 1 in. on flush side and 3/4 in. on protruding side.

(3) No available information.

(4) Drill sizes listed in column G are for close fit holes. For oversize clearance, reaming and spot-facing information, use tabulated sizes for bolts in Figure 25-20, Part 25 following.

Figure 6-18 Hole Sizes and Dimpling for Screws

ADVANCE REVISION

Serial #1 dated 5 Aug 58
(Sheet 1 of 1)

(This Advance Revision replaces existing para. 11, Part 6, Section 3)

The sheet of this Advance Revision is to be inserted in the EO as follows:

Sheet 1 facing page 57

GENERAL

11 The most frequently used nuts are listed in Figures 6-32 to 6-45 inclusive.

(a) AN nuts will be used until stocks exhausted then a changeover to the NAS series will be carried out for standarizing purposes. Depot stocking will be simplified and part numbers decreased.

(b) Demands for AN nuts may in instances be filled with NAS equivalents. Both AN and NAS nuts are covered by the same specification MIL-N-25027 (AS6) which supersedes AN-N-5 and AN-N-10.

(c) NAS nuts are lightweight, forged for high strength and self locking (upper threaded portion deformed elliptically).

(d) Nuts manufactured by various companies (Esna, Boats, Kaynar, Nut-shel and Standard Pressed Steel) will vary in appearance however all meet specification MIL-N-25027. Some of these products will have the added internal wrenching feature.

(e) All nuts manufactured by the above mentioned companies will meet the AN and NAS drawing Specs. however they will be supplied under the NAS part number.

ISSUED ON AUTHORITY OF THE CHIEF OF THE AIR STAFF

Drive Screws (AN535)

9 These screws have been designed mainly for attaching name and data plates to parts made of castings and forgings. They are made of hardened steel and are cadmium plated. After the part has been under-drilled, (see Figure 6-20), install and screw by tapping it in with a light hammer. Lengths available are as follows:

No.	Length
00	1/8 to 1/4
0	1/8 to 1/4
2	1/8 to 1/4
4	1/8 to 3/8
6	1/4 to 3/8
8	3/8 to 5/8
10	3/8 to 5/8
12	1/2 to 3/4
14	1/2 to 3/4

Example of Part No.: AN535-2-3 = No. 2 screw, 3/16 inch long.

Other Screws

10 The most frequently used screws are detailed in Figures 6-22 to 6-30 inclusive. Most of the remaining screws in the AN and NAS standards are described in Figure 6-31.

NUTS

General

11 The most frequently used nuts are listed in Figures 6-32 to 6-44 inclusive. Most of the remaining nuts in AN and NAS standards are described in Figure 6-45.

Self-locking Nuts and Pal Nuts

12 Self-locking nuts used in the RCAF conform to US Specification AN-N-5 (US Standard Drawings AN364, 365 and 336) and AN-N-10 (US Standard Drawings AN362 and 363). The following rules apply:

(a) Use self-locking nuts with bolts of the same material wherever possible. If this cannot be achieved, they should be of the same material as the surface in contact with the nut.

(b) Use bolts with self-locking nuts of sufficient length to extend through the nut with a least one complete thread protruding.

(c) Do not use self-locking nuts where the temperature is in excess of the following:

(1) Fibre or metal insert types AN364, AN365 and AN366 - 250° F.

(2) All-metal types AN362 and AN363 - 550° F.

(3) All-metal type Hi-temp - as specified.

(d) Self-locking nuts are not to be used at joints where:

(1) The bolt or nut is subject to a rotation tending to loosen the nut.

(2) The loosening of a nut, sufficient to remove all tension from the bolts, would cause loss of control or failure of the structure.

(e) Do not tap the fibre collar on a fibre insert type nut as the self-locking action of the nut is accomplished by permitting the bolt threads to impress themselves into the untapped collar.

(f) Do not use self-locking nuts and especially fibre insert type nuts on bolts with rough sawed-off ends.

(g) Do not grease bolts used with fibre insert type nuts prior to installation. Grease will act on the fibre insert, rendering it inert and destroying the locking characteristics of the nut.

(h) Never use self-locking nuts with bolts that have been drilled for cotter-pins, except in case of emergency. Drilled bolts may only be used if hole if free from burrs. Replace with applicable stock when available.

(j) Use fibre insert nuts on a once-off basis only and then discard. If any other EO states that these nuts are to be retained, the statement in said EO is to be disregarded. This policy does not apply to anchor or gang nuts, or similar devices that have fibre inserts.

Torquing

13 Torque values to be used on all nuts, including self-locking nuts, are shown in Part

Diameter of Screw	Sheet Steel			Sheet Aluminum		
	Thickness of Material	Diameter of Hole Required	Drill Size No.	Thickness of Material	Diameter of Hole Required	Drill Size No.
No. 2	.015	.063	52			
	.018	.063	52			
	.025	.067	51	.025	.063	52
	.031	.070	50	.031	.063	52
	.037	.073	49	.040	.063	52
	.050	.073	49	.050	.067	51
No. 4	.015	.086	44			
	.018	.086	44			
	.025	.089	43			
	.031	.093	42	.031	.086	44
	.037	.093	42	.040	.086	44
	.050	.096	41	.050	.086	44
No. 6	.015	.104	37			
	.018	.104	37			
	.025	.106	36			
	.031	.106	36	.031	.104	37
	.037	.110	35	.040	.104	37
	.050	.111	34	.050	.104	37
No. 7	.018	.116	32			
	.025	.116	32			
	.031	.116	32	.031	.116	32
	.037	.116	32	.040	.116	32
	.050	.120	31	.050	.116	32
No. 8	.025	.116	32			
	.031	.116	32			
	.037	.116	32	.040	.120	31
	.050	.128	30	.050	.128	30
No. 10	.018	.144	27			
	.025	.144	27			
	.031	.144	27			
	.037	.144	27	.040	.144	27
	.050	.144	27	.050	.144	27

Figure 6-19 (Sheet 1 of 2) Hole Sizes for Sheet Metal Screws

Diameter of Screw	Sheet Steel			Sheet Aluminum		
	Thickness of Material	Diameter of Hole Required	Drill Size No.	Thickness of Material	Diameter of Hole Required	Drill Size No.
No. 12	.025	.166	19			
	.031	.166	19			
	.037	.166	19			
	.050	.169	18	.050	.161	20
No. 14	.031	.185	13			
	.037	.185	13			
	.050	.181	11			

NOTE: For Thicknesses greater than .050 the Parker-Kalon Catalogue should be consulted.

Figure 6-19 (Sheet 2 of 2) Hole Sizes for Sheet Metal Screws

Size	AN504, 506 Self-tapping Machine Screws				AN535 Drive Screw	
	Threads	Diameter	Diameter Hole	Equivalent Drill Size	Diameter	Dia. of hole
00					.058	.052
0					.073	.067
2					.098	.086
4	4-40	.111 (±.003)	.0860	44	.114	.104
6	6-32	.136 (±.004)	.1040	37	.138	.120
8	8-32	.162 (±.004)	.1285	30	.164	.144
10	10-24	.188 (±.004)	.1495	25	.179	.161
12			.1540	23	.209	.191
14			.1730	17	.239	.221
1/4	1/4-20	.247(± .005)	.1990	8		

Consult Shakeproof catalogue for thicknesses over 0.050.
Coding: The dash numbers for all screws indicate the length in 16ths.
Add C for corrosion-resistant steel.
Add R for recessed head.
Head type: All self-tapping screws are available in slotted or Phillips recessed heads.

Figure 6-20 Hole Sizes for AN504, AN506 and AN535 Self-tapping Screws

Part No.	Head	Not suitable for use where required
AN530 (Parker-Kalon) Z Type	Round Head	Tinnerman Nut
AN531 (Parker-Kalon) Z Type	Flat Head	Tinnerman Nut
AN 504 (Shakeproof) Type 1	Round Head	Standard Machine Screw Nut
AN 506 (Shakeproof) Type 1	Flat Head	Standard Machine Screw Nut

Figure 6-21 Types of Self-tapping Screws

25, following. The table does not take precedence over any torque values laid down by the manufacturers.

Precautions for Use of Pal Nuts

14 To assure maximum locking efficiency and to avoid damaging the stud thread, tighten pal nuts 1/16 to 1/4 turn past a finger tight position. If the pal nut is pulled tighter than 1/4 of a turn, it will tend to dig into the stud and also the locking effectiveness of the nut is reduced. If it is turned less than 1/16 of a turn, there will be danger of the nut coming loose.

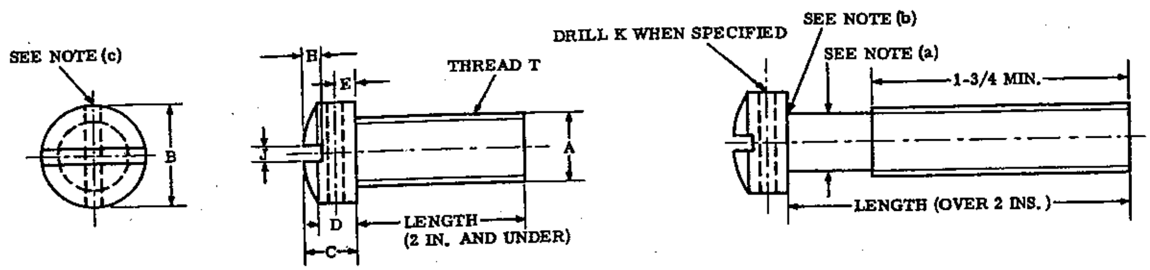
WASHERS

General

15 In addition to the washers dealt with in Figures 6-46 to 6-48 inclusive, washers AN961 and AN970 are described in Figure 6-49.

Thread T	A Max. Dia.	B Dia.		C		D	
		Max.	Min.	Max.	Min.	Max.	Min.
AN500 Coarse Thread NC-2							
No. 2-56	.0860	.140	.124	.083	.070	.062	.055
No. 3-48	.0990	.161	.145	.095	.082	.070	.064
No. 4-40	.1120	.183	.166	.107	.094	.079	.072
No. 5-40	.1250	.205	.187	.120	.106	.088	.081
No. 6-32	.1380	.226	.208	.132	.118	.096	.089
No. 8-32	.1640	.270	.250	.156	.141	.113	.106
No. 10-24	.1900	.313	.292	.180	.165	.130	.123
1/4-20	.2500	.414	.389	.237	.219	.170	.161
5/16-18	.3125	.518	.490	.295	.276	.211	.201
3/8-16	.3750	.622	.590	.355	.333	.253	.242
AN501 Fine Thread NF-2							
No. 030	.0600	.096	.085	.054	.045	.038	.029
No. 1-72	.0730	.118	.109	.066	.057	.046	.037
No. 2-84	.0860	.140	.124	.083	.070	.062	.055
No. 3-56	.0990	.161	.145	.095	.082	.070	.064
No. 4-48	.1120	.183	.166	.107	.094	.079	.072
No. 5-44	.1250	.205	.187	.120	.106	.088	.082
No. 6-40	.1380	.226	.208	.132	.118	.096	.089
No. 8-36	.1640	.270	.250	.156	.141	.113	.106
No. 10-32	.1900	.313	.292	.180	.165	.130	.123
1/4-28	.2500	.414	.389	.237	.129	.170	.161
5.16-24	.3125	.518	.490	.295	.276	.211	.201
3/8-24	.3750	.622	.590	.355	.333	.253	.242

Figure 6-22 (Sheet 1 of 4) Screw, Fillister Head (AN500 and AN501)



Thread T	E Ref.	H		J		K Drill +.004 -.001
		Max.	Min.	Max.	Min.	
AN500 Coarse Thread NC-2						
No. 2-56	.026	.030	.022	.032	.023	.031
No. 3-48	.030	.034	.026	.035	.027	.037
No. 4-40	.035	.038	.030	.039	.031	.037
No. 5-40	.038	.042	.033	.043	.035	.046
No. 6-32	.043	.045	.035	.048	.039	.046
No. 8-32	.043	.065	.056	.054	.045	.046
No. 10-24	.043	.075	.064	.060	.050	.046
1/4-20	.062	.102	.087	.075	.064	.062
5/16-18	.078	.130	.110	.084	.078	.070
3/8-16	.094	.154	.134	.094	.081	.070
AN501 Fine Thread NF-2						
No. 030		.024	.014	.031	.020	
No. 1-72		.029	.019	.033	.022	
No. 2-84	.026	.030	.022	.031	.023	.032
No. 3-56	.030	.034	.026	.035	.031	.837
No. 4-48	.035	.038	.030	.039	.031	.037
No. 5-44	.038	.042	.033	.043	.035	.046
No. 6-40	.042	.045	.035	.048	.039	.046
No. 8-36	.043	.065	.054	.054	.045	.046
No. 10-32	.043	.075	.064	.060	.050	.046
1/4-28	.062	.102	.087	.075	.064	.062
5/16-24	.078	.130	.110	.084	.072	.070
3/8-24	.094	.154	.134	.094	.081	.070

Figure 6-22 (Sheet 2 of 4) Screw, Fillister Head (AN500 and AN501)

Material and Finish Specification: Same as for AN507

(a) The diameter of the unthreaded portion shall not be less than the minimum pitch diameter nor more than the maximum major diameter of the thread.

(b) The radius of the fillet at the base of the head shall not exceed one-half the pitch of the screw thread.

(c) Drilled hole to be on centre approximately at right angles to the slot but must not break through the base or top (spherical portion) of the head.

Dash Numbers for Undrilled Carbon Steel Screws

Length		AN500 Coarse Thread NC-2						
		No. 2-56	No. 3-48	No. 4-40	No. 5-40	No. 6-32	No. 8-32	No. 10-24
3/16	+0 -1/32	2-3	3-3	4-3	5-3	6-3		
1/4		2-4	3-4	4-4	5-4	6-4	8-4	10-4
5/16		2-5	3-5	4-5	5-5	6-5	8-5	10-5
3/8		2-6	3-6	4-6	5-6	6-6	8-6	10-6
7/16		2-7	3-7	4-7	5-7	6-7	8-7	10-7
1/2		2-8	3-8	4-8	5-8	6-8	8-8	10-8
5/8		2-10	3-10	4-10	5-10	6-10	8-10	10-10
3/4		2-12	3-12	4-12	5-12	6-12	8-12	10-12
7/8						6-14	8-14	10-14
1						6-16	8-16	10-16
1-1/8	+0 -1/16					6-18	8-18	10-18
1-1/4						6-20	8-20	10-20
1-3/8						6-22	8-22	10-22
1-1/2						6-24	8-24	10-24
1-3/4						6-28	8-28	10-28
2						6-32	8-32	10-32
2-1/2	+0 -3/32							10-40
3								10-48

Figure 6-22 (Sheet 3 of 4) Screw, Fillister Head (AN500 and AN501)

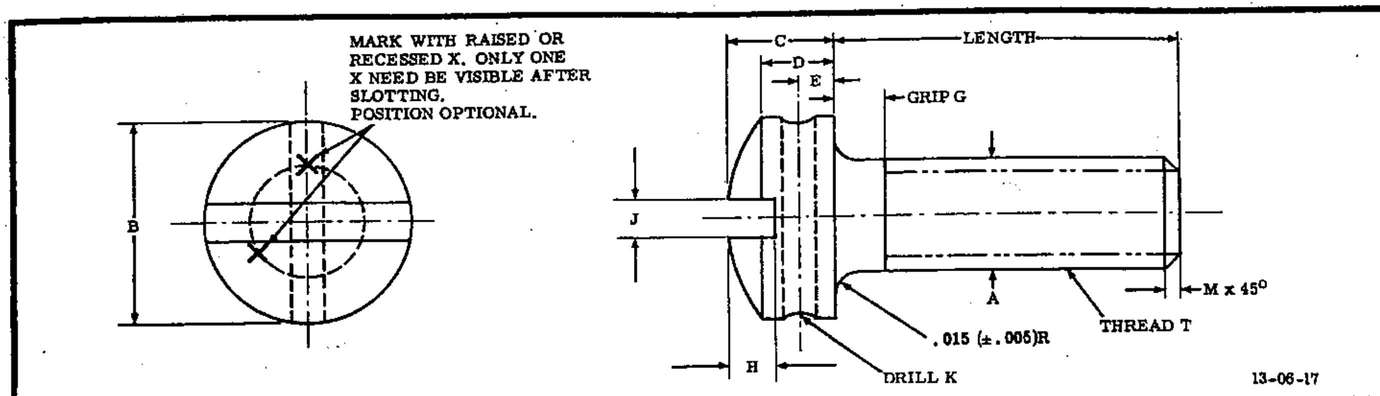
For machine screws 2 inches and shorter, the complete threads shall extend to within two threads of the bearing surface. Sizes 0-80 to 8-36 in fine thread series (AN501) and all undrilled heads inactive for design after May, 1950.

Examples of Part Nos:
AN500A2-3 = No.2-56, drilled carbon steel screw, 3/16 inch long. AN500AB416-7 = 1/4-20, drilled brass screw, 7/16 inch long. AN500AC616-8 = 3/8-16, drilled corrosion-resistant steel screw, (8/16) 1/2 inch long. AN501A10-10 = No.10-32, drilled carbon steel screw, (10/16) 5/8 inch long. AN501AC416-7 = 1/4-28, drilled corrosion-resistant screw, 7/16 inch long.

Dash Numbers for Undrilled Carbon Steel Screws

Length		AN500 Coarse Thread NC-2			AN501 Fine Thread NC-2			
		1/4-20	5/16-18	3/8-16	No. 10-32	1/4-28	5/16-24	3/8-24
3/16	+0 -1/32							
1/4					10-4			
5/16					10-5	416-5		
3/8		416-6	516-6	616-6	10-6	416-6		
7/16		416-7	516-7	616-7	10-7	416-7		
1/2		416-8	516-8	616-8	10-8	416-8	516-8	616-8
5/8		416-10	516-10	616-10	10-10	416-10	516-10	616-10
3/4		416-12	516-12	616-12	10-12	416-12	516-12	616-12
7/8		416-14	516-14	616-14	10-14	416-14	516-14	616-14
1		416-16	516-16	616-16	10-16	416-16	516-16	616-16
1-1/8	+0 -1/16	416-18	516-18	616-18	10-18	416-18	516-18	616-18
1-1/4		416-20	516-20	616-20	10-20	416-20	516-20	616-20
1-3/8		416-22	516-22	616-22	10-22	416-22	516-22	616-22
1-1/2		416-24	516-24	616-24	10-24	416-24	516-24	616-24
1-3/4		416-28	516-28	616-28	10-28	416-28	516-28	616-28
2		416-32	516-32	616-32	10-32	416-32	516-32	616-32
2-1/2	+0 -3/32	416-40	516-40	616-40	10-40	416-40	516-40	616-40
3		416-48	516-48	616-48	10-48	416-48	516-48	616-48

Figure 6-22 (Sheet 4 of 4) Screw, Fillister Head (AN500 and AN501)



Material and Finish Specification: Same as AN509 steels
Examples of Part Numbers:
AN502-10-10 = No. 10-32 NF-3A, steel screw, (10/16) 5/8 inch long.
AN503-416-14 = 1/4-20 UNC-3A, steel screw, (14/16) 7/8 inch long.
Note: Sizes 6-40 and 8-36 inactive for design after May, 1950.

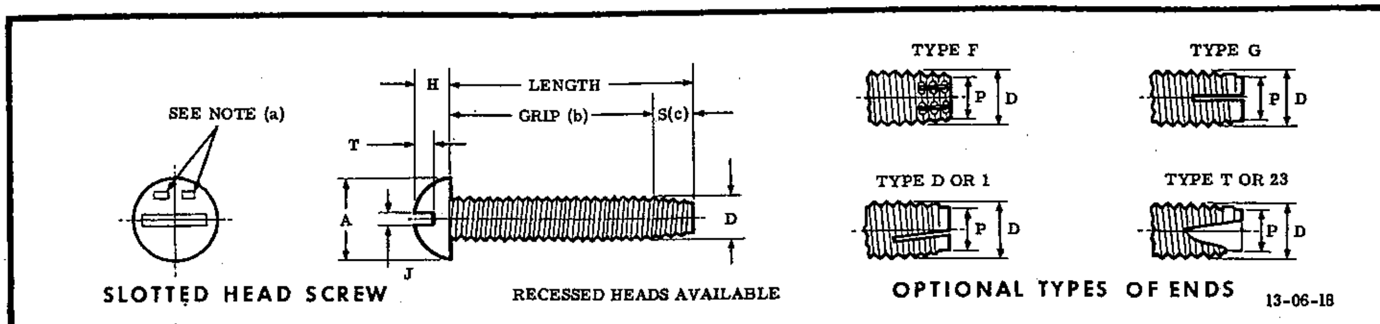
Length		AN503 Coarse Thread					AN502 Fine Thread		
		No. 6-32	No. 8-32	No. 10-24	1/4-20	5/16-18	No. 10-32	1/4-28	5/16-24
1/8		6-2	8-2						
1/4		6-4	8-4	10-4			10-4		
3/8	+0	6-6	8-6	10-6			10-6	416-6	
1/2	-1/32	6-8	8-8	10-8	416-8		10-8	416-8	
5/8			8-10	10-10	416-10		10-10	416-10	
3/4			8-12	10-12	416-12	516-12	10-12	416-12	516-12
7/8			8-14	10-14	416-14	516-14	10-14	416-14	516-14
1			8-16	10-16	416-16	516-16	10-16	416-16	516-16
1-1/8				10-18	416-18	516-18	10-18	416-18	516-18
1-1/4	+0			10-20	416-20	516-20	10-20	416-20	516-20
1-3/8	-1/16			10-22	416-22	516-22	10-22	416-22	516-22
1-1/2				10-24	416-24	516-24	10-24	416-24	516-24
1-5/8				10-26	416-26	516-26	10-26	416-26	516-26
1-3/4					416-28	516-28		416-28	516-28
1-7/8				10-30	416-30	516-30		416-30	516-30
2					416-32	516-32		416-32	516-32

Figure 6-23 (Sheet 1 of 2) Screw, Drilled Fillister Head (AN502 and AN503)

Thread T		A Max. Dia.	B Diameter		C		D		E Ref.
			Max.	Min.	Max.	Min.	Max.	Min.	
6-40	NF-3A	.1380	.226	.208	.132	.118	.096	.089	.049
8-32	NF-3A	.1640	.270	.250	.156	.141	.113	.106	.043
10-32	NF-3A	.1900	.313	.292	.180	.165	.130	.123	.043
1/4-28	UNF-3A	.2500	.614	.389	.237	.219	.170	.161	.062
5/16-24	UNF-3A	.3125	.518	.490	.295	.276	.211	.201	.078
6-32	NC-3A	.1380	.226	.208	.132	.118	.096	.089	.043
8-32	NC-3A	.1640	.270	.250	.156	.141	.113	.106	.043
10-24	NC-3A	.1900	.313	.292	.180	.165	.130	.123	.043
1/4-20	UNC-3A	.2500	.414	.389	.237	.219	.170	.161	.062
5/16-18	UNC-3A	.3125	.518	.490	.295	.276	.211	.201	.078

Thread T		Grip G		H		J		K Drill +.004 -.001	M Max.
		Max.	Min.	Max.	Min.	Max.	Min.		
6-40	NF-3A	.063	.031	.045	.035	.048	.039	.046	.031
8-32	NF-3A	.063	.031	.065	.054	.054	.045	.046	.031
10-32	NF-3A	.063	.031	.075	.064	.060	.050	.046	.031
1/4-28	UNF-3A	.078	.046	.102	.087	.075	.064	.062	.031
5/16-24	UNF-3A	.078	.046	.130	.110	.084	.072	.070	.047
6-32	NC-3A	.063	.031	.045	.035	.048	.039	.046	.031
8-32	NC-3A	.063	.031	.065	.054	.056	.045	.046	.031
10-24	NC-3A	.063	.031	.075	.064	.060	.050	.046	.031
1/4-20	UNC-3A	.078	.046	.102	.087	.075	.064	.062	.031
5/16-18	UNC-3A	.078	.046	.130	.110	.084	.072	.070	.047

Figure 6-23 (Sheet 2 of 2) Screw, Drilled Fillister Head (AN502 and AN503)



Size	No. 4-40	No. 6-32	No. 8-32	No. 10-24	1/4-20
A Dia.	.202(±.009)	.250(±.010)	.298(±.011)	.347(±.012)	.458(±.014)
D Dia.	.111(±.003)	.136(±.004)	.162(±.004)	.188(±.004)	.247(±.005)
H	.081(±.005)	.097(±.006)	.113(±.006)	.130(±.006)	.168(±.006)
J	.034(±.006)	.039(±.006)	.044(±.006)	.048(±.007)	.058(±.007)
T	.051(±.007)	.059(±.008)	.067(±.009)	.075(±.011)	.094(±.014)
P	.081(±.004)	.100(±.005)	.126(±.005)	.141(±.006)	.194(±.003)

Dash Numbers for Alloy Steel, Slotted Head Screws

Length		No. 4-40		No. 6-32		No. 8-32		No. 10-24	
		Dash No.	Grip Min.	Dash No.	Grip Min.	Dash No.	Grip Min.	Dash No.	Grip Min.
1/4		4-4	3/32	6-4	3/32	8-4	3/32		
5/16		4-5	5/32	6-5	9/64	8-5	9/64	10-5	1/8
3/8	+0	4-6	7/32	6-6	13/64	8-6	13/64	10-6	5/32
7/16	-1/32	4-7	9/32	6-7	17/64				
1/2		4-8	11/32	6-8	21/64	8-8	21/64	10-8	9/32
5/8		4-10	15/32	6-10	29/64	8-10	29/64	10-10	13/32
3/4		4-12	19/32	6-12	37/64	8-12	37/64	10-12	17/32
7/8	+0			6-14	45/64	8-14	45/64	10-14	21/32
1	-3/64			6-16	53/64	8-16	53/64	10-16	25/32
1-1/4						8-20	1-3/64	10-20	1
1-1/2								10-24	1-1/4

Dash Numbers for Alloy Steel, Slotted Head Screws

Length		No. 10-32		1/4-20		1/4-28	
		Dash No.	Grip Min.	Dash No.	Grip Min.	Dash No.	Grip Min.
5/16		1032-5	1/8				
3/8	+0	1032-6	5/32				
7/16	-1/32						
1/2		1032-8	9/32	416-8	15/64	428-8	15/64
5/8		1032-10	13/32	416-10	23/64	428-10	23/64
3/4		1032-12	17/32	416-12	31/64	428-12	31/64
7/8	+0	1032-14	21/32	416-14	39/64	428-14	39/64
1	-3/64	1032-16	25/32	416-16	47/64	428-16	47/64
1-1/4		1032-20	1	416-20	61/64	428-20	61/64
1-1/2		1032-24	1-1/4	416-24	1-13/64	428-24	1-13/64

Figure 6-24 (Sheet 1 of 2) Screw, Round Head, Self-tapping (AN504)

(a) Marking for corrosion-resistant steel screws. Only one dash need be visible. Position optional. No marking required on heads of No.4 screws.

(b) The grip length is measured from the underside of the head to the end of the full threaded portion of the shank. The minimum grip dimensions shown in the dash number table are for design purposes.

(c) Screws having a length of 8 pitches or less will have a taper length, S, of 2-1/2 to 3-1/2 times the pitch distance. Longer lengths will have a taper length, S, of 3-1/2 to 4-1/2 times the pitch distance.

(d) No.10-24 and 1/4-20 sizes inactive for design after 15 July 1955. When a No.10 or 1/4 size of screw is required, a No.10-32 or 1/4-28 size is to be used in lieu of the No.10-24 or 1/4-20 size, respectively.

Material: Alloy steel, case hardened, or corrosion-resistant steel, type 410, hardened.

Finish: Alloy steel, cadmium plated; corrosion-resistant steel, none.

Add C before first dash number for corrosion-resistant steel screws.

Add R between first and second dash numbers for recessed head screws.

Examples of Part Numbers:

AN504-4-8 - No.4-40, Alloy Steel, slotted head screw, 8/16 in length.

AN504-4R8 - No.4-40, Alloy Steel, recessed head screw, 8/16 in length.

AN504C4-8 - No.4-40, corrosion-resistant steel, slotted head screw 8/16 in length.

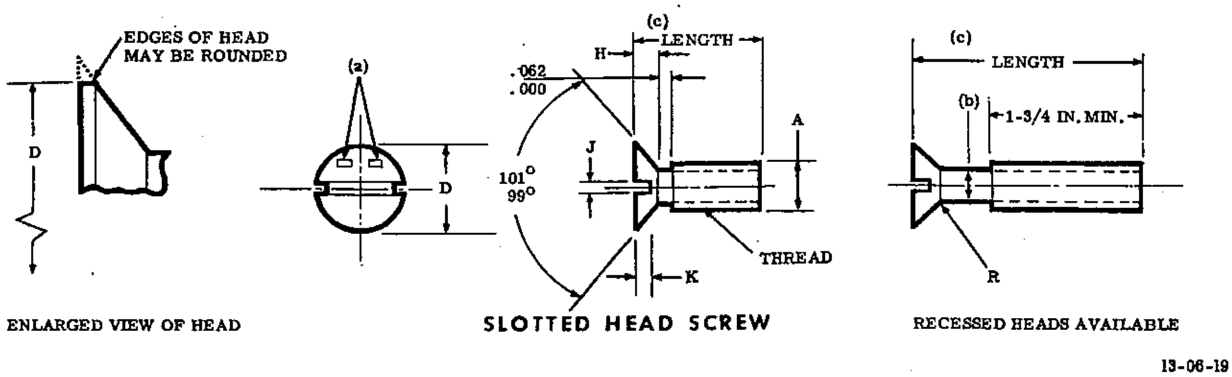
AN504C4R8 - No.4-40, corrosion-resistant steel, recessed head screw, 8/16 in length.

Tapered threads have unfinished crests.

Major diameters of complete threads conform to NC-2 and NF-2 tolerances.

Threads must extend to within one full thread of the head on screw lengths up to 3 diameters. Up to 8 diameters, threads must extend up to within two threads of the head. On longer lengths, unless otherwise specified, the length of the thread is optional with the producer but must not be less than 6 diameters.

Figure 6-24 (Sheet 2 of 2) Screw, Round Head, Self-tapping (AN504)



Size	A Dia.	D Dia.			F	H		J		K		R Rad.	
		Sharp		Min. With Max. F								Coarse Thread	Fine Thread
	Max.	Max.	Min.		Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
No. 4	.112	.225	.207	.200	.023	.048	.040	.039	.031	.024	.017	.050	.040
No. 6	.138	.279	.257	.249	.027	.060	.051	.048	.039	.030	.022	.060	.050
No. 8	.164	.332	.308	.300	.028	.072	.062	.054	.045	.036	.027	.060	.055
No.10	.190	.385	.359	.348	.032	.083	.072	.060	.050	.042	.031	.085	.060
1/4	.250	.507	.477	.462	.034	.110	.097	.075	.064	.055	.042	.100	.070
5/16	.313	.635	.600	.581	.040	.138	.123	.084	.072	.069	.053	.110	.085
3/8	.375	.762	.722	.700	.046	.165	.148	.094	.081	.083	.064	.125	.085

Rated strength in pounds
(For reference purposes only)

Size	Minimum UTS	Minimum Single Shear	Size	Minimum UTS	Minimum Single Shear
No. 4-40 NC-2A	275	165	No. 4-48 NF-2A	313	188
No. 6-32 NC-2A	410	246	No. 6-40 NF-2A	478	287
No. 8-32 NC-2A	660	396	No. 8-36 NF-2A	705	423
No.10-24 NC-2A	480	480	No.10-32 NF-2A	960	575
1/4-20 UNC-2A	1480	890	1/4-28 UNF-2A	1790	1075
5/16-18 UNC-2A	2500	1500	5/16-24 UNF-2A	2880	1725
3/8-16 UNC-2A	3730	2240	3/8-24 UNF-2A	4450	2660

Figure 6-25 (Sheet 1 of 4) Screw, Flat Head (AN507)

Material: Carbon steel, Specification QQ-S-671, type SAE 1010, 55,000 psi minimum ultimate tensile stress, or other steel meeting the same physical requirements. Brass, commercial, 55,000 psi minimum ultimate tensile stress. Aluminum alloy, Specification 24S. Corrosion-resistant steel, Specification QQ-S-763, SAE 52100.

Finish: Carbon steel, cadmium plated. Brass, cadmium plated. Aluminum, anodized. Corrosion-resistant steel, passivated.

Examples of Part Numbers:
AN507-440-3 = No.4-40 NC-2A, carbon steel screw, 3/16 inch long, slotted head.
AN507B640R12 = No.6-40 NF-2A, brass screw, black oxide finish, (12/16) 3/4 inch long, recessed head.
AN507C832R18 = No.8-32 NC-2A, corrosion-resistant steel screw, (18/16) 1-1/8 inch long, recessed head.
AN507DD1032-5 = No.10-32 NF-2A, aluminum alloy screw, 5/16 inch long, slotted head.
AN507PB420R10 = 1/4-20 UNC-2A, brass screw, cadmium plated, (10/16) 5/8 inch long, recessed head.
AN507UB616-8 = 3/8-16 UNC-2A, brass screw, plain (8/16) 1/2 inch long, slotted head.

Add R between first and second dash numbers for recessed head screws.
Add B before first dash number for brass screws with black oxide finish.
Add PB before first dash number for cadmium plated brass screws.
Add UB before first dash number for plain brass screws.
Add C before first dash number for corrosion-resistant steel screws.
Add DD before first dash number for aluminum alloy screws.

(a) Marking for corrosion-resistant steel screws. Only one visible dash necessary after slotting operation. Position optional. No marking required on heads of size No.4 screws.

(b) The diameter of the unthreaded portion of the screws shall not be less than the minimum pitch diameter nor more than the maximum major diameter of the thread.

(c) For machine screws up to 2 inches in length, the complete threads shall extend to within two threads of the bearing surface of the head or closer if practicable. Longer screws shall have a minimum complete thread length of 1-3/4 inch.

Figure 6-25 (Sheet 2 of 4) Screw, Flat Head (AN507)

L Length		No. 4-40 NC-2A	No. 4-48 NF-2A *	No. 6-32 NC-2A	No. 6-40 NF-2A *	No. 8-32 NC-2A	No. 8-36 NF-2A *	No. 10-24 NC-2A *
3/16		440-3	448-3	632-3				
1/4		440-4	448-4	632-4	640-4	832-4	836-4	
5/16	+0	440-5	448-5	632-5	640-5	832-5	836-5	1024-5
3/8	-1/32	440-6	448-6	632-6	640-6	832-6	836-6	1024-6
7/16		440-7	448-7	632-7	640-7	832-7	836-7	1024-7
1/2		440-8	448-8	632-8	640-8	832-8	836-8	1024-8
5/8		440-10	448-10	632-10	640-10	832-10	836-10	1024-10
3/4		440-12	448-12	632-12	640-12	832-12	836-12	1024-12
7/8		440-14	448-14	632-14	640-14	832-14	836-14	1024-14
1		440-16	448-16	632-16	640-16	832-16	836-16	1024-16
1-1/8		440-18	448-18	632-18	640-18	832-18	836-18	1024-18
1-1/4		440-20	448-20	632-20	640-20	832-20	836-20	1024-20
1-3/8	+0		448-22		640-22		836-22	
1-1/2	-1/16	440-24	448-24	632-24	640-24	832-24	836-24	1024-24
1-5/8			448-26		640-26		836-26	
1-3/4			448-28	632-28	640-28	832-28	836-28	1024-28
1-7/8					640-30		836-30	
2				632-32	640-32	836-32	836-32	1024-32
2-1/4	+0				640-36		836-36	
2-1/2	-3/32			632-40	640-40	832-40	836-40	1024-40
2-3/4							836-44	
3						832-48	836-48	1024-48

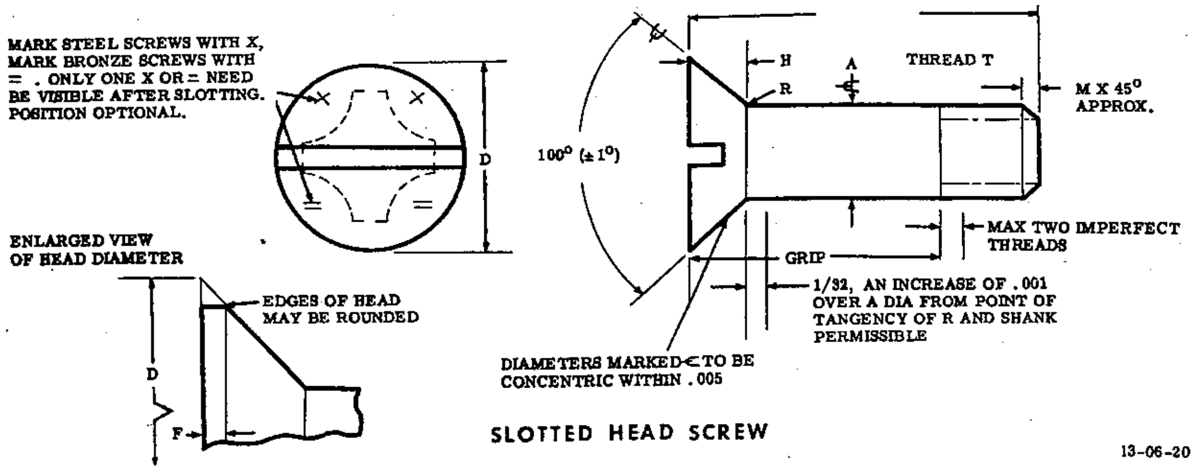
*Not preferred for airframe use.

Figure 6-25 (Sheet 3 of 4) Screw, Flat Head (AN507)

L Length		No. 10-32 NF-2A	1/4-20 UNC-2A *	1/4-28 UNF-2A *	5/16-18 UNC-2A *	5/16-24 UNF-2A	3/8-16 UNC-2A	3/8-24 UNF-2A
3/16	+0 -1/32							
1/4		1032-4						
5/16		1032-5	420-5					
3/8		1032-6	420-6	428-6				
7/16		1032-7	420-7	428-7				
1/2		1032-8	420-8	428-8	518-8	524-8	616-8	624-8
5/8		1032-10	420-10	428-10	518-10	524-10	616-10	624-10
3/4		1032-12	420-12	428-12	518-12	524-12	616-12	624-12
7/8		1032-14	420-14	428-14	518-14	524-14	616-14	624-14
1		1032-16	420-16	428-16	518-16	524-16	616-16	624-16
1-1/8	+0 -1/16	1032-18	420-18	428-18	518-18	524-18	616-18	624-18
1-1/4		1032-20	420-20	428-20	518-20	524-20	616-20	624-20
1-3/8		1032-22		428-22				
1-1/2		1032-24	420-24	428-24	518-24	524-24	616-24	624-24
1-5/8		1032-26		428-26				
1-3/4		1032-28	420-28	428-28	518-28	524-28	616-28	624-28
1-7/8		1032-30		428-30				
2		1032-32	420-32	428-32	518-32	524-32	616-32	624-32
2-1/4	+0 -3/32	1032-36		428-36				
2-1/2		1032-40	420-40	428-40	518-40	524-40	616-40	624-40
2-3/4		1032-44		428-44				
3		1032-48	420-48	428-48	518-48	524-48	616-48	624-48

*Not preferred for airframe use.

Figure 6-25 (Sheet 4 of 4) Screw, Flat Head (AN507)



Material: QQ-A-354 Aluminum alloy, QQ-S-763 Steel, corrosion-resistant, MIL-S-6049 Steel, (SAE 8740), MIL-S-6050 Steel, (SAE 8630), MIL-S-6098 Steel, (SAE 8735), MIL-S-6758 Steel, (SAE 4130), AN-S-9 Steel, (SAE 4037).

Finish: Steel, low alloy, cadmium plated. Refer to Part 20, following. Steel, corrosion-resistant, Passivated. Refer to Part 20, following. Aluminum alloy. Anodized. Refer to Part 20, following.

Hardness: Low alloy steel screws shall be within Rockwell hardness C-26 to C-32. Refer to Part 4, preceding.

Heat Treat: Low alloy steel, 125,000 psi tensile minimum. Aluminum alloy, 62,000 psi tensile minimum. Commercial Bronze, 85,000 psi tensile minimum.

Procurement Specification: MIL-S-7839.

Examples of Part Numbers:
AN509-8-12 = No.8-32 NC-3A, slotted head steel screw, 25/32 inch long.

AN509C10R8 = No.10-32 NF-3A, recessed head corrosion-resistant steel screw, 17/32 inch long.

AN509DD416-9 = 1/4-28 UNF-3A, slotted head aluminum alloy screw, 19/32 inch long.

AN509-516R18 = 5/16-24 UNF-3A, recessed head steel screw, 1-5/32 inch long.

Add C before first dash number for corrosion-resistant steel screws.
Add DD before first dash number for aluminum alloy screws.
Add R between first and second dash number for recessed head screws.

Figure 6-26 (Sheet 1 of 7) Screw, Flat Head, Structural (AN509)

Thread T		Tol. on Lengths	A Dia.		D Dia.			F	H
			Max.	Min.	Max. Sharp	Min. Sharp	Min. with Max. F	Max.	Ref.
No. 8-32	NC-3A	+1/32 -1/64	.1640	.1610	.332	.319	.283	.015	.068
No. 10-32	NF-3A	+1/32 -1/64	.1890	.1860	.385	.371	.327	.016	.080
1/4-28	UNF-3A	+1/32 -1/64	.2490	.2460	.507	.491	.447	.018	.106
5/16-24	UNF-3A	+3/64 -0	.3115	.3085	.635	.617	.569	.020	.133
3/8-24	UNF-3A	+1/32 -1/64	.3740	.3710	.762	.742	.686	.023	.159
7/16-20	UNF-3A	+1/64 -1/32	.4365	.4325	.890	.868	.805	.026	.186
1/2-20	UNF-3A	+1/64 -1/32	.4990	.4950	1.017	.992	.919	.030	.213
9/16-18	UNF-3A	+3/64 -0	.5615	.5575	1.145	1.118	1.036	.034	.240

Thread T		Tol. on Lengths	J		K		M	R Rad.	
			Max.	Min.	Max.	Min.	Max.	Max.	Min.
No. 8-32	NC-3A	+1/32 -1/64	.054	.045	.036	.027	.031	.015	.005
No. 10-32	NF-3A	+1/32 -1/64	.060	.050	.042	.031	.031	.015	.005
1/4-28	UNF-3A	+1/32 -1/64	.075	.064	.055	.042	.031	.015	.005
5/16-24	UNF-3A	+3/64 -0	.084	.072	.069	.053	.047	.020	.010
3/8-24	UNF-3A	+1/32 -1/64	.094	.081	.083	.064	.047	.020	.010
7/16-20	UNF-3A	+1/64 -1/32	.098	.082	.097	.077	.047	.020	.010
1/2-20	UNF-3A	+1/64 -1/32	.110	.094	.112	.088	.047	.020	.010
9/16-18	UNF-3A	+3/64 -0	.122	.106	.127	.103	.047	.020	.010

Figure 6-26 (Sheet 2 of 7) Screw, Flat Head, Structural (AN509)

Length	No. 8-32 Grip	No. 8-32 Tol.	No. 8-32 Dash No.	No. 10-32 Grip	No. 10-32 Tol.	No. 10-32 Dash No.	1/4-28 Grip	1/4-28 Tol.	1/4-28 Dash No.	5/16-24 Grip	5/16-24 Tol.	5/16-24 Dash No.
9/32	3/32	Tol. (+1/32-0)	8-4	7/64	Tol. (+1/32-0)	10-4						
11/32	3/32		8-5	7/64		10-5	9/64	Tol. (+1/32-0)	416-5	11/64	Tol. (+1/32-0)	516-5
13/32	3/32		8-6	7/64		10-6	9/64		416-6	11/64		516-6
15/32	3/32		8-7	7/64		10-7	9/64		416-7	11/64		516-7
17/32	3/32		8-8	7/64		10-8	9/64		416-8	11/64		516-8
19/32	5/32	Tol. (±1/64)	8-9	7/64		10-9	9/64		416-9	11/64		516-9
21/32	7/32		8-10	3/16	Tol. (±1/64)	10-10	9/64		416-10	11/64		516-10
23/32	9/32		8-11	1/4		10-11	3/16	Tol. (±1/64)	416-11	11/64		516-11
25/32	11/32		8-12	5/16		10-12	1/4		416-12	7/32	Tol. (±1/64)	516-12
27/32	13/32		8-13	3/8		10-13	5/16		416-13	9/32		516-13
29/32	15/32		8-14	7/16		10-14	3/8		416-14	11/32		516-14
31/32	17/32		8-15	1/2		10-15	7/16		416-15	13/32		516-15
1-1/32	19/32		8-16	9/16		10-16	1/2		416-16	15/32		516-16
1-3/32	21/32		8-17	5/8		10-17	9/16		416-17	17/32		516-17
1-5/32	23/32		8-18	11/16		10-18	5/8		416-18	19/32		516-18
1-7/32	25/32		8-19	3/4		10-19	11/16		416-19	21/32		516-19
1-9/32	27/32		8-20	13/16		10-20	3/4		416-20	23/32		516-20
1-11/32	29/32		8-21	7/8		10-21	13/16		416-21	25/32		516-21
1-13/32	31/32		8-22	15/16		10-22	7/8		416-22	27/32		516-22
1-15/32	1-1/32		8-23	1		10-23	15/16		416-23	29/32		516-23
1-17/32	1-3/32		8-24	1-1/16		10-24	1		416-24	31/32		516-24
1-19/32	1-5/32		8-25	1-1/8		10-25	1-1/16		416-25	1-1/32		516-25
1-21/32	1-7/32		8-26	1-3/16		10-26	1-1/8		416-26	1-3/32		516-26

Figure 6-26 (Sheet 3 of 7) Screw, Flat Head, Structural (AN509)

Length	No. 8-32			No. 10-32			1/4-28			5/16-24		
	Grip		Dash. No.	Grip		Dash No.	Grip		Dash No.	Grip		Dash No.
1-23/32	1-9/32		8-27	1-1/4		10-27	1-3/16		416-27	1-5/32		516-27
1-25/32	1-11/32		8-28	1-5/16		10-28	1-1/4		416-28	1-7/32		516-28
1-27/32	1-13/32		8-29	1-3/8		10-29	1-5/16		416-29	1-9/32		516-29
1-29/32	1-15/32		8-30	1-7/16		10-30	1-3/8		416-30	1-11/32		516-30
1-31/32	1-17/32		8-31	1-1/2		10-31	1-7/16		416-31	1-13/32		516-31
2-1/32	1-19/32		8-32	1-9/16		10-32	1-1/2		416-32	1-15/32		516-32
2-3/32	1-21/32		8-33	1-5/8		10-33	1-9/16		416-33	1-17/32		516-33
2-5/32	1-23/32		8-34	1-11/16		10-34	1-5/8		416-34	1-19/32		516-34
2-7/32	1-25/32		8-35	1-3/4		10-35	1-11/16		416-35	1-21/32		516-35
2-9/32	1-27/32		8-36	1-13/16		10-36	1-3/4		416-36	1-23/32		516-36
2-11/32	1-29/32	Tol. (±1/64)	8-37	1-7/8	Tol. (±1/64)	10-37	1-13/16	Tol. (±1/64)	416-37	1-25/32	Tol. (±1/64)	516-37
2-13/32	1-31/32		8-38	1-15/16		10-38	1-7/8		416-38	1-27/32		516-38
2-15/32				2		10-39	1-15/16		416-39	1-29/32		516-39
2-17/32				2-1/16		10-40	2		416-40	1-31/32		516-40
2-19/32				2-1/8		10-41	2-1/16		416-41	2-1/32		516-41
2-21/32				2-3/16		10-42	2-1/8		416-42	2-3/32		516-42
2-23/32				2-1/4		10-43	2-3/16		416-43	2-5/32		516-43
2-25/32				2-5/16		10-44	2-1/4		416-44	2-7/32		516-44
2-27/32				2-3/8		10-45	2-5/16		416-45	2-9/32		516-45
2-29/32				2-7/16		10-46	2-3/8		416-46	2-11/32		516-46
2-31/32				2-1/2		10-47	2-7/16		416-47	2-13/32		516-47
3-1/32				2-9/16		10-48	2-1/2		416-48	2-15/132		516-48

Figure 6-26 (Sheet 4 of 7) Screw, Flat Head, Structural (AN509)

Length	3/8-24 Grip	Tol.	3/8-24 Dash No.	7/16-20 Grip	Tol.	7/16-20 Dash No.	1/2-20 Grip	Tol.	1/2-20 Dash No.	9/16-18 Grip	Tol.	9/16-18 Dash No.
13/32	3/16	Tol. (+1/32-0)	616-5		Tol. (+1/32-0)			Tol. (+1/32-0)			Tol. (+1/32-0)	
15/32	3/16		616-6	7/32		716-6	1/4		816-6			
17/32	3/16		616-7	7/32		716-7	1/4		816-7	9/32		916-7
19/32	3/16		616-8	7/32		716-8	1/4		816-8	9/32		916-8
21/32	3/16		616-9	7/32		716-9	1/4		816-9	9/32		916-9
23/32	3/16		616-10	7/32		716-10	1/4		816-10	9/32		916-10
25/32	3/16		616-11	7/32		716-11	1/4		816-11	9/32		916-11
27/32	3/16		616-12	7/32		716-12	1/4		816-12	9/32		916-12
29/32	7/32	Tol. (±1/64)	616-13	7/32		716-13	1/4		816-13	9/32		916-13
31/32	9/32		616-14	1/4	Tol. (±1/64)	716-14	1/4		816-14	9/32		916-14
1-1/32	11/32		616-15	5/16		716-15	1/4		816-15	9/32		916-15
1-3/32	13/32		616-16	3/8		716-16	1/4		816-16	9/32		916-16
1-5/32	15/32		616-17	7/16		716-17	5/16	Tol. (±1/64)	816-17	9/32		916-17
1-7/32	17/32		616-18	1/2		716-18	3/8		816-18	9/32		916-18
1-9/32	19/32		616-19	9/16		716-19	7/16		816-19	11/32	Tol. (±1/64)	916-19
1-11/32	21/32		616-20	5/8		716-20	1/2		816-20	13/32		916-20
1-13/32	23/32		616-21	11/16		716-21	9/6		816-21	15/32		916-21
1-15/32	25/32		616-22	3/4		716-22	5/8		816-22	17/32		916-22
1-17/32	27/32		616-23	13/16		716-23	11/16		816-23	19/32		916-23
1-19/32	29/32		616-24	7/8		716-24	3/4		816-24	21/32		916-24
1-21/32	31/32		616-25	15/16		716-25	13/16		816-25	23/32		916-25
1-23/32	1-1/32		616-26	1		716-26	7/8		816-26	25/32		916-26
1-25/32	1-3/32		616-27	1-1/16		716-27	15/16		816-27	27/32		916-27
1-27/32	1-5/32		616-28	1-1/8		716-28	1		816-28	29/32		916-28
1-29/32	1-7/32		616-29	1-3/16		716-29	1-1/16		816-29	31/32		916-29
1-31/32	1-9/32		616-30	1-1/4		716-30	1-1/8		816-30	1-1/32		916-30
2-1/32	1-11/32		616-31	1-5/16		716-31	1-3/16		816-31	1-3/32		916-31
2-3/32	1-13/32		616-32	1-3/8		716-32	1-1/4		816-32	1-5/32		916-32
2-5/32	1-15/32		616-33	1-7/16		716-33	1-5/16		816-33	1-7/32		916-33
2-7/32	1-17/32		616-34	1-1/2		716-34	1-3/8		816-34	1-9/32		916-34

Figure 6-26 (Sheet 5 of 7) Screw, Flat Head, Structural (AN509)

Length	3/8-24			7/16-20			1/2-20			9/16-18		
	Grip		Dash No.	Grip		Dash No.	Grip		Dash No.	Grip		Dash No.
2-9/32	1-19/32		616-35	1-9/16		716-35	1-7/16		816-35	1-11/32		916-35
2-11/32	1-21/32		616-36	1-5/8		716-36	1-1/2		816-36	1-13/32		916-36
2-13/32	1-23/32		616-37	1-11/16		716-37	1-9/16		816-37	1-15/32		916-37
2-15/32	1-25/32		616-38	1-3/4		716-38	1-5/8		816-38	1-17/32		916-38
2-17/32	1-27/32		616-39	1-13/16		716-39	1-11/16		816-39	1-19/32		916-39
2-19/32	1-29/32		616-40	1-7/8		716-40	1-3/4		816-40	1-21/32		916-40
2-21/32	1-31/32		616-41	1-15/16		716-41	1-13/16		816-41	1-23/32		916-41
2-23/32	2-1/32		616-42	2		716-42	1-7/8		816-42	1-25/32		916-42
2-25/32	2-3/32		616-43	2-1/16		716-43	1-15/16		816-43	1-27/32		916-43
2-27/32	2-5/32		616-44	2-1/8		716-44	2		816-44	1-29/32		916-44
2-29/32	2-7/32		616-45	2-3/16		716-45	2-1/16		816-45	1-31/32		916-45
2-31/32	2-9/32		616-46	2-1/4		716-46	2-1/8		816-46	2-1/32		916-46
3-1/32	2-11/32		616-47	2-5/16		716-47	2-3/16		816-47	2-3/32		916-47
3-3/32	2-13/32		616-48	2-3/8		716-48	2-1/4		816-48	2-5/32		916-48
3-5/32							2-5/16		816-49	2-7/32		916-49
3-7/32							2-3/8		816-50	2-9/32		916-50
3-9/32							2-7/16		816-51	2-11/32		916-51
3-11/32		Tol. (±1/64)			Tol. (±1/64)		2-1/2	Tol. (±1/64)	816-52	2-13/32	Tol. (±1/64)	916-52
3-13/32							2-9/16		816-53	2-15/32		916-53
3-15/32							2-5/8		816-54	2-17/32		916-54
3-17/32							2-11/16		816-55	2-19/32		916-55
3-19/32							2-3/4		816-56	2-21/32		916-56
3-21/32							2-13/16		816-57	2-23/32		916-57
3-23/32							2-7/8		816-58	2-25/32		916-58
3-25/32							2-15/16		816-59	2-27/32		916-59
3-27/32							3		816-60	2-29/32		916-60
3-29/32							3-1/16		816-61	2-31/32		916-61
3-31/32							3-1/8		816-62	3-1/32		916-62
4-1/32							3-3/16		816-63	3-3/32		916-63
4-3/32							3-1/4		816-64	3-5/32		916-64

Figure 6-26 (Sheet 6 of 7) Screw, Flat Head, Structural (AN509)

Size	Ultimate Tensile Strength (Minimum) Pounds [1]			Ultimate Double Shear Strength (Minimum) Pounds [2]		
	Low-alloy Steel	Corrosion-resistant Steel	Aluminum Alloy	Low-alloy Steel	Corrosion-resistant Steel	Aluminum Alloy
Coarse Thread						
No. 6-32 NC-3	1,120	760	560	2,120	1,480	1,080
No. 8-32 NC-3	1,740	1,180	860	3,000	2,100	1,570
No. 10-24 NC-3	2,170	1,480	1,080	4,250	2,770	2,092
1/4-20 NC-3	3,960	2,700	1,960	7,360	5,000	3,650
5/16-18 NC-3	6,520	4,440	3,230	11,500	7,820	5,700
Fine Thread						
No. 6-40 NF-3	1,260	860	630	2,120	1,480	1,080
No. 8-36 NF-3	1,820	1,240	900	3,000	2,100	1,570
No. 10-32 NF-3	2,490	1,690	1,230	4,250	2,770	2,092
1/4-28 NF-3	4,520	3,080	2,240	7,360	5,000	3,650
5/16-24 NF-3	7,240	4,920	3,590	11,500	7,820	5,700
3/8-24 NF-3	10,950	7,450	5,430	16,560	11,250	8,250
7/16-20 NF-3	14,800	10,070	7,350	22,500	15,300	11,200
1/2-20 NF-3	19,950	13,750	9,900	29,400	20,000	14,600
9/16-18 NF-3	25,300	17,200	12,560	37,400	25,300	18,500

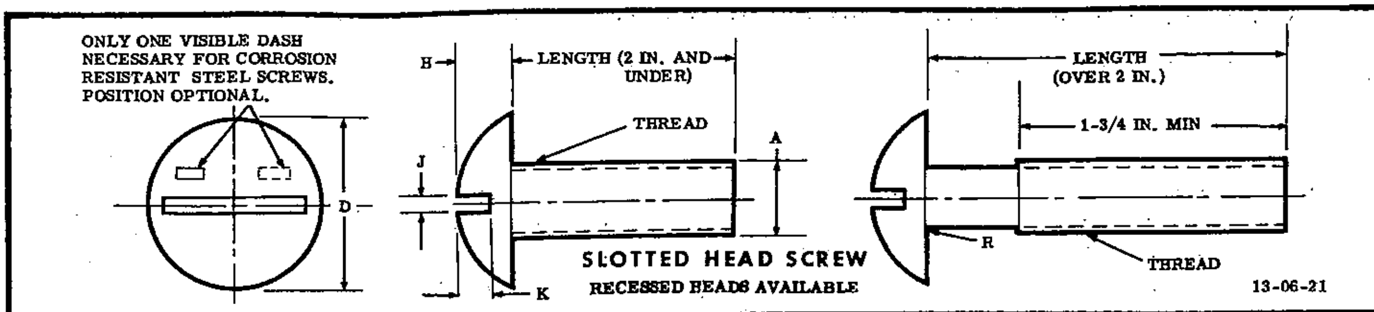
Strength Requirements

1. The values shown for the ultimate tensile strengths are for minimum values and are based on: 125,000 psi for low-alloy steels.
85,000 psi for corrosion-resistant steels.
62,000 psi for aluminum alloy.

The stress areas used for the calculation of the tensile strength values are based on the average of the mean pitch and minor diameters of the external thread.

2. Ultimate shear strengths are computed on the basis of 60 percent of the ultimate tensile strengths.

Figure 6-26 (Sheet 7 of 7) Screw, Flat Head, Structural (AN509)



Size		A Dia. Max.	D Dia.		H Max.	J		K		R Rad. Max.	UTS Root Dia. based on 55,000 psi	Single Shear Root Dia.
			Max.	Min.		Max.	Min.	Max.	Min.			
No. 2-56	NC-2A	.086	.162	.146	.069	.031	.023	.048	.037	.009	170	102
No. 3-48	NC-2A	.099	.187	.169	.078	.035	.027	.053	.040	.010	225	135
No. 4-40	NC-2A	.112	.211	.193	.086	.039	.031	.058	.044	.013	275	165
No. 5-40	NC-2A	.125	.236	.217	.095	.043	.035	.063	.047	.013	370	222
No. 6-32	NC-2A	.138	.260	.240	.103	.048	.039	.068	.051	.016	410	246
No. 8-32	NC-2A	.164	.309	.287	.120	.054	.045	.077	.058	.016	660	396
No. 10-24	NC-2A	.190	.359	.334	.137	.060	.050	.087	.065	.020	800	480
1/4-20	UNC-2A	.250	.472	.443	.175	.075	.064	.109	.082	.025	1480	890
5/16-18	UNC-2A	.313	.590	.557	.216	.084	.072	.132	.099	.028	2500	1500
3/8-16	UNC-2A	.375	.708	.670	.256	.094	.081	.155	.117	.031	3730	2240
No. 0-80	NF-2A	.060	.113	.099	.053	.023	.016	.039	.029	.006	82	49
No. 1-72	NF-2A	.073	.138	.122	.061	.026	.019	.044	.033	.007	132	79
No. 2-64	NF-2A	.086	.162	.146	.069	.031	.023	.048	.037	.008	187	112
No. 3-56	NF-2A	.099	.187	.169	.078	.035	.027	.053	.040	.009	247	148
No. 4-48	NF-2A	.112	.211	.193	.086	.039	.031	.058	.044	.010	313	188
No. 5-44	NF-2A	.125	.236	.217	.095	.043	.035	.063	.047	.011	396	238
No. 6-40	NF-2A	.138	.260	.240	.103	.048	.039	.068	.051	.013	478	287
No. 8-36	NF-2A	.164	.309	.287	.120	.054	.045	.077	.058	.014	705	423
No. 10-32	NF-2A	.190	.359	.334	.137	.060	.050	.087	.065	.016	960	575
1/4-28	UNF-2A	.250	.472	.443	.175	.075	.064	.109	.082	.018	1790	1075

Figure 6-27 (Sheet 1 of 3) Screw, Round Head, (AN515 and AN520)

Material and Finish Specification: Same as AN507

Procurement Specification: FF-S-91

Add R between first and second dash numbers for recessed-head screws.
Add B before first dash number for brass screws with black oxide finish.
Add PB before first dash number for cadmium plated brass screws.
Add UB before first dash number for plain brass screws.
Add C before first dash number for corrosion-resistant steel screws.
Add DD before first dash number for aluminum alloy screws.

Dash Numbers for Carbon Steel Screws - AN520 Fine Thread

L Length		*No. 0-80	*No. 1-72	*No. 2-64	*No. 3-56	*No. 4-48	*No. 5-44	*No. 6-40	*No. 8-36	No. 10-32	1/4-28
1/8		0-2	1-2								
3/16		0-3	1-3	2-3	3-3	4-3					
1/4		0-4	1-4	2-4	3-4	4-4	5-4	6-4	8-4	10-4	
5/16	+0	0-5	1-5	2-5	3-5	4-5	5-5	6-5	8-5	10-5	
3/8	-1/32	0-6	1-6	2-6	3-6	4-6	5-6	6-6	8-6	10-6	416-6
7/16		0-7	1-7	2-7	3-7	4-7	5-7	6-7	8-7	10-7	416-7
1/2		0-8	1-8	2-8	3-8	4-8	5-8	6-8	8-8	10-8	416-8
5/8				2-10	3-10	4-10	5-10	6-10	8-10	10-10	416-10
3/4				2-12	3-12	4-12	5-12	6-12	8-12	10-12	416-12
7/8						4-14	5-14	6-14	8-14	10-14	416-14
1						4-16	5-16	6-16	8-16	10-16	416-16
1-1/8						4-18	5-18	6-18	8-18	10-18	416-18
1-1/4						4-20	5-20	6-20	8-20	10-20	416-20
1-3/8						4-22	5-22	6-22	8-22	10-22	416-22
1-1/2	+0					4-24	5-24	6-24	8-24	10-24	416-24
1-5/8	-1/16					4-26	5-26	6-26	8-26	10-26	416-26
1-3/4						4-28	5-28	6-28	8-28	10-28	416-28
1-7/8								6-30	8-30	10-30	416-30
2								6-32	8-32	10-32	416-32
2-1/4	+0							6-36	8-36	10-36	416-36
2-1/2	-3/32							6-40	8-40	10-40	416-40
2-3/4									8-44	10-44	416-44
3									8-48	10-48	416-48

*Not preferred for airframe use.

Figure 6-27 (Sheet 2 of 3) Screw, Round Head, (AN515 and AN520)

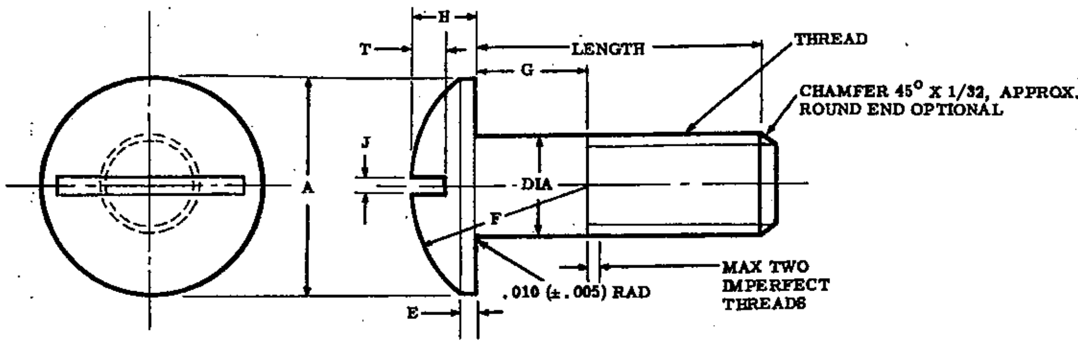
Examples of Part Numbers:

AN515-4-8 = No.4-40 carbon steel screw, 1/2 inch long, slotted head.
AN515B6R10 = No.6-32 brass screw with black oxide finish, 5/8 inch long, recessed head.
AN515B10-24 = No.10-24 brass screw with black oxide finish, 1-1/2 inch long, slotted head.
AN515PB8-7 = No.8-32 cadmium plated brass screw, 7/16 inch long, slotted head.
AN520UB3-10 = No.3-56 plain brass screw, 5/8 inch long, slotted head.
AN520C5-16 = No.5-44 corrosion-resistant steel screw, 1 inch long, slotted head.
AN520DD416-8 = No.1/4-28 aluminum alloy screw, 1/2 inch long, slotted head.

Dash Numbers for Carbon Steel Screws - AN515 Coarse Thread

L Length		No. 2-56	*No. 3-48	No. 4-40	*No. 5-40	No. 6-32	No. 8-32	*No. 10-24	*1/4-20	*5/16-18	*3/8-16
1/8		2-2	3-2								
3/16		2-3	3-3	4-3	5-3	6-3					
1/4		2-4	3-4	4-4	5-4	6-4	8-4	10-4			
5/16	+0	2-5	3-5	4-5	5-5	6-5	8-5	10-5	416-5		
3/8	-1/32	2-6	3-6	4-6	5-6	6-6	8-6	10-6	416-6		
7/16		2-7	3-7	4-7	5-7	6-7	8-7	10-7	416-7		
1 1/2		2-8	3-8	4-8	5-8	6-8	8-8	10-8	416-8	516-8	616-8
5/8		2-10	3-10	4-10	5-10	6-10	8-10	10-10	416-10	516-10	616-10
3/4		2-12	3-12	4-12	5-12	6-12	8-12	10-12	416-12	516-12	616-12
7/8			3-14	4-14	5-14	6-14	8-14	10-14	416-14	516-14	616-14
1			3-16	4-16	5-16	6-16	8-16	10-16	416-16	516-16	616-16
1-1/8				4-18	5-18	6-18	8-18	10-18	416-18	516-18	616-18
1-1/4				4-20	5-20	6-20	8-20	10-20	416-20	516-20	616-20
1-3/8				4-22	5-22	6-22	8-22	10-22	416-22	516-22	616-22
1-1/2	+0			4-24	5-24	6-24	8-24	10-24	416-24	516-24	616-24
1-5/8	-1/16			4-26	5-26	6-26	8-26	10-26	416-26	516-26	616-26
1-3/4				4-28	5-28	6-28	8-28	10-28	416-28	516-28	616-28
1-7/8						6-30	8-30	10-30	416-30	516-30	616-30
2						6-32	8-32	10-32	416-32	516-32	616-32
2-1/4						6-36	8-36	10-36	416-36	516-36	616-36
2-1/2	+0					6-40	8-40	10-40	416-40	516-40	616-40
2-3/4	-3/32						8-44	10-44	416-44	516-44	616-44
3							8-48	10-48	416-48	516-48	616-48

Figure 6-27 (Sheet 3 of 3) Screw, Round Head, (AN515 and AN520)



Size	Dia. +.000 -.002	A Dia.	B Dia.	C Rad.	E +.005 -.000	F Rad.	H (±.005)	J	T (±.005)
No. 8-32 NC-3 No. 8-36 NF-3	.164	.375	.312	.078	.023	.312	.087	.043 +.007 -.006	.049
No. 10-32 NF-3	.190	.437	.375	.078	.025	.398	.094	.047 +.008 -.006	.054
No. 1/4-28 NF-3	.250	.500	.437	.097	.028	.474	.101	.053 +.013 -.002	.058

Material: Steel, Specification AN-QQ-S-689, (SAE 2330) tensile strength, 125,000 psi (min.). Aluminum alloy, Specification QQ-A-354, (AL 24), tensile strength, 62,000 psi (min.).

Finish: Steel, cadmium plated, or zinc plated. Aluminum alloy, anodized.

Procurement Specification: AN-S-52.

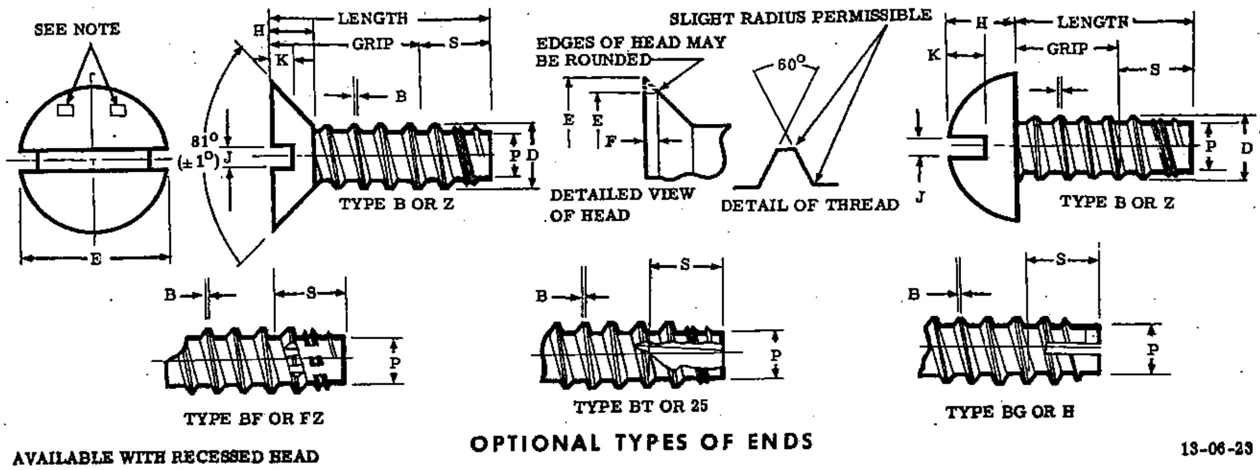
Add R between first and second dash numbers for recessed head screws.
Add D before first dash number for aluminum alloy screws, size 8 available with NC thread only.

Example of Part No:
AN525-10-6 = No.10-32 slotted head steel screw, 3/8 long with 1/32 grip.
AN525D10-6 = No.10-32 slotted head aluminum alloy screw, 3/8 long with 1/32 grip.
AN525-10R6 = No.10-32 recessed head steel screw, 3/8 long with 1/32 grip.

Figure 6-28 (Sheet 1 of 2) Screw, Washer Head (AN525)

Length (±1/32)	G	Dash Numbers for Slotted Head Steel Screws.			
		No. 8-32	No. 8-36	No. 10-32	1/4-28
3/8	1/32	832-6	8-6	10-6	416-6
7/16	1/16	832-7	8-7	10-7	416-7
1/2	1/8	832-8	8-8	10-8	416-8
9/16	5/32	832-9	8-9	10-9	416-9
5/8	7/32	832-10	8-10	10-10	416-10
11/16	9/32	832-11	8-11	10-11	416-11
3/4	11/32	832-12	8-12	10-12	416-12
7/8	15/32	832-14	8-14	10-14	416-14
1	19/32	832-16	8-16	10-16	416-16
1-1/8	23/32	832-18	8-18	10-18	416-18
1-1/4	27/32	832-20	8-20	10-20	416-20
1-3/8	31/32	832-22	8-22	10-22	416-22
1-1/2	1-3/32	832-24	8-24	10-24	416-24
1-5/8	1-7/32	832-26	8-26	10-26	416-26
1-3/4	1-11/32	832-28	8-28	10-28	416-28
1-7/8	1-15/32	832-30	8-30	10-30	416-30
2	1-19/32	832-32	8-32	10-32	416-32

Figure 6-28 (Sheet 2 of 2) Screw, Washer Head (AN525)



AN531 Flat Head

Size	Threads Per Inch	D Max. Dia.	E Dia. Max. Sharp	E Dia. Min. Sharp	E Dia. Min.+ Max.F	F Max.	H Max.	H Min.	J Max.	J Min.	K Max.	K Min.	P Dia. Max.	P Dia. Min.
No. 4	24	.114	.225	.207	.200	.016	.067	.055	.039	.031	.030	.020	.079	.074
No. 6	20	.139	.279	.257	.249	.019	.083	.069	.048	.039	.038	.024	.095	.089
No. 8	18	.166	.332	.308	.300	.022	.100	.084	.054	.045	.045	.029	.112	.106
No. 10	16	.189	.385	.359	.348	.025	.116	.098	.060	.050	.053	.034	.130	.123
1/4	14	.246	.491	.461	.447	.031	.148	.127	.075	.064	.068	.044	.179	.171

AN530 Round Head

Size	Threads Per Inch	D Max. Dia.	E Dia. Max.	E Dia. Min.	H Max.	J Max.	J Min.	K Max.	K Min.	P Dia. Max.	P Dia. Min.
No. 2	32	.088	.162	.146	.069	.031	.023	.048	.037	.058	.054
No. 4	24	.114	.211	.193	.086	.039	.031	.058	.044	.079	.074
No. 6	20	.139	.260	.240	.103	.048	.039	.068	.051	.095	.089
No. 8	18	.166	.309	.287	.120	.054	.045	.077	.058	.112	.106
No. 10	16	.189	.359	.334	.137	.060	.050	.087	.065	.130	.123
1/4	14	.246	.457	.429	.170	.075	.064	.106	.080	.179	.171

Marking for corrosion-resistant steel screws. Only one dash need be visible. Position optional. No marking required on heads of No.2 and No.4 screws.

The grip length is measured from the underside of the head to the end of the full threaded portion of the shank. The minimum grip dimensions shown in the dash number table are for design purposes only and are not an inspection requirement.

Maximum crest of thread, B, up to and including size No.8 equals 0.004 inch. Maximum crest of thread over size No.8 equals 0.006 inch. Tapered threads have unfinished crests.

Taper length, S, is 2 to 2-1/2 times the pitch of the thread.

Screws designated as thread forming have plain ends (not fluted or slotted). Screws designated as thread cutting have fluted or slotted ends.

Material: Alloy steel, case hardened, or corrosion-resistant steel.

Finish: Alloy steel, cadmium plated. Corrosion-resistant steel. None.

Procurement Specification: MIL-S-6033.

Add C before first dash number for corrosion-resistant steel screws.

Add F between first and second dash numbers for screws with fluted or slotted

Figure 6-29 (Sheet 1 of 2) Screw, Sheet Metal (AN530 and AN531)

Length		No. 2		No. 4		No. 6		No. 8		No. 10		1/4	
		Dash No.	Grip Min.	Dash No.	Grip Min.	Dash No.	Grip Min.	Dash No.	Grip Min.	Dash No.	Grip Min.	Dash No.	Grip Min.
AN531 Flat Head													
1/4				4-4	.115								
3/8	+0			4-6	.240	6-6	.219	8-6	.205				
1/2	-1/32			4-8	.365	6-8	.344	8-8	.330	10-8	.313		
5/8						6-10	.469	8-10	.455	10-10	.438	14-10	.415
3/4						6-12	.578	8-12	.564	10-12	.547	14-12	.524
7/8	+0					6-14	.703	8-14	.689	10-14	.672	14-14	.649
1	-3/64					6-16	.828	8-16	.814	10-16	.797	14-16	.774
1-1/4						6-20	1.078	8-20	1.203	10-20	1.047	14-20	1.024
1-1/2						6-24	1.328	8-24	1.314	10-24	1.297	14-24	1.274
1-3/4								8-28	1.549	10-28	1.532	14-28	1.509
2	+0							8-32	1.800	10-32	1.782	14-32	1.759
2-1/4	-1/16							8-36	2.049	10-36	2.032	14-36	2.009
2-1/2								8-40	2.300	10-40	2.282	14-40	2.259
AN530 Round Head													
3/16		2-3	.078										
1/4	+0	2-4	.141	4-4	.115	6-4	.094						
3/8				4-6	.240	6-6	.219	8-6	.205	10-6	.188		
1/2	-1/32			4-8	.365	6-8	.344	8-8	.330	10-8	.313		
5/8						6-10	.469	8-10	.455	10-10	.438	14-10	.415
3/4						6-12	.578	8-12	.564	10-12	.547	14-12	.524
7/8	+0					6-14	.708	8-14	.689	10-14	.672	14-14	.649
1	-3/64					6-16	.828	8-16	.814	10-16	.797	14-16	.774
1-1/4						6-20	1.078	8-20	1.203	10-20	1.047	14-20	1.024
1-1/2						6-24	1.328	8-24	1.314	10-24	1.297	14-24	1.274
1-3/4	+0							8-28	1.549	10-28	1.512	14-28	1.509
2	-1/16							8-32	1.800	10-32	1.782	14-32	1.759
2-1/4								8-36	2.049	10-36	2.013	14-36	2.009
2-1/2								8-40	2.300	10-40	2.282	14-40	2.259

ends. (Thread cutting). If R reappears in coding, add F immediately following R. Add R between first and second dash numbers for recessed head screws.

Examples of Part Numbers:

AN530-6-8 = No.6, alloy steel, slotted head, thread forming screw, 8/16 in length.

AN530-6R8 = No.6, alloy steel, recessed head, thread forming screw, 8/16 in length.

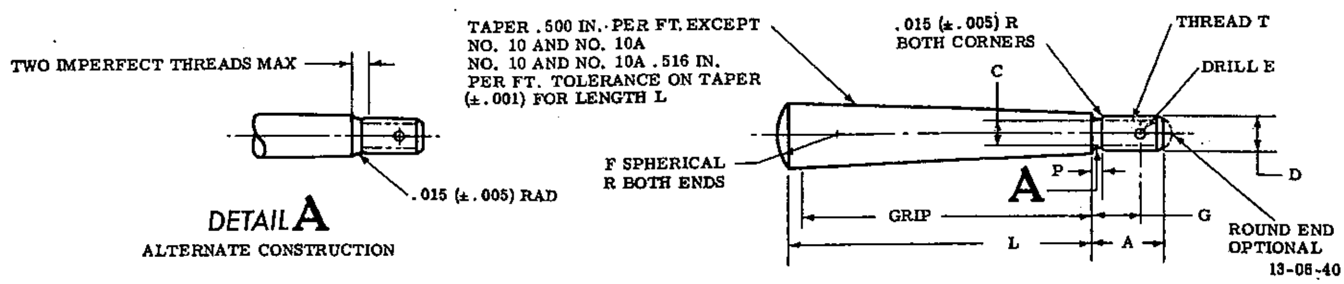
AN530-6RF8 = No.6, alloy steel, recessed head, fluted or thread cutting screw, 8/16 in length.

AN530C6-8 = No.6, corrosion-resistant steel, slotted head, thread forming screw, 8/16 in length.

AN530C6R8 = No.6, corrosion-resistant steel, recessed head, thread forming screw, 8/16 in length.

AN530C6RF8 = No.6, corrosion-resistant steel, recessed head, fluted or thread cutting screw, 8/16 in length.

Figure 6-29 (Sheet 2 of 2) Screw, Sheet Metal (AN530 and AN531)



Dimensions	First Dash Numbers				
	1	2	3	4	5
Thread T	10-32	10-32	1/4-28	5/16-24	3/8-24
A	7/16	7/16	29/64	33/64	35/64
C(±.005)	.141	.141	.196	.250	.313
D(±.002)	.205	.255	.317	.355	.455
E (+.010) (-.000)	No. 50 (.070)	No. 50 (.070)	No. 48 (.076)	No. 48 (.076)	No. 36 (.106)
F	1/2	1/2	1/2	1/2	1/2
G	5/16	5/16	21/64	21/64	23/64
P	3/64	3/64	3/64	1/16	1/16

Dimensions	First Dash Numbers					
	6	7	8	9	10	10A
Thread T	7/16-20	1/2-20	9/16-18	3/4-16	7/8-14	7/8-14
A	35/64	19/32	21/32	47/64	51/64	51/64
C(±.005)	.360	.422	.482	.660	.773	.773
D(±.002)	.505	.605	.755	.905	1.050	1.153
E (+.010) (-.000)	No. 36 (.106)	No. 36 (.106)	No. 28 (.141)	No. 28 (.141)	No. 28 (.141)	No. 28 (.141)
F	3/4	3/4	1	1	1-1/4	1-1/4
G	23/64	13/32	15/32	35/64	39/64	39/64
P	1/16	1/16	5/64	3/32	3/32	3/32

Engineering Information					
	1	2	3	4	5
Nut	AN320-3	AN320-3	AN320-4	AN320-5	AN320-6
Washer *	AN975-3	AN975-3	AN975-4	AN975-5	AN975-6
Cotter	AN380-2-2	AN380-2-2	AN380-2-2	AN380-2-2	AN380-3-3
Self Lock-nut	AN364-1032	AN364-1032	AN364-428	AN364-524	AN364-624

Engineering Information						
	6	7	8	9	10	10A
Nut	AN320-7	AN320-8	AN320-9	AN320-12	AN320-14	AN320-14
Washer *	AN975-7	AN975-8	AN975-9	AN975-12	AN975-14	AN975-14
Cotter	AN380-3-3	AN380-3-3	AN380-4-4	AN380-4-5	AN380-4-5	AN380-4-5
Self Lock-nut	AN364-720	AN364-820	AN364-918	AN364-1216	AN364-1414	AN364-1414

Figure 6-30 (Sheet 1 of 2) Pin, Threaded Taper (AN386)

Second Dash No. C.P. Hole	Second Dash No. No. Hole	Grip	First Dash Numbers L=Grip(+1/8) 1	2	3	4	L=Grip(+3/16) 5	6	7	8	L=Grip(+1/4) 9	10	10A
6	6A	3/4											
7	7A	7/8											
8	8A	1											
9	9A	1-1/8											
10	10A	1-1/4											
11	11A	1-3/8											
12	12A	1-1/2											
13	13A	1-5/8											
14	14A	1-3/4											
15	15A	1-7/8											
16	16A	2											
17	17A	2-1/8											
18	18A	2-1/4											
19	19A	2-3/8											
20	20A	2-1/2											
21	21A	2-5/8											
22	22A	2-3/4											
23	23A	2-7/8											
24	24A	3											
25	25A	3-1/8											
26	26A	3-1/4											
27	27A	3-3/8											
28	28A	3-1/2											
29	29A	3-5/8											
30	30A	3-3/4											
31	31A	3-7/8											
32	32A	4											
34	34A	4-1/4											
36	36A	4-1/2											
38	38A	4-3/4											
40	40A	5											
42	42A	5-1/4											
44	44A	5-1/2											
46	46A	5-3/4											
48	48A	6											

Listings cover full range obtainable from standard B & S taper reamers, numbers of which are indicated by first dash number. No.10A requires No.10 reamer.

Do not specify pins longer than those listed between heavy lines.

*Washer used with both types of nuts.

Material: Steel, Specification: SAE 2330, SAE 4037, SAE 4130, SAE 8630, SAE 8735 or SAE 8740.

Tensile Strength: 125,000 to 145,000 psi.

Finish: Cadmium plate.

Examples of Part Numbers:

AN386-1-8 = Pin No. 1. Taper 8/8 or 1 in. grip with cotter-pin hole.

AN386-1-8A = Pin No. 1. Taper 8/8 or 1 in. grip without cotter-pin hole.

Place the following instructions on drawings, immediately after the pin number:

Small end of tapered shank shall not extend more than 1/16 in. above surface of work.

Tapered surface shall be smooth and free from tool marks.

Figure 6-30 (Sheet 2 of 2) Pin, Threaded Taper (AN386)

(AN255) SCREW, EXTERNALLY RELIEVED BODY

	For use with electrical junction box assemblies and not for aircraft structural use.
Material:	Carbon steel, cadmium plated.
Size Range and Lengths:	AN255-6 = 6-32, 7/16 inch long. AN255-8 = 8-32, 3/4 inch long. AN255-10 = 10-32, 3/4 inch long.

(AN508) SCREW, ROUND HEAD, MACHINE

	For electrical use.
Material:	Commercial brass, tin or silver plated.
Size Range:	AN508-4 = 4-40; AN508-6 = 6-32; AN508-8 = 8-32; AN508-10 = 10-32.
Lengths:	1/8 inch in 4-40 and 3/16 inch to 3/8 inch in Nos.6, 8 and 10.
Part No.Coding:	AN508-4-2 = 4-40, 1/8 inch long. AN508-6-3 = 6-32, 3/16 inch long.

(AN545) SCREW, WOOD, ROUND HEAD AND (AN550) SCREW, WOOD, FLAT HEAD

Material:	Steel or brass.
Size Range:	Nos.2,3,4,5,6,8,10,12,14 and 16 in steel. Brass screws available from No.2 to 12 only.
Part No. Coding:	AN545-10-6 = No.10 slotted head steel screw, 3/4 inch long. AN545B4-12 = No.4 slotted head brass screw, 1-1/2 inch long. AN550-6R4 = No.6 recessed head steel screw, 1/2 inch long. AN550B3-5 = No.3 slotted head brass screw, 5/8 inch long.

(AN526) SCREW, MACHINE, TRUSS HEAD

Material:	Carbon steel, corrosion-resistant steel and aluminum alloy. Material properties same as AN507.
Size Range:	6-32 to 1/4-20 and 6-40 to 1/4-28.
Lengths:	1/4 inch and 5/16 inch to 3 inches in Nos.6, 8 and 10. 3/8 inch to 3 inches in 1/4 inch size.

(Continued)

Figure 6-31 (Sheet 1 of 3) Screw Specifications

Part No. Coding: Similar to AN507.
AN526-632-4 = 6-32, carbon steel, 1/4 inch long, slotted head.
AN526C640R6 = 6-40, corrosion-resistant steel, recessed head, 3/8 inch long.
AN526DD832-5 = 8-32, aluminum alloy, 5/16 inch long, slotted head.

(AN565) SETSCREW, HEXAGON AND FLUTED SOCKET, HEADLESS

Material: High grade alloy steel (SAE 4037, 4137, 8630, 8740) corrosion-resistant steel.

Wrenching: Hexagon, 4-fluted and 6-fluted socket heads.

Points: A, flat point; B, cone point; D, cup point; E, half-dog point; F, oval point.

Size Range: 2-56, 4-40 and 6-32, with fluted socket.
2-56 to 8-32, with hex socket.
10-32 to 1/2-20 with hex socket.

Lengths: 1/16 inch to 3 inches.

Part No. Coding: AN565B1032H12 = 10-32, steel, type B point, hex socket, 3/4 inch long.
AN565B4L5 = 4-40, steel, type B point, fluted socket, 5/16 inch long.
AN565AC428H7 = 1/4-28, corrosion-resistant steel, type A point, hex socket, 7/16 inch long.

(NAS220 TO NAS226) SCREW, BRAZIER HEAD, PHILLIPS RECESS

Material: Alloy steel, same as AN3 series, cadmium plated. High-strength bronze, 85,000 psi, cadmium plated. Aluminum alloy, same as AN3 series, anodized.

NAS220
Size: 8-32
Length: 9/32 inch (Dash No.4) to 2-13/32 inches (Dash No.38)
For grip length, subtract 7/16 inch.

NAS221
Size: 10-32
Length: 9/32 inch (Dash No.4) to 3-1/32 inches (Dash No.48)
For grip length, subtract 15/32 inch.

NAS222
Size: 1/4-28
Length: 11/32 inch (Dash No.5) to 3-1/32 inches (Dash No.48)
For grip length, subtract 17/32 inch.

(Continued)

Figure 6-31 (Sheet 2 of 3) Screw Specifications

NAS223	Size:	5/16-24
	Length:	23/64 inch (Dash No.5) to 3-3/64 inches (Dash No.48).
	For grip length, subtract 37/64 inch.	
NAS224	Size:	3/8-24
	Length:	13/32 inch (Dash No.5) to 3-3/32 inches (Dash No.48).
	For grip length, subtract 11/16 inch.	
NAS225	Size:	7/16-20
	Length:	29/64 inch (Dash No.6) to 3-5/64 inches (Dash No.48).
	For grip length, subtract 45/64 inch.	
NAS226	Size:	1/2-20
	Length:	29/64 inch (Dash No.6) to 4-5/64 inches (Dash No.64).
	For grip length, subtract 53/64 inch.	

Increments in 1/16 inch.

Part No.Coding: NAS220-7 = 8-32, steel, 15/32 inch long.
NAS221DD8 = 10-32, aluminum alloy, 17/32 inch long.
NAS222BZ9 = 1/4-28, bronze, 19/32 inch long.

(NAS387) SCREW, 100° OVAL RECESSED HEAD, MACHINE, NF AND NC THREAD

Material: Steel, cadmium plated. Code letter P indicates chromium plating.

Size Range: 4-40, 6-32 and 8-32.
10-32, 1/4-28, 5/16-24 and 3/8-24.

Lengths: 3/16 inch to 3 inches.

Part No.Coding: NAS387-440-8 = 4-40, 1/2 inch long.
NAS387-440-7P = 4-40, 7/16 inch long, chromium plated.
NAS387-616-12 = 3/8-16, 3/4 inch long.

(NAS517) SCREW, 100° CLOSE TOLERANCE, FLAT HEAD

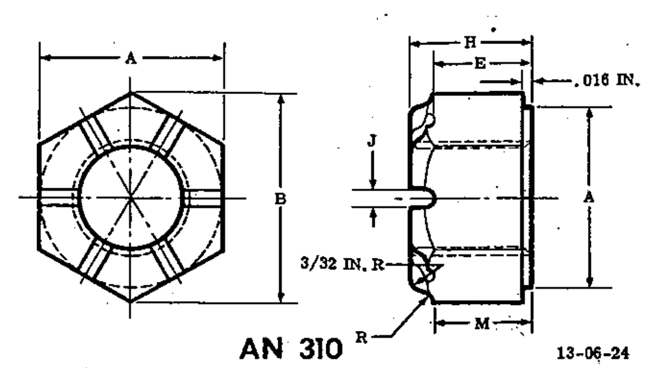
Material: Alloy steel, same as AN509, but heat treated 160,000 to 180,000 psi. Cadmium plated.

Size Range: 8-32 and from 10-32 to 1/2-20.

Grip Lengths: Fully threaded to 2 inches.

Part No.Coding: NAS517-2-10 = 8-32, 5/8 inch grip.
NAS517-4-17 = 1/4-28, 1-1/16 inch grip.

Figure 6-31 (Sheet 3 of 3) Screw Specifications



Finish:
Steel nuts: Cadmium plated. Aluminum alloy nuts: Anodized. Stainless steel nuts: Passivated.

Procurement Specification:

MIL-N-6034

Add C before dash number for corrosion-resistant steel nuts.

Add D before dash number for aluminum alloy.

Examples of Part Nos.

AN310C4 - Corrosion-resistant steel nut, 1/4-28 NF-3.

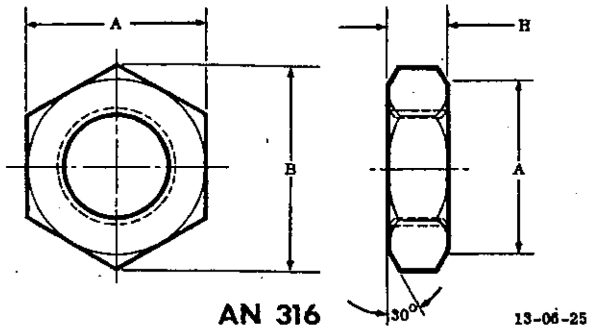
AN310D8 - Aluminum alloy nut, 1/2-20 NF-3.

AN310-5 - Steel nut, 5/16-24 NF-3.

Material Specification: (See Figure 6-33.)

Part No. AN 310	Thread T NF-3	UTS Minimum lbs.		A	B Approx.	E	H	J +1/32 -0	M	R
		Steel	Al. Alloy							
-3	No. 10-32	2,210	1,100	.375 +.002/-.010	7/16	7/64	1/4	5/64	.110	3/32
-4	1/4 -28	4,080	2,030	.438 +.002/-.010	1/2	1/8	9/32	5/64	.125	3/32
-5	5/16-24	6,500	3,220	.500 +.002/-.010	37/64	11/64	21/64	5/64	.172	3/32
-6	3/8 -24	10,100	5,020	.563 +.002/-.010	21/32	7/32	13/32	1/8	.218	3/32
-7	7/16-20	13,600	6,750	.625 +.002/-.011	23/32	17/64	29/64	1/8	.265	3/32
-8	1/2 -20	18,500	9,180	.750 +.002/-.012	7/8	23/64	9/16	1/8	.359	1/8
-9	9/16-18	23,600	11,700	.875 +.002/-.012	1- 1/64	25/64	39/64	5/32	.390	5/32
-10	5/8 -18	30,100	14,900	1.000 +.002/-.014	1- 5/32	15/32	23/32	5/32	.468	5/32
-12	3/4 -16	44,000	21,800	1.125 +.002/-.016	1-19/64	9/16	13/16	5/32	.562	3/16
-14	7/8 -14	60,000	29,800	1.313 +.002/-.017	1-33/64	21/32	29/32	5/32	.656	3/16
-16	1 -14	80,700	40,000	1.500 +.002/-.019	1-47/64	3/4	1	5/32	.750	3/16
-18	1-1/8 -12	101,800	50,500	1.688 +.002/-.021	1-61/64	13/16	1- 5/32	5/32	.844	1/4
-20	1-1/4 -12	130,200	64,400	1.875 +.002/-.023	2-11/64	7/8	1- 1/4	5/32	.938	1/4

Figure 6-32 Nut, Castle (AN310)



Finish:
Steel nuts: Cadmium plated. Stainless steel nuts: Passivated.

Procurement Specification: MIL-N-6034

Add C before dash number for corrosion-resistant steel nuts.

Add R after dash number for RH thread.

Add L after dash number for LH thread.

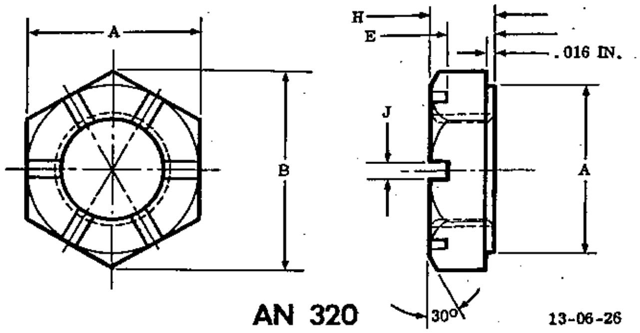
Examples of Part Nos.
AN316-4R - Steel nut, 1/4-28 NF-3, RH thread.
AN316C4L - Corrosion-resistant nut, 1/4-28, LH thread.
AN316-5R - Steel nut, 5/16-24 NF-3, RH thread.

Part No. AN316	Thread T NF-3	UTS Minimum lbs.	A	B Approx.	H
-4	1/4	2,040	.438 +.002 -.010	1/2	1/8
-5	5/16	3,250	.500 +.002 -.010	37/64	5/32
-6	3/8	5,050	.563 +.002 -.010	21/32	3/16
-7	7/16	6,800	.625 +.002 -.011	23/32	7/32
-8	1/2	9,250	.750 +.002 -.012	7/8	1/4
-9	9/16	11,800	.875 +.002 -.012	1- 1/64	9/32
-10	5/8	15,050	1.000 +.002 -.014	1- 5/32	5/16
-12	3/4	22,000	1.125 +.002 -.016	1-19/64	3/8
-14	7/8	30,000	1.313 +.002 -.017	1-33/64	7/16
-16	1	40,350	1.500 +.002 -.019	1-47/64	1/2

Material Specifications for Figures 6-32, 6-33 and 6-34

Material Specification	Material and SAE Nos.
MIL-S-6049	Steel; Chrome-nickel-molybdenum (8740)
MIL-S-6050	Steel; Chrome-nickel-molybdenum (8630)
MIL-S-6098	Steel; Chrome-nickel-molybdenum (8735)
MIL-S-6721	Steel; Corrosion and heat resistant (18-8 stabilized)
MIL-S-6758	Steel; Chrome-molybdenum (4130)
MIL-S-7097	Steel; Carbon (1018, 1020, or 1025)
MIL-S-7720	Steel; Corrosion-resistant (18-8)
MIL-S-7952	Steel; Sheet and strip, uncoated carbon (1020 and 1025)
AN-S-4	Steel; Carbon (1035)
AN-S-9	Steel; Molybdenum (4037)
AN-QQ-S-689	Steel; Nickel (2330)
QQ-A-354 or QQ-A-355	Aluminum alloy (24S) (AN310 and AN320 only)
AN-QQ-S-689	Steel; Nickel (2330)
QQ-A-354 or QQ-A-355	Aluminum alloy (24S) (AN310 and AN320 only)

Figure 6-33 Nut, Check (AN316)



Add C before dash number for corrosion-resistant steel nuts.

Add D before dash number for aluminum alloy.

Examples of Part Nos.

AN320-3 - Steel nut, 10-32 NF-3.
AN320C4 - Corrosion-resistant nut, 1/4-28.
AN320-5 - Steel nut, 5/16-24 NF-3.
AN320D8 - Aluminum alloy nut, 1/2-20 NF-3.

Finish:
Steel nuts: Cadmium plated. Aluminum alloy nuts: Anodized. Stainless steel nuts: Passivated.

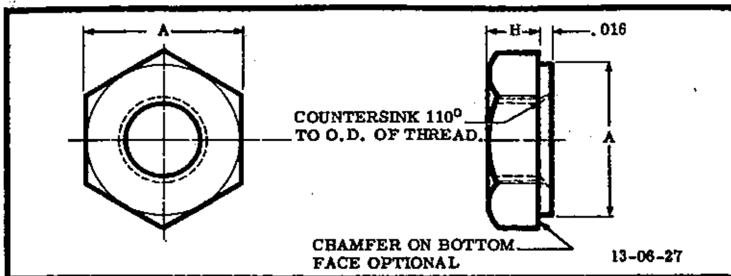
Procurement Specification:

MIL-N-6034

Material Specification: (See Figure 6-33.)

Part No. AN320	Thread T NF-3	UTS Minimum lbs.		A	B Approx.	E	H	J +1/32 -0
		Steel	Al. Alloy					
-1	No. 6-40	-	-	.313 +.002 -.010	23/64	5/64	5/32	5/64
-2	No. 8-36	-	-	.344 +.002 -.010	25/64	5/64	5/32	5/64
-3	No. 10-32	1,105	550	.375 +.002 -.010	7/16	3/32	3/16	5/64
-4	1/4 -28	2,040	1,015	.438 +.002 -.010	1/2	3/32	3/16	5/64
-5	5/16-24	3,250	1,610	.500 +.002 -.010	37/64	3/32	3/16	5/64
-6	3/8 -24	5,050	2,510	.563 +.002 -.010	21/32	7/64	7/32	1/8
-7	7/16-20	6,800	3,375	.625 +.002 -.011	23/32	7/64	7/32	1/8
-8	1/2 -20	9,250	4,590	.750 +.002 -.012	7/8	9/64	1/4	1/8
-9	9/16-18	11,800	5,850	.875 +.002 -.012	1- 1/64	3/16	5/16	5/32
-10	5/8 -18	15,050	7,450	1.000 +.002 -.014	1- 5/32	3/16	5/16	5/32
-12	3/4 -16	22,000	10,900	1.125 +.002 -.016	1-19/64	1/4	3/8	5/32
-14	7/8 -14	30,000	14,900	1.313 +.002 -.017	1-33/64	5/16	7/16	5/32
-16	1 -14	40,350	20,000	1.500 +.002 -.019	1-47/64	3/8	1/2	5/32
-18	1-1/8 -12	50,900	25,250	1.688 +.002 -.021	1-61/64	13/32	9/16	5/32
-20	1-1/4 -12	65,100	32,200	1.875 +.002 -.023	2-11/64	15/32	5/8	5/32

Figure 6-34 Nut, Castle, Shear (AN320)



AN340

Dash No.	Thread	A	H
2	No. 2-56 NC-2	.184 (± .004)	.061 +.005 -.004
3	No. 3-48 NC-2	.184 (± .004)	.061 +.005 -.004
4	No. 4-40 NC-2	.245 + .005 - .004	.092 +.006 -.005
5	No. 5-40 NC-2	.307 + .006 - .005	.108 (±.006)
6	No. 6-32 NC-2	.307 + .006 - .005	.108 (± .006)
8	No. 8-32 NC-2	.338 (± .006)	.123 + .007 - .006

AN341

Dash No.	Thread	A	H
4	No. 4-40 NC-2	.250 +.000 -.009	.092 +.006 -.005
6	No. 6-32 NC-2	.312 +.001 -.010	.108 (± .006)
8	No. 8-32 NC-2	.344 +.000 -.012	.123 +.007 -.006
10	No.10-32 NF-2	.374 +.001 -.012	.123 +.007 -.006
416	1/4-28 NF-2	.437 +.001 -.014	.185 +.008 -.007
516	5/16-24 NF-2	.562 +.001 -.017	.216 +.009 -.008
616	3/8-24 NF-2	.625 +.000 -.018	.248 (±.009)

AN345

Dash No.	Thread	A	H
0	No. 0-80 NF-2	.153 (±.003)	.046 +.004 -.003
10	No. 10-32 NF-2	.368 +.007 -.006	.123 +.007 -.006
416	1/4-28 NF-2B	.430 +.008 -.007	.185 +.008 -.007
516	5/16-24 UNF-2B	.555 +.008 -.010	.215 +.010 -.007
616	3/8-24 UNF-2B	.615 +.010 -.008	.245 +.012 -.007

AN340

Material: Carbon steel, commercial grade, 50,000 psi ultimate tensile strength. Corrosion-resistant steel, QQ-S-770. Aluminum alloy, 62,000 psi ultimate tensile strength. (Inactive for design after July 1955.) Commercial brass.

Finish: Steel, cadmium plated. Corrosion-resistant steel, passivated. Aluminum alloy, anodized. Brass, none.

AN341

Material: Brass, commercial grade.
Finish: Tin plate.

AN345

Material: Carbon steel, commercial grade, 50,000 psi ultimate tensile strength. Corrosion-resistant steel, QQ-S-770. Aluminum alloy, 62,000 psi ultimate tensile strength. (Inactive for design after July 1955.) Commercial brass.

Finish: Steel, cadmium plated. Corrosion-resistant steel, passivated. Aluminum alloy, anodized. Brass, none.

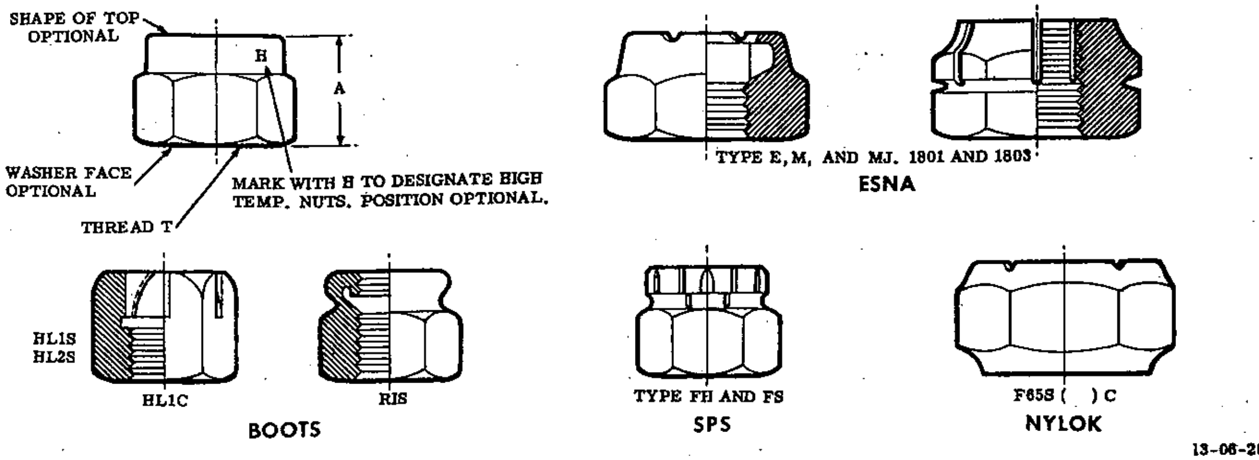
Add B before dash number for brass nuts.
Add C before dash number for corrosion-resistant steel nuts.
Add DD before dash number for aluminum alloy nuts.

AN340, AN341 and AN345

Examples of Part Numbers:
- AN340-6 = No.6-32 NC-2, Carbon steel nut.
- AN341-10 = No.10-32 NF-2 Brass nut.
- AN345B416 = 1/4-28 UNF-2B, Brass nut.
- AN345C516 = 5/16-24 UNF-2B, Corrosion-resistant nut.
- AN345DD10 = No.10-32 NF-2, Aluminum alloy nut.
- AN345-616 = 3/8-24 UNF-2B, Carbon steel nut.

Procurement Specification: MIL-S-933
- AN340 Nut - Non-structural (coarse thread).
- AN345 Nut - Non-structural (fine thread).
- AN341 Nut - Hexagon (for electrical use).

Figure 6-35 Nuts, Non-structural (AN340, AN341 and AN345)



All nuts are self-locking.

Parts listed as equivalent are functionally interchangeable.

AN Part numbers should be specified wherever possible. If a company's part is required, specify the commercial part number followed by the word ONLY.

Temperature Limits:

On AN365 (22NM, 42NE, 52NE, R1S, 22FS and F65S-C) = 250°F maximum.

On 59FH = 750° maximum.

On HL1C-SP = 1200°F maximum.

On AN363 (NMJ) = 250°F maximum.

On AN363 (1801, HL1S, HL2S and 22FH) = 550°F maximum.

On 1803 = 800°F Maximum.

NMJ series conform to strength requirements of AN365 series steel nuts.

Materials:

22NM, 42NE, 52NE, HL1S, HL2S, R1S, 1801, 22FH, 22FS and F65S-C - Carbon steel. NMJ, 14S-T6 - Anodized. HL1C-SP, 59FH and 1803 - Stainless steel.

Finish:

Carbon steel, cadmium plated. Stainless steel, silver plated.

Procurement Specification:

AN-N-10.

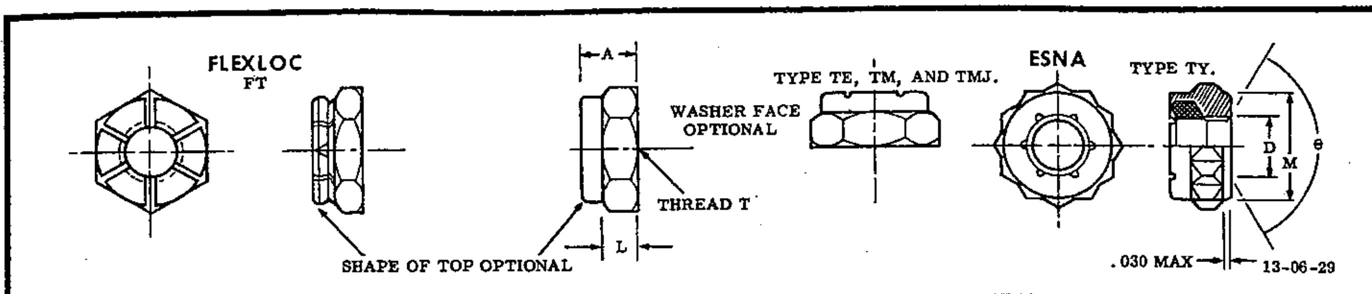
Figure 6-36 (Sheet 1 of 3) Nuts, Self-locking (AN363 and AN365)

AN363			
AN Part No.	Equivalent Commercial Part No.	Thread T	A
AN363 - 632	22FH - 632	6 - 32NC - 3	.172
AN363C632	59FH - 632		.172
AN363 - 832	22FH - 832	8 - 32NC - 2	.234
	1801 - 82	8 - 32NC - 3B	.245 (±.005)
AN363C832	59FH - 832	8 - 32NC - 2	.234
	1803 - 82	8 - 32NC - 3B	.245 (±.005)
AN363 - 1032	22FH - 1032	10 - 32NF - 3	.234
	1801 - 02		.245 (±.005)
	HL2S - 1032		.234 Nom.
AN363C1032	59FH - 1032		.234
	1803 - 02		.245 (±.005)
	HL1C1032SP		.234 Nom.
AN363 - 428	22FH - 428	1/4-28NF - 3	.312
	1801 - 048		.323 (±.005)
	HL2S - 428		.313 Nom.
AN363C428	59FH - 428		.312
	1803 - 048		.323 (±.005)
	HL1C428SP		.313 Nom.
AN363 - 524	22FH - 524	5/16-24NF - 3	.344
	1801 - 054		.355 (±.005)
	HL2S - 524		.344 Nom.
AN363C524	59FH - 524		.344
	1803 - 054		.355 (±.005)
	HL1C524SP		.344 Nom.
AN363 - 624	22FH - 624	3/8-24NF - 3	.453
	1801 - 064		.464 (±.005)
AN363C624	59FH - 624		.453
	1803 - 064		.464 (±.005)
	HL1C624SP		.453 Nom.
AN363 - 720	22FH - 720	7/16-20NF - 3	.453
AN363C720	59FH - 720		.453
AN363 - 820	22FH - 820	1/2-20NF - 3	.594
AN363C820	59FH - 820		.594

Figure 6-36 (Sheet 2 of 3) Nuts, Self-locking (AN363 and AN365)

AN365			
AN Part No.	Equivalent Commercial Part No.	Thread T	A
	NMJ - 62	6 - 32NC - 3B	.178 (±.010)
	NMJ - 82	8 - 32NC - 3B	.266
	NMJ - 02	10 - 32NF - 3	.266
AN365-440	22NM - 40	4 - 40NC - 3B	.143 (±.010)
	22FS - 440	4 - 40NC - 2	.141
AN365-632	22NM - 62	6 - 32NC - 3B	.178 (±.010)
	22FS - 632	6 - 32NC - 2	.172
AN365-832	22NM - 82	8 - 32NC - 3B	.229 (±.010)
	22FS - 832	8 - 32 - 2	.234
AN365-1032	22NM - 02	10-32NF - 3	.239 (±.010)
	R1S1032		.234 Nom.
	22FS - 1032		.234
	F65S1032C		.250
AN365-428	42NE - 048	1/4-28NF - 3	.313
	R1S428		.313 Nom.
	22FS - 428		.312
	F65S428C		.328
AN365-524	42NE - 054	5/16-24NF - 3	.344
	R1S524		.344 Nom.
	22FS - 524		.344
	F65S524C		.359
AN365-624	52NE - 064	3/8-24NF - 3	.453
	R1S624		.453 Nom.
	22FS - 624		.453
	F65S624C		.469
	HL1S624		.453 Nom.
AN365-720	52NE - 070	7/16-20NF - 3	.453
	R1S720		.453 Nom.
	22FS - 720		.453
AN365-820	52NE - 080	1/2-20NF - 3	.594
	R1S820		.594 Nom.
	22FS - 820		.594

Figure 6-36 (Sheet 3 of 3) Nuts, Self-locking (AN363 and AN365)



AN Part No.	Equivalent Commercial Part No.	Thread T	A	D	L Ref.	M Min.	θ
AN364-632	22NTM-62	6-32NC-3B	.125	.148 to .173	.090		120°
	22FT-632	6-32NC-2					
	NTMJ-632	6-32NC-3B	.132 (±.010)		.090		
AN364-832	22NTM-82	8-32NC-3B	.172	.174 to .199	.110		120°
	22FT-832	8-32NC-2					
	NTMJ-82	8-32NC-3B	.180 (±.010)		.110		
AN364-1032	22NTM-02	10-32NF-3	.172	.200 to .225	.110		120°
	22FT-1032						
	12TY-02		.172 (±.010)		.143	.300	
	NTMJ-02		.180 (±.010)		.110		
AN364-428	52NTE-048	1/4-28NF-3	.188 to .218	.265 to .280	.125		90°
	12TY-048		.203 (±.010)		.163	.365	
	22FT-428		.203				
	52NTE-054	5/16-24NF-3	.235 to .265	.327 to .342	.158		90°
	12TY-054				.195	.431	
	22FT-524		.250				
	52NTE-064	3/8-24NF-3	.251 to .281	.390 to .405	.150		90°
	12TY-064		.266		.207	.527	
	22FT-624						

All nuts are self-locking.

Parts listed as equivalent are functionally interchangeable.

AN Part numbers should be specified wherever possible. If a company's part is required, specify the commercial part number followed by the word ONLY.

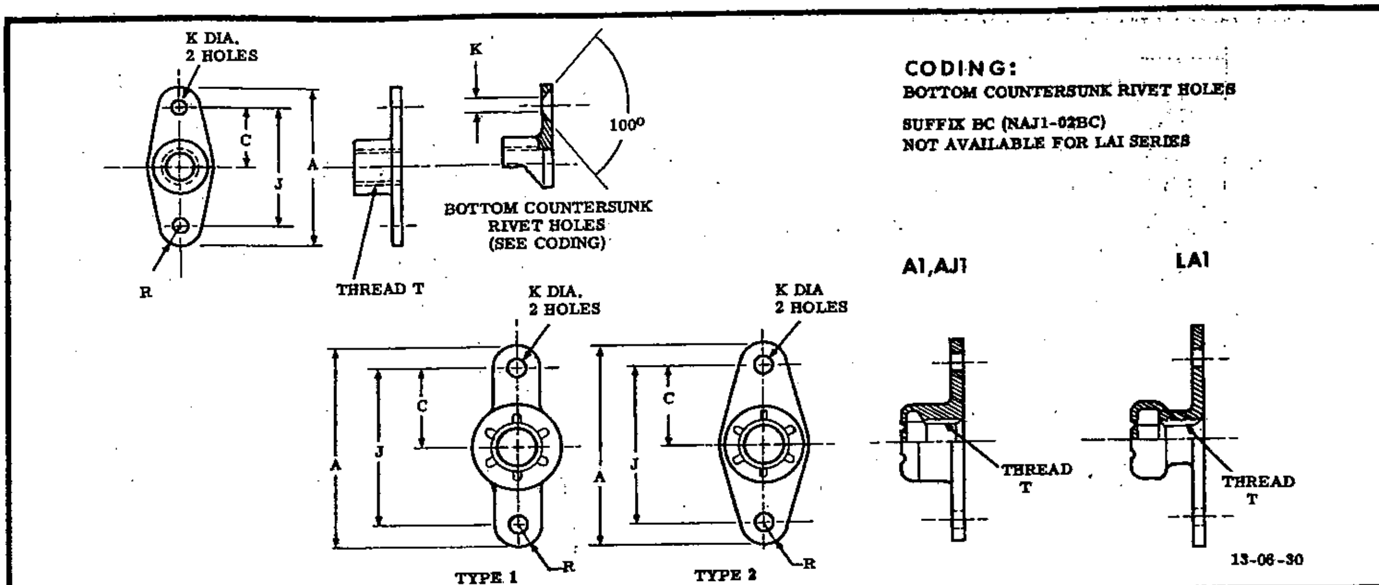
TMJ series and 22TM series are equivalent in strength.

Temperature Limits: 22NTM, 52NTE, 12TY, NTMJ = 250°F maximum. 22FT = 550°F maximum.

Materials: 22NTM, 52NTE, 12TY and 22FT - Carbon steel. NTMJ, 14S-T6 - Aluminum alloy. Locking insert, red nylon.

Finish: Carbon steel, cadmium plated. Aluminum alloy, anodized.

Figure 6-37 Nut, Self-locking (AN364)



AN Part No.	Thread T	Equivalent Commercial Part No.	Base Type	R	A	C	J (±.002)	K +.005 -.000
AN366F632	6-32NC-3B	22NA1-62	2	.141	.969			
		NAJ1-62	1	.115	.922			
AN366F832	8-32NC-3B	22NLA1-82		.141	.969	.344	.688	
		NAJ1-82	2	.115	.922			.0988
AN366F1032	10-32NF-3B	22NLA1-02		.141	.969			
	10-32NF-3	NAJ1-02	1	.115	.922			
AN366F428	1/4-28NF-3	22NLA1-048	2	.141	1.281	.500	1.000	
		NAJ1-048	1	.140				

AN Part numbers should be specified wherever possible. If a company's part is required, specify the commercial part number followed by the word ONLY.

Temperature Limits: 250°F.

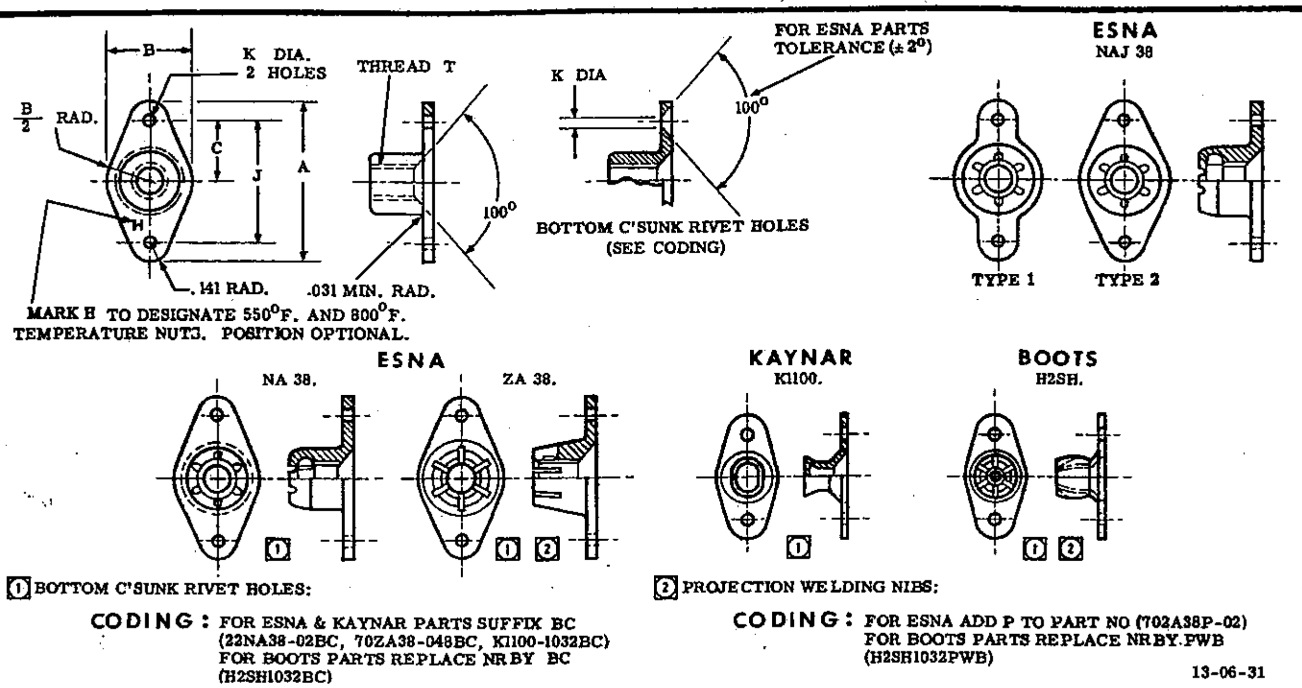
See AN362 also. All nuts approved as AN362 are automatically approved as AN366F.

NAJ1 series and 22NA1 series are equivalent in strength.

Materials: 22NA1, 22NLA1 - Carbon steel. NAJ1 - 24S-T6 aluminum alloy.

Finish: Carbon steel, cadmium plated. Aluminum alloy, anodized.

Figure 6-38 Nut-plate, Self-locking Fixed, Non-countersunk (AN366)



All nuts are self-locking.

The centre of the tapped hole must not deviate in any direction from the centre of the plate nut, as determined by the rivet holes, by more than .005 inch.

Parts listed equivalent are functionally interchangeable.

AN Part number should be specified wherever possible. If a company's part is required, specify the commercial part number followed by the word ONLY.

Temperature Limits: 22NA38, NAJ38 = 250°F maximum. K1100, H2SH = 550°F maximum. 70ZA38 = 800°F maximum. NAJ38 series is equivalent in strength to 22NA38 series.

Material: 22NA38, H2SH-NR, K1100 - Carbon steel. Locking insert - red nylon. 70ZA38 - Stainless steel. NAJ38 - Aluminum alloy 24S-T6. Locking insert - red nylon.

Finish: Carbon steel - Cadmium plated. Stainless steel - Silver plated. Aluminum alloy - Anodized.

Add A after dash number for nuts having non-metallic inserts.

Add B after dash number for nuts fabricated entirely from metal.

Add F after dash number for nuts either all metal or with non-metallic insert.

Add DF after dash number for aluminum alloy nuts.

Figure 6-39 (Sheet 1 of 2) Nut-plate, Self-locking Fixed 100° (AN361 and AN373)

Example of Part Number:

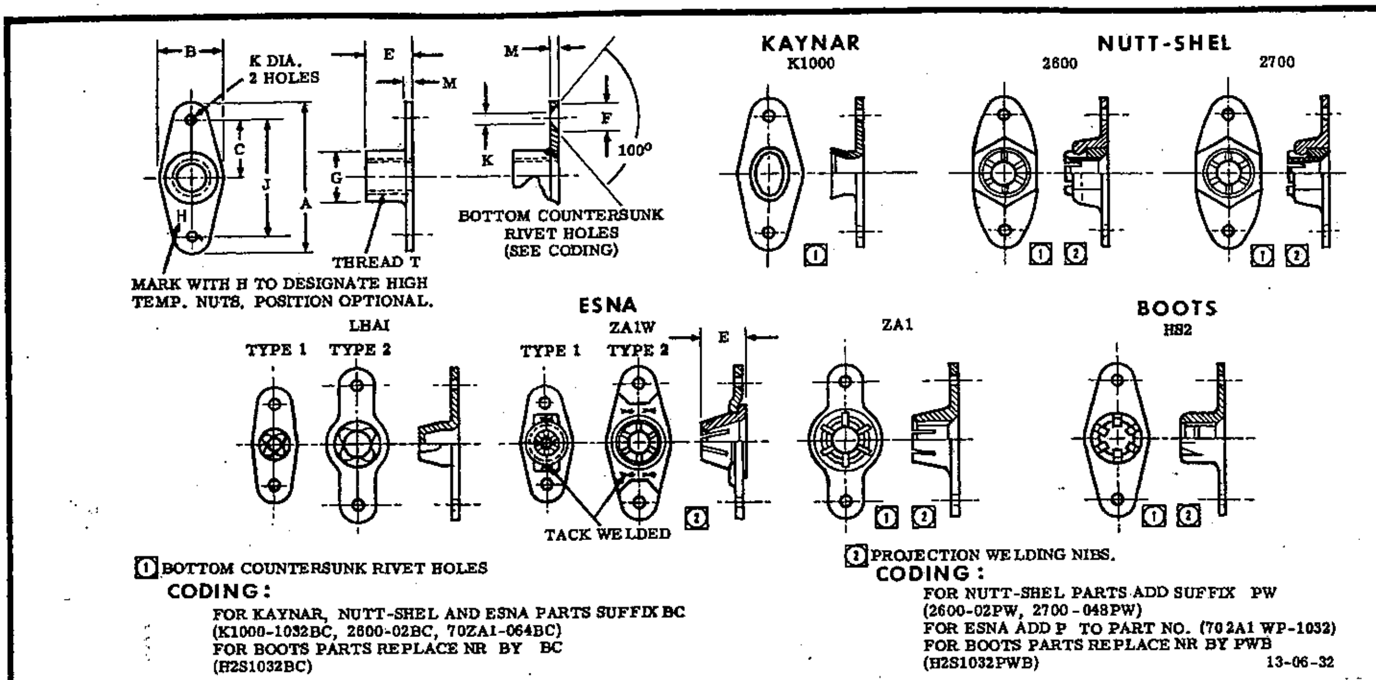
AN373DF28B = Aluminum alloy all metal 1/4-28.
AN373F28A = Steel nut with non-metallic insert 1/4-28.

Procurement Specification:

AN361 = AN-N-10
AN373 = AN-N-5

AN Part No.	Equivalent Commercial Part No.	Thread T	A	B	C	J (±.002)	K +.005 -.000
AN373F832	22NA38-82	8-32NC-3B	.969	.438	.344 (±.005)	.688	.098
	NAJ38-82(Type 2)	8-32NC-3B	.922	.391	.344 (±.005)	.688	.098
AN361C832	70ZA38-82	8-32NC-3B	.969	.438	.344	.688	.098
AN373F1032	22NA38-02	10-32NF-3B	.969	.438	.344 (±.005)	.688	.098
	NAJ38-02(Type 1)	10-32NF-3	.922	.438	.344 (±.005)	.688	.098
AN361-1032	K1100-1032	10-32NF-3B	.969	.438	.344	.688	.098
	H2SH1032NR	10-32NF-3	.969	.453 Max.	.344	.688	.098
AN361C1032	70ZA38-02	10-32NF-3	.969	.438	.344	.688	.098
AN373F428	22NA38-048	1/4-28NF-3	1.281	.656	.500 (±.005)	1.000	.098
AN361C428	70ZA38-048	1/4-28NF-3	1.281	.656	.500	1.000	.098
AN373F524	22NA38-054	5/16-24NF-3	1.281	.750	.500 (±.005)	1.000	.130
AN361C524	70ZA38-054	5/16-24NF-3	1.281	.750	.500	1.000	.130
	NAJ38-62(Type 1)	6-32NC-3B	.922	.391	.344 (±.005)	.688	.098

Figure 6-39 (Sheet 2 of 2) Nut-plate, Self-locking Fixed 100° (AN361 and AN373)



AN Part No.	Thread T	Equivalent Commercial Part No.	Base Type	A	B	C
AN362 F632	632NC-3B	12LHA1-62	2	.922	.328	.344
AN362 C632	632NC-2	70ZA1W-62	1	.969	.391	.344
AN362 F832	832NC-3B	12LHA1-82	1	.922	.328	.344
	832NC-2	H2S832NR		.969	.391	.344
	832NC-2	2600-82		.969	.391	.344 (±.005)
AN362 C832	832NC-3B	70ZA1W-82	1	.969	.391	.344
	832NC-2	2700-82		.969	.391	.344 (±.005)
AN362 F1032	1032NF-3	12LHA1-02	2	.922	.391	.344
	1032NF-3	H2S1032NR		.969	.391	.344
	1032NF-3B	K1000-1032		.969	.391	.344
	1032NF-3	2600-02		.969	.391	.344 (±.005)
AN362 C1032	1032NF-3	70ZA1W-02	1	.969	.391	.344
	1032NF-3	2700-02		.969	.391	.344 (±.005)
AN362 F428	1/4-28NF-3	12LHA1-048	2	1.281	.500	.500
	1/4-28NF-3	H2S428NR		1.281	.500	.500
	1/4-28UNF-3B	K1000-428		1.281	.500	.500
	1/4-28NF-3	2600-048		1.281	.500	.500 (±.005)
AN362 C428	1/4-28NF-3	70ZA1W-048	1	1.281	.500	.500
	1/4-28NF-3	2700-048		1.281	.500	.500 (±.005)
AN362 F524	5/16-24NF-3	52ZA1-054		1.281	.516	.500
AN362 C524	5/16-24NF-3	70ZA1W-054	2	1.281	.528	.500
AN362 F624	3/8-24NF-3	52ZA1-064		1.281	.625	.500
AN362 C624	3/8-24NF-3	70ZA1-064		1.281	.625	.500

Figure 6-40 (Sheet 1 of 2) Nut-plate, Fixed Non-countersunk, High Temperature (AN362)

All nuts are self-locking.

The centre of the tapped hole must not deviate in any direction from the centre of the plate nut, as determined by the rivet holes, by more than .005 inch.

Parts listed equivalent are functionally interchangeable.

AN Part number should be specified wherever possible. If a company's part is required, specify the commercial part number followed by the word ONLY.

Temperature Limits: 12LHA1, 52ZA1, 2600, K1000, H2S-NR = 550°F maximum. 70ZA1W, 70ZA1-064, 2700 = 800°F maximum.

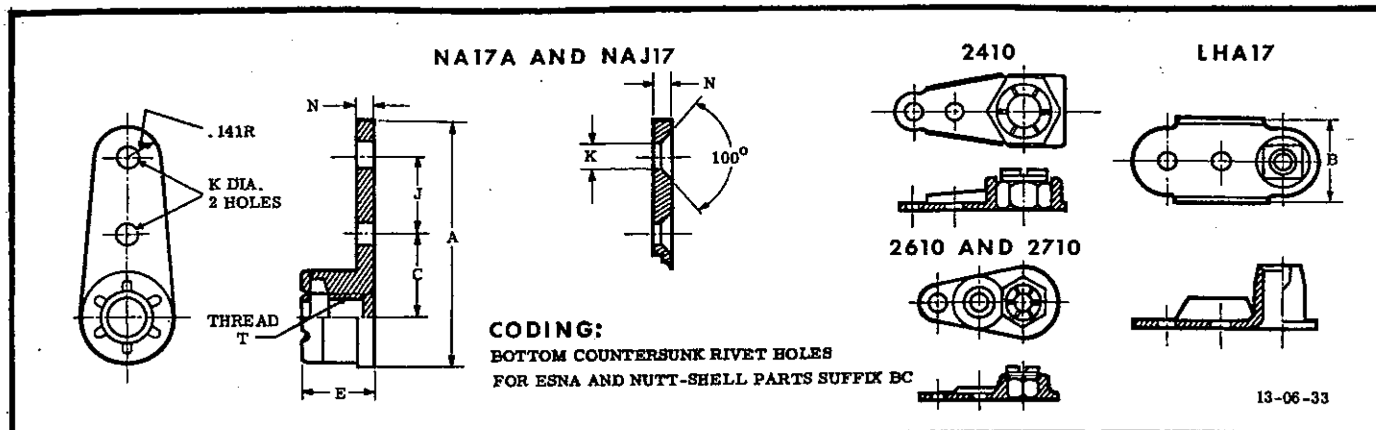
Material: 12LHA1, H2S-NR, 52ZA1, 2600, K1000 - Carbon steel. 2700 - Corrosion-resistant steel. 70ZA1W, 70ZA1 - Stainless steel.

Finish: Carbon steel - Cadmium plated. Corrosion-resistant steel and stainless steel - Silver plated.

Procurement Specification: AN-N-10.

AN Part No.	E	F	G	J (±.002)	K +.005 -.000	M
AN362 F632	.185 (±.005)		.175	.688	.098	.034 (±.005)
AN362 C632	.231 (±.005)		.226	.688	.098	.034 (±.005)
AN362 F832	.280 (±.005)		.209	.688	.098	.034 (±.010)
	.265	.200	.250 +.005 -.000	.688	.098	.040
	.229	.200		.688	.098	.035
AN362 C832	.246 (±.005)		.274	.688	.098	.034 (±.010)
	.229			.688	.098	.035
AN362 F1032	.246 (±.005)		.233	.688	.098	.034 (±.010)
	.265	.200	.281 +.005 -.000	.688	.098	.040
	.183	.200	.234	.688	.098	.032
	.229	.200		.688	.098	.035
AN362 C1032	.246 (±.005)		.300	.688	.098	.034 (±.005)
	.229			.688	.098	.035
AN362 F428	.280 (±.005)		.301	1.000	.098	.042 (±.010)
	.335	.200	.350 +.005 -.000	1.000	.098	.050
	.240	.200	.296	1.000	.098	.040
	.307	.200		1.000	.098	.035
AN362 C428	.324 (±.005)		.392	1.000	.098	.034 (±.005)
	.307			1.000	.098	.035
AN362 F524	.355 (±.005)	.230 (±.010)	.500	1.000	.130	.065 (±.010)
AN362 C524	.354 (±.005)		.455	1.000	.130	.034 (±.005)
AN362 F624	.448 (±.005)	.230 (±.010)	.547	1.000	.130	.065
AN362 C624	.448 (±.005)	.230 (±.010)	.547	1.000	.130	.065

Figure 6-40 (Sheet 2 of 2) Nut-plate, Fixed Non-countersunk, High Temperature (AN362)



Part No.	Thread T	A	C	E	J (±.002)	K +.005 -.000	N +.010 -.020	B (±.010)
*22NA17A-62	6-32NC-3B	.991	.344	.281	.312	.098	.065	
*22NA17A-82	8-32NC-3B							
NAJ17-82		.935		.266			.060	
*22NA17A-02	10-32NF-3B	.991		.281			.065	
NAJ17-02				.283			.060	
*22NA17A-048	1/4-28NF-3	1.023		313			.065	
68NA17A-048								
22NA17A-054	5/16-24NF-3	1.210	.500	.359		.130		
2610-02	10-32NF-3	1.078	.344	.234	.313	.098	.050	
2710-02				.229	.312		.035	
2610-048	1/4-28NF-3			.313	.313		.050	
2710-048				.307	.312		.035	
2410-054	5/16-24NF-3	1.250	.500	.312		.130		
12LHA17-62	6-32NC-3B	.960	.344	.185	.312	.098	.034	.328
12LHA17-82	8-32NC-3B	.960		.246				
12LHA17-02	10-32NF-3	.986		.246				.390
12LHA17-048	1/4-28NF-3	1.023		.280				.500
70ZA17-02	10-32NF-3	.991	.344	.245	.312	.098	.040	
70ZA17-048	1/4-28NF-3	1.023		.323			.065	

Figure 6-41 (Sheet 1 of 2) Anchor Nut, One Lug, Fixed, Non-countersunk

Thread Size	Equivalent Parts		Esna
	Esna	Nutt-Shel	
No. 6-32	*22NA17A-62		
	12LHA17-62		
No. 8-32	*22NA17A-82		NAJ17
	12LHA17-82		
No. 10-32	*22NA17A-02		NAJ17
	12LHA-02		
		2610-02	
	70ZA17-02	2710-02	
1/4-28	*22NA17A-048		
	68NA17A-048		
	12LHA-048	2610-048	
	70ZA17-048	2710-048	
5/16-24	*22NA17A-054		
		2410-054	

* Inactive for new design.

All anchor nuts are self-locking.

Temperature Limits: 22NA17A, 68NA17A, NAJ17 = 250°F. 12LHA17, 2410, 2610 = 550°F. 70ZA17, 2710 = 800°F.

Parts listed as equivalent are functionally interchangeable. The word ONLY must be added to the drawing callout if a certain part is to be used only, otherwise automatic substitution of an equivalent part may be made.

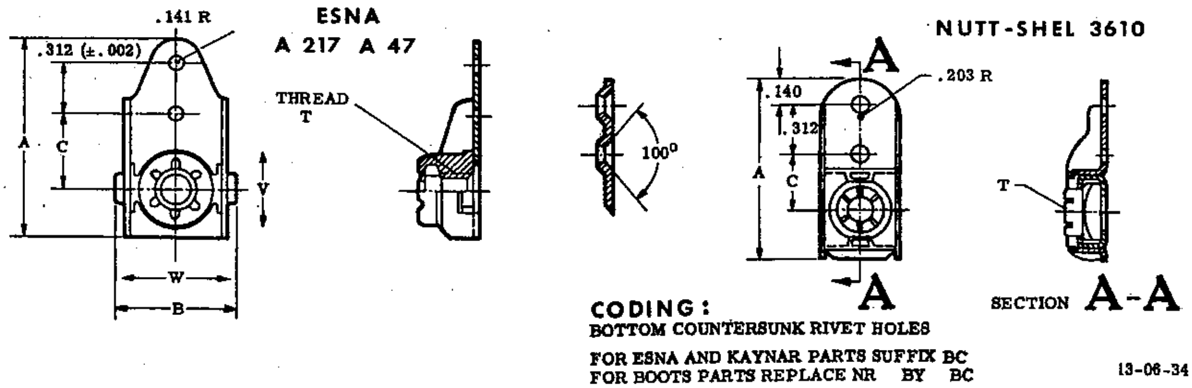
NAJ17 series are equal to 22NA17A series in strength.

Material: 22NA17A, 2410, 2610, LHA17 - Carbon steel. Locking insert - Nylon. 70ZA17 - Stainless steel. 2710 - Corrosion-resistant steel. 68NA17A - Aluminum alloy, 17S-T4. Locking insert - Nylon. NAJ17 - Aluminum alloy, 24S-T6.

Finish: Carbon steel - Cadmium plated. Stainless steel and corrosion-resistant steel - Silver plated. Aluminum alloy - Anodized.

Procurement Specifications: AN-N-5 and AN-N-10.

Figure 6-41 (Sheet 2 of 2) Anchor Nut, One Lug, Fixed, Non-countersunk



Part No.	Thread T	A	B	C	Min. Total Float V	Min. Total Float W	Approx. Wt. lb. (100)
*22NA217-22-82	8-32NC-3B	1.063	.672	.344 (±.005)	.094	.074	1.10
*22NA217-22-02	10-32NF-3B						1.00
22NA217-22-048	1/4-28NF-3	1.250	.734	.500 (±.005)			1.40
22NA47-82	8-32NC-3B	1.047	.484	.344 (±.002)	.055	.045	.93
22NA47-02	10-32NF-3B						
F2000-10-832	8-32UNC-2B	1.000		.344			.38
F2000-10-1032	10-32UNF-3B						.39
F2000-10-428	1/4-28UNF-3B	1.219		.500			.72

Part No.	Thread T	A	B	C	Total Float V	Total Float W	Approx. Wt. lb. (100)
H66S832SNR	8-32NC-2	1.031		.344	.062	.062	.63
H66S1032SNR	10-32NF-3						.65
H66S428SNR	1/4-28NF-3	1.297		.500			1.19
3610-82	8-32NF-2	1.078		.344	.060	.060	.60
3610-02	10-32NF-3	1.078		.344	.060	.060	.65
3610-048	1/4-28NF-3	1.250		.500	.060	.060	1.52

Figure 6-42 (Sheet 1 of 2) Anchor Nut, One Lug, Floating, Non-countersunk

Thread Size	Equivalent Parts				
	Esna	Kaynar	Boots	Nutt-Shel	Esna
No. 8-32	*22NA217-22-82				22NA47-82
		F2000-10-832	H66S83SNR	3610-82	
No. 10-32	*22NA217-22-02				22NA47-02
		F2000-10-1032	H66S1032SNR	3610-02	
1/4-28	22NA217-22-048				
		F2000-10-428	H66S428SNR	3610-048	

* Inactive for new design.

All nuts are self-locking.

Temperature Limits:

22NA217-22, 22NA47 = 250°F.
F2000-10, 3610, H66S-SNR = 550°F.

Parts listed as equivalent are functionally interchangeable. The word ONLY must be added to the drawing callout if certain part is to be used only, otherwise automatic substitution of an equivalent part may be made.

Material:

22NA217-22, 22NA47, F2000-10, H66S-SNR, 3610 - Carbon steel.
Locking insert on 22NA217-22, 22NA47 - Nylon.

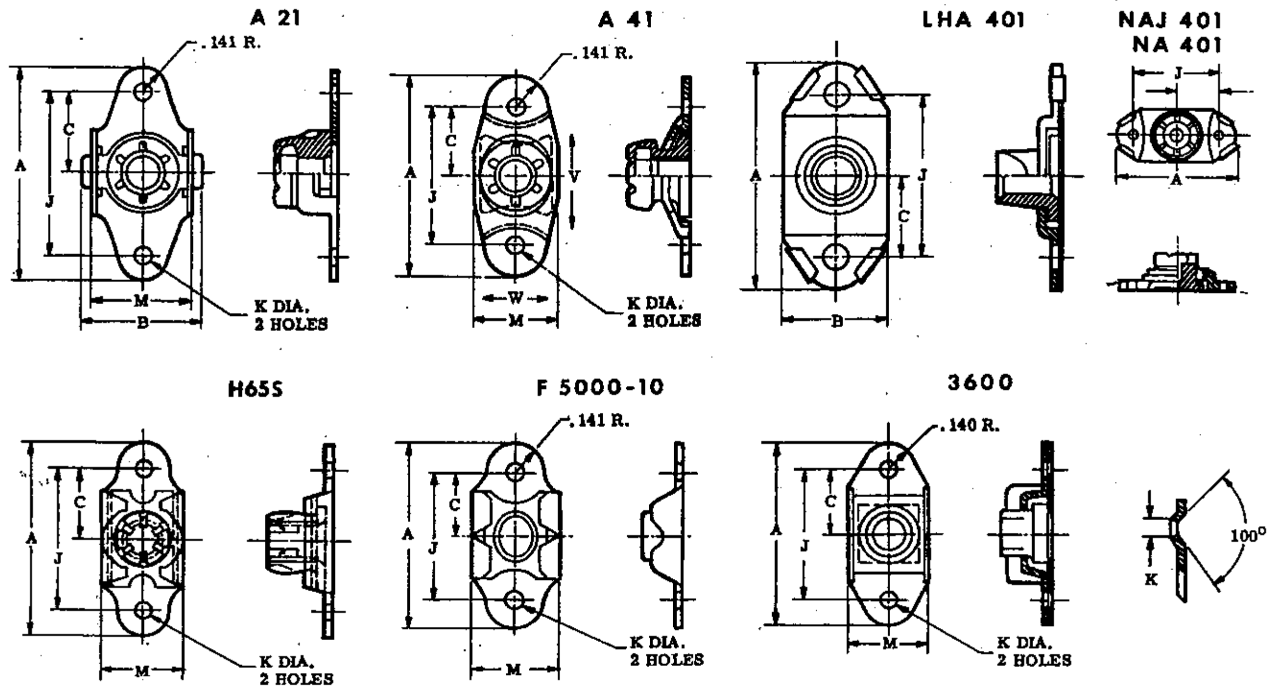
Finish:

Carbon steel - Cadmium plated.

Procurement Specifications:

AN-N-5 and AN-N-10.

Figure 6-42 (Sheet 2 of 2) Anchor Nut, One Lug, Floating, Non-countersunk



CODING: BOTTOM COUNTERSUNK RIVET HOLES FOR ALL PARTS SUFIX BC (NOT AVAILABLE IN A41, A401 TYPES).

13-06-35

* Inactive for new design.

All nuts are self-locking.

Temperature Limits:

22NA21-22, 22NA41-22, NAJ401, NA401 = 250°F maximum.
12LHA401, 3600, F5000-10, H65S-S = 550°F maximum.

Parts listed as equivalent are functionally interchangeable. The word ONLY must be added to the drawing callout if a certain part is to be used only, otherwise automatic substitution of an equivalent part may be made.

NAJ401 series are equal in strength to 22NA21 series.

Material:

NA401, *22NA21-22, *22NA41-22, 3600, F5000-10, H65S-S, LHA401 - Carbon steel.
NAJ401 - Aluminum alloy 14S-T6, 24S-T6.
Insert *22NA21-22, *22NA41-22, NA401, NAJ401 - Red nylon.

Finish:

Carbon steel - Cadmium plated.
Aluminum alloy - Anodized.

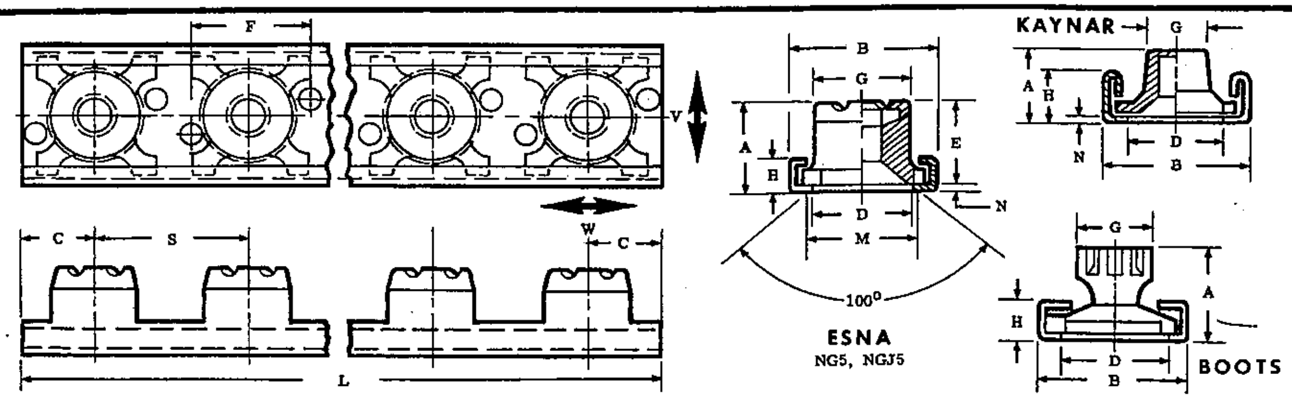
Procurement Specifications:

AN-N-5 and AN-N-10.

Figure 6-43 (Sheet 1 of 2) Anchor Nut, Two Lug, Floating, Non-countersunk

Part No.	Thread	A	B	C (±.005)	J (±.002)	K +.005 -.000	M	Min. Total Float V	Min. Total Float W	App. Wt. (100)
Esna										
*22NA21-22-62	6-32NC-3B	.969	.672	.344	.688	.098	.531	.094	.074	1.20
*22NA41-22-82	8-32NC-3B			.344 (±.015)			.359	.054	.049	.68
*22NA41-22-02	10-32NF-3B						.385			
*22NA21-22-048	1/4-28NF-3	1.281	.734	.500	1.000		.594	.094	.074	1.40
*22NA21-22-054	5/16-24NF-3		.797			.130	.672			1.90
12LHA401-62	6-32NC-3B	.968 Max.		.344 (±.010)	.688	.098	.406 Max.	.060	.060	.52
12LHA401-82	8-32NC-3B									.56
12LHA401-02	10-32NF-3									.59
12LHA401-048	1/4-28NF-3	1.296		.500	1.000	.098	1.296	.060	.060	.98
NA401-048	1/4-28NF-3	1.280		.500	1.000	.098	.516	.060	.060	.78
NA401-054	5/16-24NF-3	1.280		.500	1.000	.130	.594	.060	.060	1.25
NAJ401-62	6-32NC-3B	.968 Max.		.344 (±.010)	.688	.098	.406 Max.	.060	.060	.20
NAJ401-82	8-32NC-3B									.36
NAJ401-02	10-32NF-3									.36
Nutt-Shel										
3600-82	8-32NC-2	.969		.344	.688	.098	.391	.060	.060	.58
3600-02	10-32NF-3									.62
3600-048	1/4-28NF-3	1.281		.500	1.000		.500			1.21
Kaynar										
F5000-10-832	8-32NC-2B	.969		.344 (±.002)	.688	.098	.406	.062	.062	.36
F5000-10-1032	10-32NF-3B									.37
F5000-10-428	1/4-28UNF-3B	1.281		.500 (±.002)	1.000		.500			.71
Boots										
H65S832S	8-32NC-2	.969		.344 (±.002)	.688	.098	.406	.062	.062	.56
H65S1032S	10-32NF-3									.58
H65S428S	1/4-28NF-3	1.281		.500 (±.002)	1.000		.515			1.10

Figure 6-43 (Sheet 2 of 2) Anchor Nut, Two Lug, Floating, Non-countersunk



TOLERANCES: UNLESS OTHERWISE SPECIFIED: DECIMALS (±.015), ANGLES (±2°)

Basic Part No.	Thread Size	A	B	C	D	E
NGJ5-82	8-32NC-3B	.376	.578	S/2-.031	.391	.344
NGJ5-02	10-32NF-3	.395	.578	S/2-.031	.406	.363
*NG5-02	10-32NF-3B	.375	.578	S/2-.031	.406	.344
G1100-1032	10-32NF-3B	.297	.578	S/2	.437	.265
HT54SH-832	8-32NC-2	.391	.578	S/2-.031	.437	
HT54SH-1032	10-32NF-3	.391	.578	S/2-.031	.437	

	F Max.	G	H	M	N (±.005)	Min. Total Float V	Min. Total Float W
NJG5-82	.519	.313	.141	.366	.032	.022	.031
NJG5-02	.519	.375	.141	.411	.032	.022	.031
*NJG5-02	.519	.375	.141	.411	.032	.022	.031
G1100-1032		.234	.220		.032 (±.015)	1/32	1/16
HT54SH-832		.250	.156				
HT54SH-1032		.281	.156				

Example of drawing callout:

22NG5-02-J5-25 Gang channel nut type G5

- 22 to basic part number designates steel nuts cadmium plated
- Letter N designates nuts with nylon locking inserts
- Designates number of nuts
- Designates nuts spaced at 5/8 inch
- Letter J designates material of channel - Aluminum alloy 24S-T4
- Designates number 10-32 nuts

Figure 6-44 (Sheet 1 of 2) Gang Channel Nuts, Countersunk

Thread Size	Esna	SDT Length	Nut Spacing
No. 8-32	NGJ5-82-J5	71.813	.625
	NGJ5-82-J6	71.938	.750
	NGJ5-82-J7	71.688	.875
	NGJ5-82-J8	71.938	1.000
	NGJ5-82-J10	71.188	1.250
	NGJ5-82-J12	71.938	1.500
	NGJ5-82-J14	71.688	1.750
	NGJ5-82-J16	71.938	2.000
	NGJ5-82-J18	71.938	2.250
	NGJ5-82-J20	69.938	2.500
	NGJ5-82-J24	71.938	3.000

* Inactive for new design.

All nuts are self-locking.

No rivet attachment to be made at end of channel.

Gang channels listed above are for maximum temperature of 250°F.

Parts listed as equivalent are functionally interchangeable.

NGJ5 series and 22NG5 series are equivalent in strength.

Material: 22NG5-02-J, HT54SH1032, G1100-1032 - Carbon steel. 22NG5-02-J, NGJ5 - Aluminum alloy 24S-T6. Locking insert on 22NG5-02-J and NGJ5 - Nylon.

Finish: Carbon steel - Cadmium plated. Aluminum alloy - Anodized.

Procurement Specification:

AN-N-5

Thread Size	Equivalent Parts				Esna		Kaynar		Boots	
	Esna		Kaynar	Boots	NGJ5, 22NG5					
	NGJ5-02-	22NG5-02-	G1100-1032-	HT54SH-1032-	Std. Length L	Nut Spacing S	Std. Length L	Nut Spacing S	Std. Length L	Nut Spacing S
No. 10-32	-J5	-J5	-5	-5	71.813	.625	71-7/8	5/8	71.81	.625
	-J6	-J6	-6	-6	71.938	.750	72	3/4	71.94	.750
	-J7	-J7	-7	-7	71.688	.875	71-3/4	7/8	71.69	.875
	-J8	-J8	-8	-8	71.938	1.000	72	1	71.94	1.000
			-9				72	1-1/8		
	-J10	-J10	-10	-10	71.188	1.250	71-1/4	1-1/4	72.44	1.250
			-11				71-1/2	1-3/8		
	-J12	-J12	-12	-12	71.938	1.500	72	1-1/2	71.94	1.500
			-13				71-1/2	1-5/8		
	-J14	-J14	-14	-14	71.688	1.750	71-3/4	1-3/4	71.69	1.750
			-15				71-1/4	1-7/8		
	-J16	-J16	-16	-16	71.938	2.000	72	2	71.94	2.000
	-J18	-J18	-18	-18	71.938	2.250	72	2-1/4	71.94	2.250
	-J20	-J20	-20	-20	69.938	2.500	70	2-1/2	72.44	2.500
	-J24	-J24	-24	-24	71.938	3.000	72	3	71.94	3.000

Figure 6-44 (Sheet 2 of 2) Gang Channel Nuts, Countersunk

(AN256) NUT, SELF-LOCKING, RIGHT ANGLE PLATE

Material:	Steel or aluminum alloy, same as AN365.
Size Range:	6-32, 8-32 and 10-32
Part No. Coding:	AN256-6 = 6-32, aluminum alloy nut. AN256F8 = 8-32, steel nut. AN256-10 = 10-32, aluminum alloy nut.

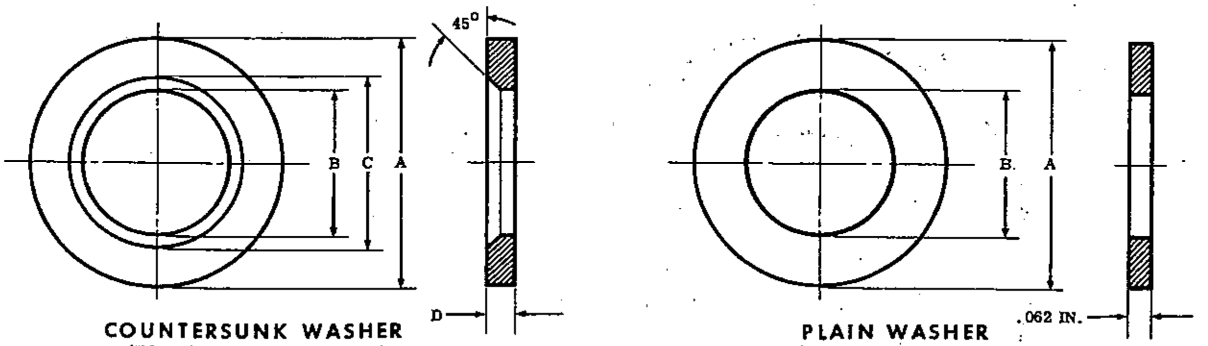
(AN315) NUT, PLAIN, AIRFRAME

Material:	Steel, corrosion-resistant steel and aluminum alloy.
Size Range:	6-40 to 1-1/4-12. Available in right and left-hand thread.
Part No. Coding:	AN315-640R = 6-40, steel nut, right-hand thread. AN315C3L = 10-32, corrosion-resistant steel nut, left-hand thread. AN315D4R = 1/4-28, aluminum alloy nut, right-hand thread.

(AN924) NUT, FLARED TUBE, BULKHEAD FITTING

Material:	Steel, SAE4037, 4130, 8630, 8740; corrosion-resistant steel, aluminum alloy, 14S, 17S, 24S.
Size Range:	5/16-24 to 7/8-14 (NF) and 1-1/16-12 to 3-1/2-12 (N). Tube OD from 1/8 inch to 3 inches.
Part No. Coding:	Add letter S to indicate corrosion-resistant steel 304L and 347. Add letter C to indicate 302, 304, 316 or 321. AN924-2 = 5/16, steel nut, for 1/8 OD tube. AN924-4D = 7/16, aluminum alloy nut, for 1/4 OD tube. AN924-8S = 3/4, corrosion-resistant steel nut for 1/2 OD tube. AN924-10C = 7/8, corrosion-resistant steel nut for 5/8 OD tube.

Figure 6-45 Nut Specifications



Thread Size	MS Part No.		A Dia.	B Dia.		C Dia.		D
	Countersunk	Plain		Max.	Min.	Max.	Min.	
1/4	MS20002C4	MS20002-4	.531	.260	.252	.344	.334	.078
5/16	MS20002C5	MS20002-5	.593	.324	.315	.406	.396	.078
3/8	MS20002C6	MS20002-6	.687	.388	.378	.495	.483	.078
7/16	MS20002C7	MS20002-7	.781	.451	.441	.557	.543	.078
1/2	MS20002C8	MS20002-8	.875	.515	.504	.620	.604	.078
9/16	MS20002C9	MS20002-9	.968	.579	.568	.687	.667	.078
5/8	MS20002C10	MS20002-10	1.062	.643	.631	.785	.765	.078
3/4	MS20002C12	MS20002-12	1.250	.770	.757	.910	.890	.078
7/8	MS20002C14	MS20002-14	1.437	.897	.884	1.035	1.015	.078
1	MS20002C16	MS20002-16	1.625	1.025	1.010	1.160	1.140	.078
1-1/8	MS20002C18	MS20002-18	1.875	1.150	1.135	1.285	1.265	.078
1-1/4	MS20002C20	MS20002-20	2.125	1.275	1.260	1.447	1.427	.094
1-3/8	MS20002C22	MS20002-22	2.313	1.400	1.385	1.572	1.552	.094
1-1/2	MS20002C24	MS20002-24	2.500	1.525	1.510	1.697	1.677	.094

Material: Steel, Specification AN-QQ-S-685; SAE 4130 or SAE 1035, 1040 or 1050.

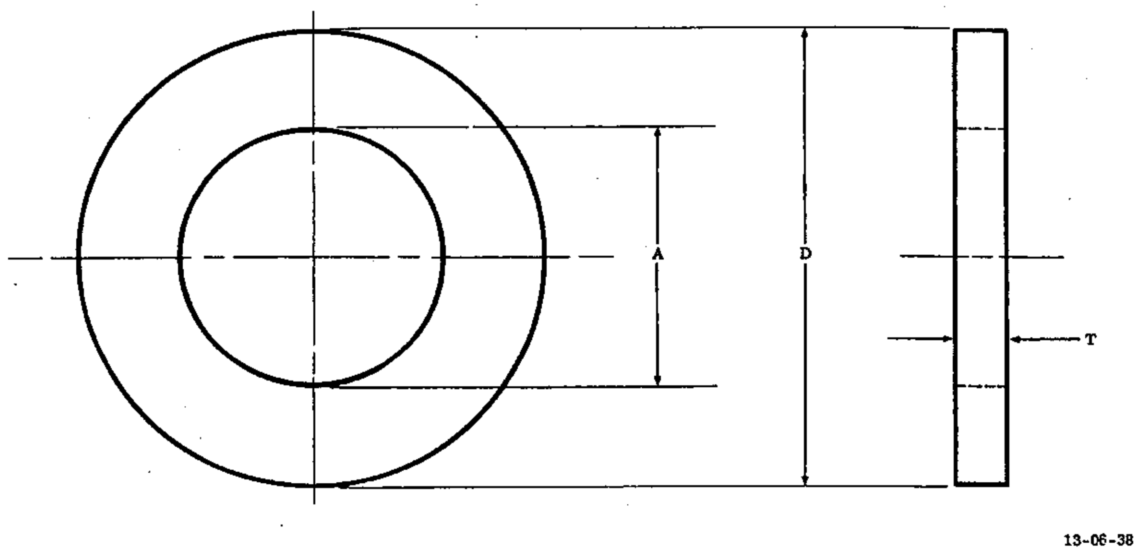
Heat-treat: 125,000 to 145,000 psi.

Finish: Cadmium plate.

Washer faces must be flat within .005 inch and parallel within .002 inch.

These washers are primarily for use with the 160,000 psi internal wrenching bolts shown on MS20004 to MS20024.

Figure 6-46 Washer, Countersunk and Plain, High Strength (MS20002)



* Copper and aluminum washers inactive for design after 14 March 1952. Aluminum alloy washers replace and are interchangeable with the aluminum washers.

Washer faces must be flat within .007 and parallel within .002.

Tolerances: Unless otherwise specified, decimals ±.010, on dimension T for aluminum or aluminum alloy washers, .016 (±.003), .032 (±.004), .064 (±.006), .091 (±.007).

Material: Carbon steel, Specification AN-S-11, SAE 1020 and SAE 1025, or Specification QQ-S-636, SAE 1010, cold-rolled half or full hard. Corrosion-resistant steel, Specification MIL-S-5059 or Specification MIL-S-6721. Aluminum, Specification QQ-A-561 or Specification QQ-A-359. Aluminum alloy, Specification QQ-A-362, condition T3 or T4. Brass, Specification QQ-B-611, composition C or D, 1/2H or 3/4H, Copper, Specification QQ-C-501.

Finish: Carbon steel, cadmium plated. Aluminum and aluminum alloy, when specified, anodized.

P coding in table identifies anodized aluminum and aluminum alloy washers.

L coding in table identifies the light series of washers.

Examples of Part Nos.

AN960-716 = Carbon steel washer for 7/16 thread size, .064 inch thick.

AN960PD10L = Anodized aluminum alloy washer for number 10 thread size, .016 inch thick.

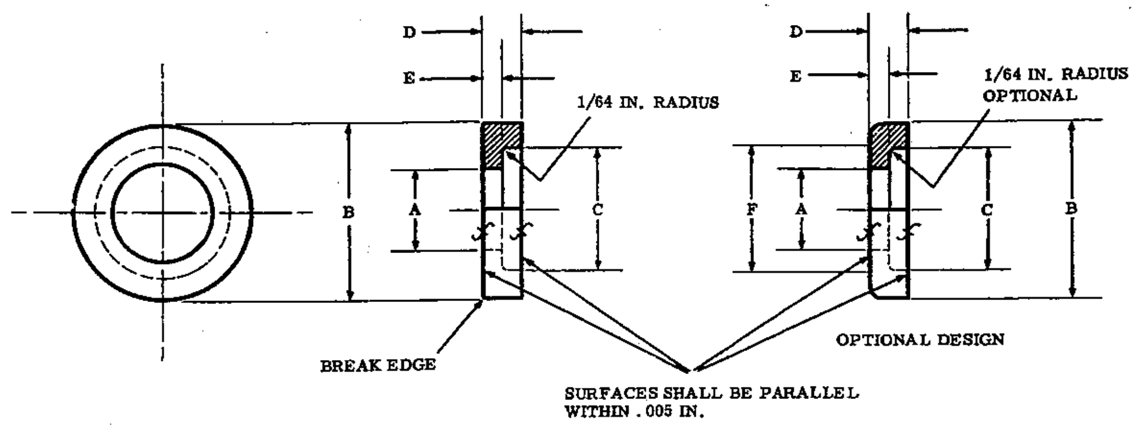
Figure 6-47 (Sheet 1 of 3) Washer, Flat (AN960)

Thread Size	A Dia.	D +.020 -.005 Dia.	T	Dash Numbers							
				Carbon Steel	Corr. Res. Steel	Aluminum Alloy Anodized	Aluminum Alloy Un-anodized	* Aluminum Anodized	* Aluminum Un-anodized	Brass	* Copper
	.078	.375	.035								CU14
	.094	.375	.035								CU13
No. 2	.099	.250	.016	2L	C2L	PD2L	D2L				
			.032	2	C2	PD2	D				
No. 3	.109	.250	.016	3L	C3L	PD3L	D3L	PA3L	A3L		
			.032	3	C3	PD3	D3	PA3	A3	B3	
No. 4	.125	.312	.016	4L	C4L	PD4L	D4L	PA4L	A4L		
			.032	4	C4	PD4	D4	PA4	A4	B4	
			.035								CU12
No. 5	.140	.438	.042								CU11
No. 6	.149	.375	.016	6L	C6L	PD6L	D6L	PA6L	A6L		
			.032	6	C6	PD6	D6	PA6	A6	B6	
No. 8	.174	.375	.016	8L	C8L	PD8L	D8L	PA8L	A8L		
			.032	8	C8	PD8	D8	PA8	A8	B8	
	.188	.500	.049								CU7
No. 10	.203	.438	.016			PD10L	D10L	PA10L	A10L		
			.032	10L	C10L						
			.049								CU316
			.064	10	C10	PD10	D10	PA10	A10	B10	
	.234	.625	.065								CU5
1/4	.265	.500	.016			PD416L	D416L	PA416L	A416L		
			.032	416L	C416L						
			.064	416	C416	PD416	D416	PA416	A416	B416	
5/16	.328	.562	.016			PD516L	D516L	PA516L	A516L		
			.032	516L	C516L						
			.064	516	C516	PD516	D516	PA516	A516	B516	
3/8	.390	.625	.016			PD616L	D616L	PA616L	A616L		
			.032	616L	C616L						
			.064	616	C616	PD616	D616	PA616	A616	B616	
7/16	.453	.750	.016			PD716L	D716L	PA716L	A716L		
			.032	716L	C716L						
			.064	716	C716	PD716	D716	PA716	A716	B716	
1/2	.515	.875	.016			PD816L	D816L	PA816L			
			.032	816L	C816L						
			.064	816	C816	PD816	D816	PA816	A816	B816	
9/16	.578	1.062	.016			PD916L	D916L	PA916L	A916L		
			.032	916L	C916L						

Figure 6-47 (Sheet 2 of 3) Washer, Flat (AN960)

Thread Size	A Dia.	D +.020 -.005 Dia.	T	Dash Numbers							
				Carbon Steel	Corr. Res. Steel	Aluminum Alloy		* Aluminum		Brass	* Copper
						Anodized	Un-anodized	Anodized	Un-anodized		
9/16	.578	1.062	.064	916	C916	PD916	D916	PA916	A916	B916	
5/8	.640	1.188	.016			PD1016L	D1016L	PA1016L	A1016L		
			.032	1016L	C1016L						
			.064	1016	C1016	PD1016	D1016	PA1016	A1016	B1016	
3/4	.765	1.312	.016			PD1216L	D1216L	PA1216L	A1216L		
			.032	1216L	C1216L						
			.091	1216	C1216	PD1216	D1216	PA1216	A1216	B1216	
7/8	.890	1.500	.016			PD1416L	D1416L	PA1416L	A1416L		
			.032	1416L	C1416L						
			.091	1416	C1416	PD1416	D1416	PA1416	A1416	B1416	
1	1.105	1.750	.016			PD1616L	D1616L	PA1616L	A1616L		
			.032	1616L	C1616L						
			.091	1616	C1616	PD1616	D1616	PA1616	A1616	B1616	
1-1/16	1.028	1.812	.016			PD1716L	D1716L	PA1716L	A1716L		
			.032	1716L							
			.091	1716	C1716	PD1716	D1716	PA1716	A1716	B1716	
1-1/8	1.140	1.875	.016			PD1816L	D1816L				
			.032	1816L							
			.091	1816	C1816	PD1816	D1816			B1816	
1-1/4	1.265	2.000	.016			PD2016L	D2016L				
			.032	2016L							
			.091	2016	C2016	PD2016	D2016			B2016	
1-5/16	1.328	2.062	.016			PD2116L	D2116L	PA2116L	A2116L		
			.032	2116L							
			.091	2116	C2116	PD2116	D2116	PA2116	A2116	B2116	
1-5/8	1.640	2.375	.016			PD2616L	D2616L	PA2616L	A2616L		
			.032	2616L							
			.091	2616	C2616	PD2616	D2616	PA2616	A2616	B2616	
1-7/8	1.890	2.625	.016			PD3016L	D3016L	PA3016L	A3016L		
			.032	3016L							
			.091	3016	C3016	PD3016	D3016	PA3016	A3016	B3016	
2-1/4	2.265	3.000	.016			PD3616L	D3616L	PA3616L	A3616L		
			.032	3616L							
			.091	3616	C3616	PD3616	D3616	PA3616	A3616	B3616	
2-1/2	2.515	3.250	.016			PD4016L	D4016L	PA4016L	A4016L		
			.032	4016L							
			.091	4016	C4016	PD4016	D4016	PA4016	A4016	B4016	

Figure 6-47 (Sheet 3 of 3) Washer, Flat (AN960)



AN Part No.	Screw Size	A	B	C	D	E	F Min. Dia.
AN975-3	No. 10	13/64	15/32	11/32	3/16	1/6	3/8
AN975-4	1/4	17/64	9/16	13/32	13/64	5/64	7/16
AN975-5	5/16	21/64	11/16	17/32	13/64	5/64	1/2
AN975-6	3/8	25/64	25/32	19/32	13/64	5/64	9/16
AN975-7	7/16	29/64	27/32	21/32	13/64	5/64	5/8
AN975-8	1/2	33/64	15/16	23/32	7/32	3/32	3/4
AN975-9	9/16	37/64	1-3/32	27/32	7/32	3/32	7/8
AN975-12	3/4	49/64	1-9/32	1	15/64	7/64	1-1/8
AN975-14	7/8	57/64	1-15/32	1-3/16	15/64	7/64	1-5/16

Material: Carbon steel, SAE 1015, SAE 1018, SAE 1025.

Finish: Cadmium plated.

Figure 6-48 Washer, Taper Pin (AN975)

(AN961) WASHER, FLAT, ELECTRICAL

Material:
Brass, tin or silver plated.

Size Range:
Nos. 4, 6, 8 and 10, 0.032 inch thick.
1/4, 5/16, 3/8, 1/2 and 5/8 inches, 0.064 inch thick.
Bolt holes correspond to the respective AN960 sizes.

Part No. Coding:
AN961-4 = No.4 bolt size washer.
AN961-616 = 3/8 bolt size washer.

(AN970) WASHER, FLAT, FOR WOOD

Material:
Steel, cadmium plated.

Size Range:
No.10 to 5/8 inch.
Hole in washer is 1/64 inch larger than nominal bolt size.

Part No. Coding:
AN970-3 = No.10 bolt size washer.
AN970-4 = 1/4 bolt size washer.

Figure 6-49 Washer Specifications

PART 7

QUICK-RELEASE FASTENERS AND VIBRATION INSULATORS

PART 7

QUICK RELEASE FASTENERS AND VIBRATION INSULATORS

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PART 7 SECTION 1

QUICK RELEASE FASTENERS

QUICK RELEASE FASTENERS

General

1 Quick release fasteners are used to secure engine cowlings, fairing, panels and similar sheet metal components requiring repeated and rapid attachment and removal, without being subjected to undue wear or localized fatigue of the surrounding metal. The quick release fasteners dealt with in this part are: Dzus, Camloc, Airloc, Paneloc-Zahodakian, Lion and Oddie. For general instructions regarding the inspection of these fasteners, refer to EO 05-1-2Q.

Interchangeability

2 The interchangeability tables, (see Figure 7-1), cover the main types of cowl fasteners approved for the use by the RCAF. The tables have been prepared as an aid in making replacements. In every case only complete assemblies may be interchanged, not the individual parts making up the assembly, i.e. studs, grommets or receptacles. The tables cover the following series of Dzus (Item 1) fasteners:

A Round Head

AJ Round Head, Long Undercut

AW Wing Type Round Head

AJW Wing Type Round Head, Long Undercut

F Flush Head

FJ Flush Head, Long Undercut

FW Wing Type Flush Head

FJW Wing Type Flush Head, Long Undercut

FA Flush Head, Rounded Edge

3 The AW, AJ, AJW, FW, FJ and FJW series are not shown, since the callouts are the same as for the A and F series, respectively, except for the addition of W and/or J.

Installation

4 Special tools are provided for the installation of all types of fasteners and must be used to ensure proper assembly, refer to CAP 10. For instructions on dimpling procedure, refer to Part 5, preceding.

Installation Limits

5 Flush head studs are to be flush with the external skin surface within the limits shown in Figure 7-2.

6 For illustration of critical zones of aircraft, refer to Part 5, preceding.

Ejector Springs

7 Ejector springs may be used with most fasteners.

DZUS FASTENERS

General

8 The Dzuz fastener, (see Figure 7-3), consists of a stud provided with a slotted head, a light alloy grommet and a wire spring. The stud is retained in the outer sheet-metal member by means of a light alloy grommet. The spring is rivetted at each looped end to the underside of the inner member. When the stud is given a quarter turn in the clockwise direction, a helix slot machined in the stud end engages with the centre portion of the spring, drawing it up and thus pulling two members together.

Stud

9 The stud is made with oval or flush heads which are usually slotted, but wing heads are available, if required. The sleeve portion under the head is made in various lengths according to the application of the fastener and to the thickness of the plate in which the stud is fitted. The hole in the outer member is fitted with a light alloy

Round Head								
Material Thickness	Dzus		Shake-proof SP-OS-5	1 Inch Mounting Centres Airloc 99835-1	Dzus A6-1/2	Shake-proof SP-OS-7	1-1/8 Inch Mounting Centres Airloc 99839-1	Camloc 4002
	A5	A6						
.045 to .050			-5	-.050		-5	-.050	
.051 to .054			-5	-.060		-5	-.060	-1
.055 to .060			-6	-.060		-6	-.060	-1
.061 to .064			-6	-.070		-6	-.070	-1
.065 to .070			-7	-.070		-7	-.070	-1
.071 to .074			-7	-.080		-7	-.080	-1
.075 to .080			-8	-.080		-8	-.080	-1
.081 to .084			-8	-.090		-8	-.090	-2
.085 to .090			-9	-.090		-9	-.090	-2
.091 to .094			-9	-.100		-9	-.100	-2
.095 to .100			-10	-.100		-10	-.100	-2
.101 to .104			-10	-.110		-10	-.110	-2
.105 to .110			-11	-.110		-11	-.110	-2
.111 to .114			-11	-.120		-11	-.120	-3
.115 to .120			-12	-.120		-12	-.120	-3
.121 to .124			-12	-.130		-12	-.130	-3
.125 to .130			-13	-.130		-13	-.130	-3
.131 to .134			-13	-.140		-13	-.140	-3
.135 to .140			-14	-.140		-14	-.140	-3
.141 to .144			-14	-.150		-14	-.150	-4
.145 to .150	-30		-15	-.150		-15	-.150	-4
.151 to .154	-30		-15	-.160		-15	-.160	-4
.155 to .160	-30		-16	-.160		-16	-.160	-4
.161 to .164	-30	-35	-16	-.170		-16	-.170	-4
.165 to .170	-30	-35	-17	-.170		-17	-.170	-4
.171 to .174	-30	-35	-17	-.180		-17	-.180	-5
.175 to .180	-30	-35	-18	-.180		-18	-.180	-5
.181 to .184	-30	-35	-18	-.190		-18	-.190	-5
.185 to .190	-30	-35	-19	-.190		-19	-.190	-5
.191 to .194	-30	-35	-19	-.200		-19	-.200	-5
.195 to .200	-35	-35	-20	-.200		-20	-.200	-5

Figure 7-1 (Sheet 1 of 4) Interchangeability Tables

Round Head								
Material Thickness	Dzus		Shake-proof SP-OS-5	1 Inch Mounting Centres Airloc 99835-1	Dzus A6-1/2	Shake-proof SP-OS-7	1-1/8 Inch Mounting Centres Airloc 99839-1	Camloc 4002
	A5	A6						
.201 to .204	-35	-35	-20	-.210		-20	-.210	-6
.205 to .210	-35	-35	-21	-.210		-21	-.210	-6
.211 to .214	-35	-40	-21	-.220	-40	-21	-.220	-6
.215 to .220	-35	-40	-22	-.220	-40	-22	-.220	-6
.221 to .224	-35	-40	-22	-.230	-40	-22	-.230	-6
.225 to .230	-35	-40	-23	-.230	-40	-23	-.230	-6
.231 to .234	-35	-40	-23	-.240	-40	-23	-.240	-7
.235 to .240	-35	-40	-24	-.240	-40	-24	-.240	-7
.241 to .244	-35	-40	-24	-.250	-40	-24	-.250	-7
.245 to .250	-40	-40	-25	-.250	-40	-25	-.250	-7
.251 to .254	-40	-40	-25	-.260	-40	-25	-.260	-7
.255 to .260	-40	-40		-.260	-40		-.260	-7
.261 to .264	-40	-45		-.270	-40		-.270	-8
.265 to .270	-40	-45		-.270	-40		-.270	-8
.271 to .274	-40	-45		-.280	-40		-.280	-8
.275 to .280	-40	-45		-.280	-40		-.280	-8
.281 to .284	-40	-45		-.290	-40		-.290	-8
.285 to .290	-40	-45		-.290	-40		-.290	-8
.291 to .294	-40	-45		-.300	-40		-.300	-9
.295 to .300	-40	-45		-.300	-40		-.300	-9
.301 to .304	-40	-45		-.310	-40		-.310	-9
.305 to .310	-40	-45		-.310	-40		-.310	-9
.311 to .314	-40	-50		-.320	-50		-.320	-9
.315 to .320	-40	-50		-.320	-50		-.320	-9
.321 to .324	-40	-50		-.330	-50		-.330	-10
.325 to .330	-40	-50		-.330	-50		-.330	-10
.331 to .334	-40	-50		-.340	-50		-.340	-10
.335 to .340	-40	-50		-.340	-50		-.340	-10
.341 to .344	-40	-50		-.350	-50		-.350	-10
.345 to .350	-50	-50		-.350	-50		-.350	-10
.351 to .354	-50	-50		-.360				

Figure 7-1 (Sheet 2 of 4) Interchangeability Tables

Flush Head										
Material Thickness	Dzus			Shake-proof SP-SF-5	1 Inch Mounting Centres Airloc 98265-1	Dzus		Shake-proof SP-SF-7	1-3/8 Inch Mounting Centres Airloc 98266-1	Camloc 4002
	F5	F6	FA5			F 6-1/2	FA 6-1/2			
.045 to .050				-5	-.050			-5	-.050	
.051 to .054				-5	-.060			-5	-.060	-1
.055 to .060				-6	-.060			-6	-.060	-1
.061 to .064		-40		-6	-.070			-6	-.070	-1
.065 to .070		-40		-7	-.070			-7	-.070	-1
.071 to .074		-40		-7	-.080			-7	-.080	-1
.075 to .080		-40		-8	-.080			-8	-.080	-1
.081 to .084		-40		-8	-.090			-8	-.090	-2
.085 to .090		-40		-9	-.090			-9	-.090	-2
.091 to .094		-40		-9	-.100			-9	-.100	-2
.095 to .100	-35	-40		-10	-.100			-10	-.100	-2
.101 to .104	-35	-40	-35	-10	-.110			-10	-.110	-2
.105 to .110	-35	-40	-35	-11	-.110			-11	-.110	-2
.111 to .114	-35	-45	-35	-11	-.120			-11	-.120	-3
.115 to .120	-35	-45	-35	-12	-.120		-45	-12	-.120	-3
.121 to .124	-35	-45	-35	-12	-.130		-45	-12	-.130	-3
.125 to .130	-35	-45	-35	-13	-.130		-45	-13	-.130	-3
.131 to .134	-35	-45	-35	-13	-.140		-45	-13	-.140	-3
.135 to .140	-35	-45	-35	-14	-.140		-45	-14	-.140	-3
.141 to .144	-35	-45	-35	-14	-.150		-45	-14	-.150	-4
.145 to .150	-40	-45	-35	-15	-.150		-45	-15	-.150	-4
.151 to .154	-40	-45	-40	-15	-.160		-45	-15	-.160	-4
.155 to .160	-40	-45	-40	-16	-.160		-45	-16	-.160	-4
.161 to .164	-40	-50	-40	-16	-.170	-50	-45	-16	-.170	-4
.165 to .170	-40	-50	-40	-17	-.170	-50	-45	-17	-.170	-4
.171 to .174	-40	-50	-40	-17	-.180	-50	-45	-17	-.180	-5
.175 to .180	-40	-50	-40	-18	-.180	-50	-45	-18	-.180	-5
.181 to .184	-40	-50	-40	-18	-.190	-50	-45	-18	-.190	-5
.185 to .190	-40	-50	-40	-19	-.190	-50	-45	-19	-.190	-5
.191 to .194	-40	-50	-40	-19	-.200	-50	-45	-19	-.200	-5
.195 to .200	-45	-50	-40	-20	-.200	-50	-45	-20	-.200	-5

Figure 7-1 (Sheet 3 of 4) Interchangeability Tables

Flush Head										
Material Thickness	Dzus			Shake-proof SP-SF-5	1 Inch Mounting Centres Airlock 98265-1	Dzus		Shake-proof SP-SF-7	1-3/8 Inch Mounting Centres Airloc 98266-1	Cam-lock 4002
	F5	F6	FA5			F 6-1/2	FA 6-1/2			
.201 to .204	-45	-50	-45	-20	-.210	-50	-45	-20	-.210	-6
.205 to .210	-45	-50	-45	-21	-.210	-50	-45	-21	-.210	-6
.211 to .214	-45	-50	-45	-21	-.220	-50	-45	-21	-.220	-6
.215 to .220	-45	-50	-45	-22	-.220	-50	-55	-22	-.220	-6
.221 to .224	-45	-50	-45	-22	-.230	-50	-55	-22	-.230	-6
.225 to .230	-45	-50	-45	-23	-.230	-50	-55	-23	-.230	-6
.231 to .234	-45	-50	-45	-23	-.240	-50	-55	-23	-.240	-7
.235 to .240	-45	-50	-45	-24	-.240	-50	-55	-24	-.240	-7
.241 to .244	-45	-50	-45	-24	-.250	-50	-55	-24	-.250	-7
.245 to .250	-50	-50	-45	-25	-.250	-50	-55	-25	-.250	-7
.251 to .254	-50	-50	-50	-25	-.260	-50	-55	-25	-.260	-7
.255 to .260	-50	-50	-50		-.260	-50	-55		-.260	-7
.261 to .264	-50	-60	-50		-.270	-50	-55		-.270	-8
.265 to .270	-50	-60	-50		-.270	-60	-55		-.270	-8
.271 to .274	-50	-60	-50		-.280	-60	-55		-.280	-8
.275 to .280	-50	-60	-50		-.280	-60	-55		-.280	-8
.281 to .284	-50	-60	-50		-.290	-60	-55		-.290	-8
.285 to .290	-50	-60	-50		-.290	-60	-55		-.290	-8
.291 to .294	-50	-60	-50		-.300	-60	-55		-.300	-9
.295 to .300	-50	-60	-50		-.300	-60	-55		-.300	-9
.301 to .304	-50	-60			-.310	-60	-55		-.310	-9
.305 to .310	-50	-60			-.310	-60	-55		-.310	-9
.311 to .314	-50	-60			-.320	-60	-55		-.320	-9
.315 to .320	-50	-60			-.320	-60	-55		-.320	-9
.321 to .324	-50	-60			-.330	-60	-65		-.330	-10
.325 to .330	-50	-60			-.330	-60	-65		-.330	-10
.331 to .334	-50	-60			-.340	-60	-65		-.340	-10
.335 to .340	-50	-60			-.340	-60	-65		-.340	-10
.341 to .344	-50	-60			-.350	-60	-65		-.350	-10
.345 to .350	-60	-60			-.350	-60	-65		-.350	-10

Figure 7-1 (Sheet 4 of 4) Interchangeability Tables

grommet which prevents the stud from falling out when the fastener is unlocked.

Spring

10 The fastener spring is a short length of spring-steel wire. The ends are coiled in opposite directions to form spirals, through the eyes of which the spring is rivetted to the inner member. The centre portion of the spring engages with the helix slot in the end of the stud. When the fastener is in its locked position, the spring is deflected by the helix slot and the outer member is held in position under compression. The recommended deflection for all springs where the pitch of the rivet centres is over 1 inch is 0.062 (± 0.010) inch, while the deflection for most other types is 0.047 (±0.010) inch, exception being made in the case of the small-type spring. The latter can be identified by the diameter of the wire, which is 0.09 inch and by the rivet centre pitch which is 1 inch. The deflection of the small-type spring is 0.062 (± 0.010) inch.

Installation

11 Check that the correct type of spring is used with the required types of stud. Where a defective fastener is to be replaced by a new one, use the defective parts as a guide to the size and shape of the replacement parts required. Measure the length of the stud from the ˙ wer edge of the locking slot to the upper surface of the head, for all flush-type fasteners, or to the underside of the head for round-headed fasteners, (see Figure 7-3). If the length of stud differs from the lengths of the nearest size available, use the next larger size and insert shim-washers to the required thickness under the spring seats to bring the spring deflection to the recommended figure. The procedure and special tools required for fitting the various types of fasteners are shown in Figures 7-4 and 7-5.

Special Tolerance for Critical Zones	Standard Tolerance for Other Zones
.005 above	.010 above
.002 below	.002 below

Figure 7-2
Installation Limits for Dzuz Fasteners

Removal of Fasteners

12 If any part is defective, replace as follows:

(a) To remove a defective stud, cut away the aluminum grommet, using a trepanning tool, centered by means of the sleeve end of the stud.

(b) To remove a spring, drill out the rivets.

(c) If a grommet is loose, reset using the appropriate drift and block for the type of fastener held in the grommet. If the grommet can not be successfully reset, replace.

CAMLOC FASTENERS

General

13 The Camloc fastener, (see Figure 7-6), consists of a stud, a grommet and a receptacle. A snap ring is used in most applications to retain the grommet. For Camloc fastener dimensions, see Figure 7-7.

Stud

14 The stud assembly is a complete unit, the stud cross pin having been factory assembled, centered and staked. This ensures perfect fit and guarantees proper centering of the pin. Spring tension of the stud assembly permits use of several dash numbers longer than shown on stud chart, if desired. In cases of varying sheet thickness due to tolerances which cause high locking torque, the stud can easily be replaced with one of suitable length without opening adjacent fasteners and removing the panel. This ensures a low locking torque for all fasteners in final assembly. Stud assemblies 4002-2 to 4002-15 inclusive, are installed with special Camloc pliers by compressing the spring cup and

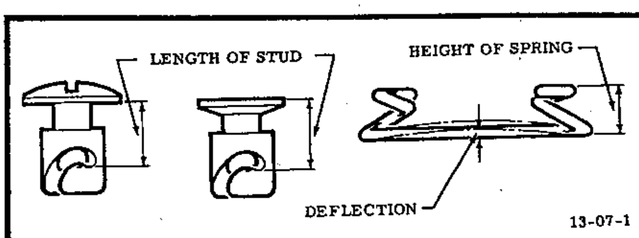
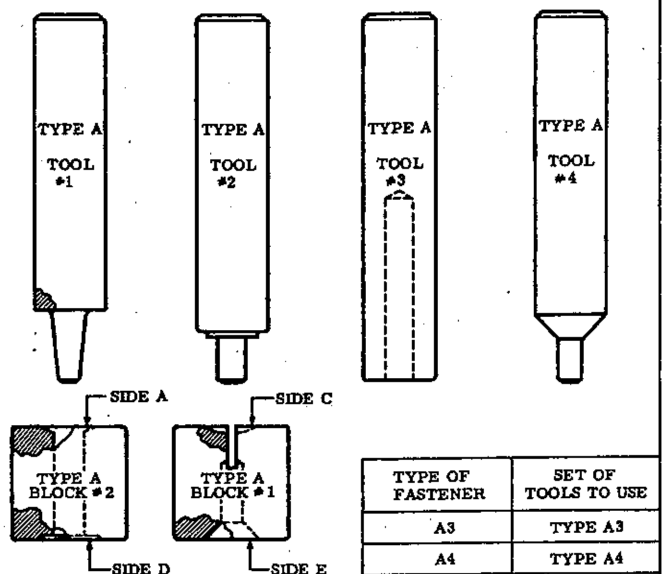


Figure 7-3 Dzuz Stud and Spring Dimensions

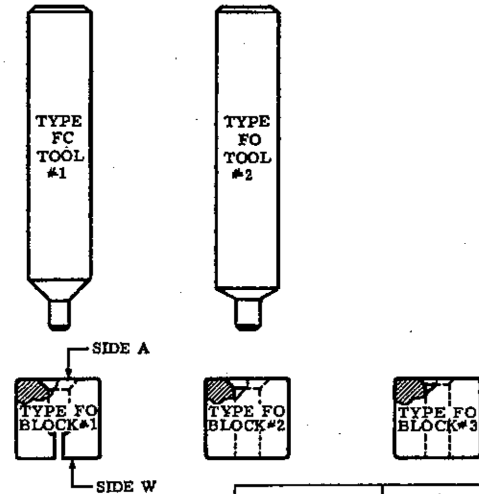
FOR TYPE A AND AJ FASTENERS
WITH OR WITHOUT GROMMET INSTALLATION



FOR INSTALLATION WITHOUT GROMMET - ORDER TOOL NO. 3 & 4 AND BLOCK NO. 1 ONLY.

TYPE OF FASTENER	SET OF TOOLS TO USE
A3	TYPE A3
A4	TYPE A4
A5	TYPE A5
A6	TYPE A6
A6-1/2	TYPE A6-1/2
A7	TYPE A7

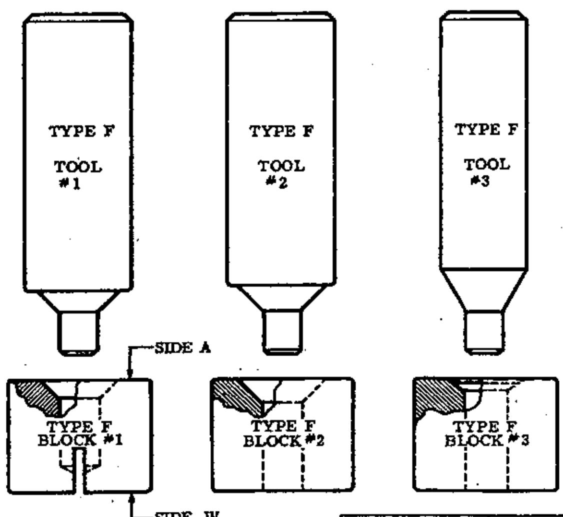
FOR TYPE F- FJ FASTENERS
WITHOUT GROMMET INSTALLATION



SOLD IN SETS ONLY

TYPE OF FASTENER	SET OF TOOLS TO USE
F3	TYPE F03
F4	TYPE F04
F5	TYPE F05
F6	TYPE F06
F6-1/2	TYPE F06-1/2

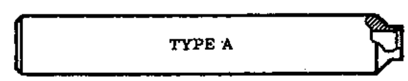
FOR TYPE F-FJ-FA FASTENERS
WITH GROMMET INSTALLATION



SOLD IN SETS ONLY

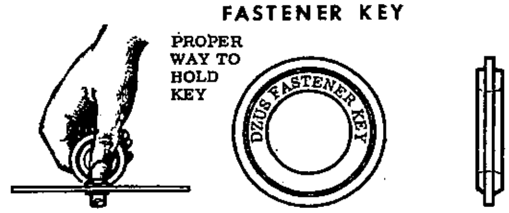
TYPE OF FASTENER	SET OF TOOLS TO USE
F4	TYPE F4
F5	TYPE F5
F6	TYPE F6
F6-1/2	TYPE F6-1/2
F7	TYPE F7

STAKING TOOL
FOR TYPE A AND AJ FASTENERS



TYPE OF FASTENER	TYPE OF TOOL TO USE	TYPE OF FASTENER	TYPE OF TOOL TO USE
A3	A3	A6	A6
A4	A4	A6-1/2	A6-1/2
A5	A5	A7	A7

FASTENER KEY



MECHANICS SHOULD BE INSTRUCTED TO USE THIS KEY WHEN OPENING OR LOCKING FASTENER. ITS USE PREVENTS DAMAGE CAUSED BY SLIPPAGE OF BAD SCREW DRIVERS. IF REQUIRED FOR USE WITH A3, A4, F3 OR F4 FASTENER SPECIFY THIS ON ORDER AND KEYS WILL BE SUPPLIED WITH EDGE GROUND TO FIT HEAD SLOT.

ALL INSTALLATION TOOLS DESIGNED FOR HAND INSTALLATION - STRIKE WITH SOFT FACED MALLET ONLY. POWER INSTALLATION TOOLS MAY BE MADE ON ORDER.

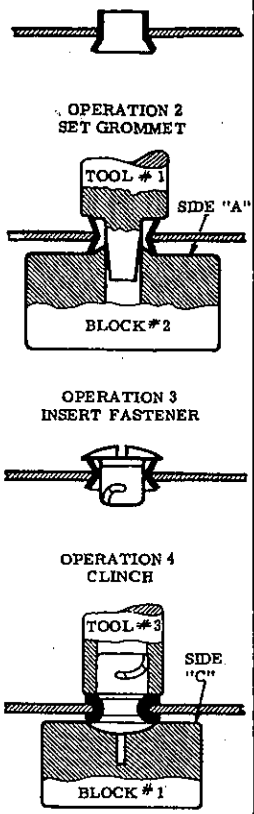
13-07-2

Figure 7-4 Installation Tools - Dzuz Fasteners

FOR TYPE A-AJ

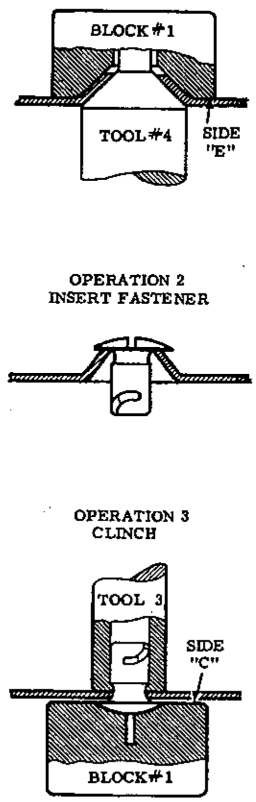
WITH GROMMET
OPERATION 1
DRILL & INSERT GROMMET

TYPE	DRILL
A4 & AJ4	5/16
A5 & AJ5	3/8
A6 & AJ6	7/16
A6-1/2 & AJ6-1/2	1/2
A7 & AJ7	17/32
A3 & AJ3	7/32



WITHOUT GROMMET
OPERATION 1
DRILL & DIMPLE

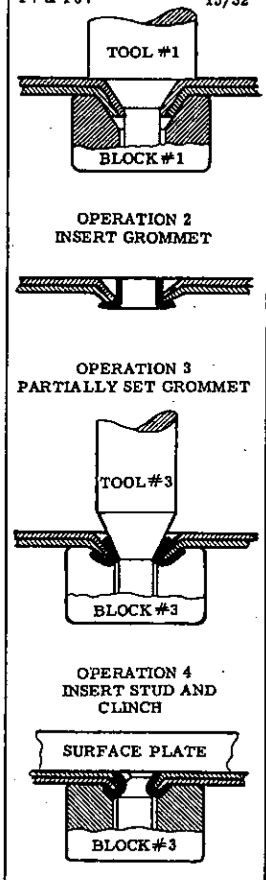
TYPE	DRILL
A3 & AJ3	5/32
A4 & AJ4	13/64
A5 & AJ5	17/64
A6 & AJ6	21/64
A6-1/2 & AJ6-1/2	23/64
A7 & AJ7	3/8



FOR TYPE F-FA-FJ

WITH GROMMET
OPERATION 1
DRILL & DIMPLE

TYPE	DRILL
F4 & FJ4	17/64
F5 & FJ5	5/16
F6 & FJ6	3/8
F6-1/2 - FJ6-1/2 & FA6-1/2	7/16
F7 & FJ7	15/32



WITHOUT GROMMET
OPERATION 1
DRILL & DIMPLE

TYPE	DRILL
F3 & FJ3	9/64
F4 & FJ4	13/64
F5 & FJ5	15/64
F6 & FJ6	19/64
F6-1/2 & FJ6-1/2	21/64

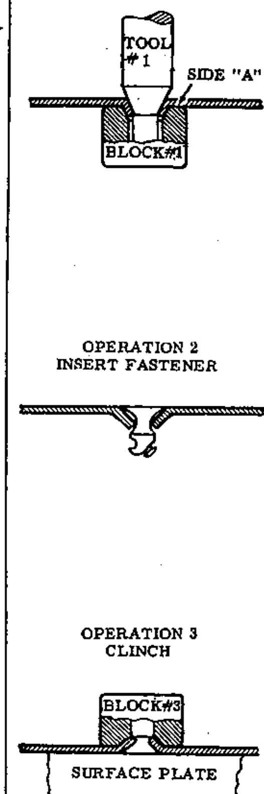
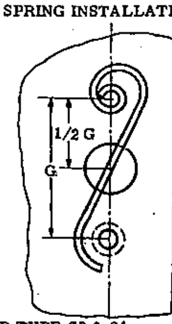


FIG. 1

FOR STANDARD SPRING INSTALLATION

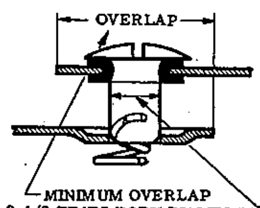


FOR TYPE S3 & S4 SPRINGS-DRILL #41(.096) HOLE AND COUNTERSINK 3/16 X 110°

FOR TYPE S5-S6 & S7 SPRINGS-DRILL #30(.128) HOLE AND COUNTERSINK 1/4 X 110°.

FIG. 2

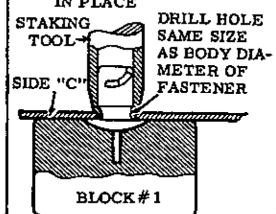
MINIMUM OVERLAP



MINIMUM OVERLAP 2-1/2 TIMES BODY DIAMETER OF FASTENER

FIG. 3

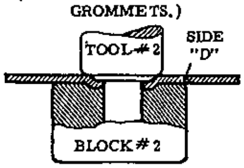
STAKING FASTENER IN PLACE



USE TYPE OF STAKING TOOL CORRESPONDING TO TYPE OF FASTENER BEING INSTALLED.

DIMPLING SUPPORT TYPE A-AJ

(WHEN INSTALLED WITH GROMMETS.)

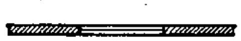


DRILL & DIMPLE

TYPE	DRILL
A4 & AJ4	1/4
A5 & AJ5	5/16
A6 & AJ6	3/8
A6-1/2 & AJ6-1/2	13/32
A7 & AJ7	7/16
A3 & AJ3	3/16

DRILLING SUPPORT TYPE A-AJ

(WHEN INSTALLED WITHOUT GROMMETS.)

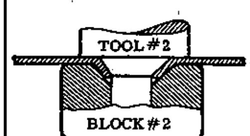


DRILL & COUNTERSINK

TYPE	DRILL
A3 & AJ3	7/32
A4 & AJ4	9/32
A5 & AJ5	11/32
A6 & AJ6	13/32
A6-1/2 & AJ6-1/2	7/16
A7 & AJ7	15/32

DIMPLING SUPPORT TYPE F-FA-FJ

(WITH OR WITHOUT GROMMET INSTALLATION.)



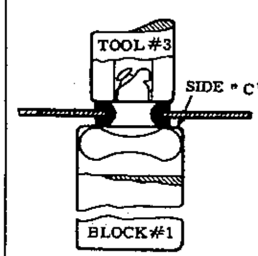
DRILL & DIMPLE

TYPE	DRILL
F3 & FJ3	3/16
F4 & FJ4	1/4
F5 & FJ5	5/16
F6 & FJ6	3/8
F6-1/2 - FJ6-1/2 & FA6-1/2	13/32
F7 & FJ7	7/16

WING TYPES

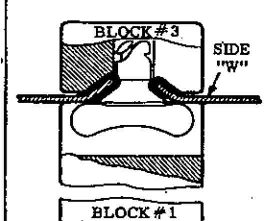
TYPE A-AJ

OPERATION 4
CLINCH
OTHER OPERATIONS SAME AS FOR TYPES A & AJ



TYPE F-FA & FJ

OPERATION 4
INSERT FASTENER AND CLINCH OTHER OPERATIONS SAME AS FOR TYPES F-FA & FJ.



13-07-3

Figure 7-5 Installation - Dzuz Fasteners inserting the stud into the grommet. When the spring is released, the stud assembly cannot come out. Stud assemblies 4002-16 to 4002-25 inclusive are retained in the grommet by means of a special split washer which is furnished with these stud assemblies. No pliers are required. The stud is inserted into the grommet and the split washer is placed on the stud shank between the cross pin and the spring cup. The recommended type of stud for general use is No. 4002-( )F cross recess head.

Grommet

15 Grommets are used in all Camloc installations. They prevent the stud head from wearing on the removable panel and are especially desirable in soft or abrasive materials, such as magnesium, plywood, bonded materials and plastic. The grommet also protects the outer panel against abrasive action of locking and unlocking the fastener and assures uniform bearing on the panel in case of misalignment. Various types of grommets are available. The recommended grommet for general use is 4002G, which is a steel grommet for flush installation. The snap ring to be used with each grommet is R4G.

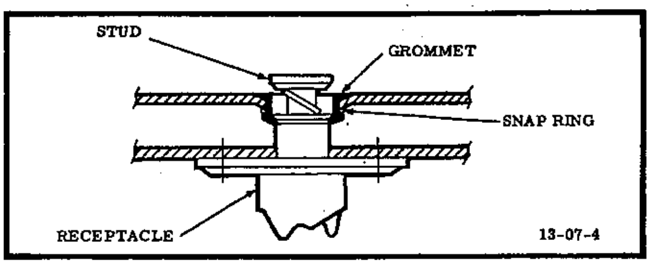
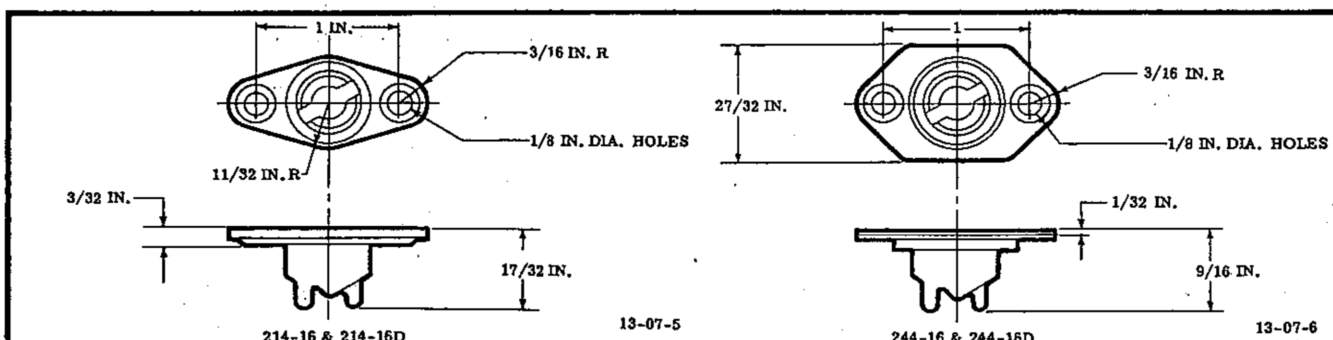


Figure 7-6 Camloc Fastener

Receptacle

16 The long sloping surface on the receptacle produces a uniform locking torque. As the locked position is reached, the cross pin snaps into a detent and prevents the possibility of accidentally unlocking. The combination of the detent and spring-loaded stud assembly permits the use of the same stud length for a wide range of material thickness without danger of opening through vibration. The receptacle is a silicon bronze diecasting and is permanently attached to the inner panel. It is furnished in both rigid and floating types, the latter to accommodate misalignment of the panels.



Camloc Part No.	Rivet Holes	Material	Type
214-16	Plain	Silicon Bronze	Rigid
214-16D	Dimpled		
244-16	Plain	Silicon Bronze and steel	Floating (allows 1/16 float)
244-16D	Dimpled		

The hole required on inner panel to accomodate the grommet must be 11/16 diameter. Same hole size is applicable for rigid or floating types of receptacles.

Figure 7-7 Camloc Fastener Dimensions

Edge Distance

17 The absolute minimum edge distance for both grommet and receptacle is 1/2 inch measured from the edge of the stud or rivet hole.

Grommet Installation

18 For grommet installation, see Figure 7-8.

Replacement of Receptacle

19 To replace the Camloc receptacle, remove the rivets and install a new receptacle by rivetting into place. If the cowling or cowling support is damaged, it may be necessary to install a new section on which the receptacle is to be rivetted.

Replacement of Grommet

20 When necessary to replace a grommet in a cowling sheet, either cut the grommet out by use of pliers or enlarge the dimple by pressure from the top. A new grommet can then be pressed into place and the dimple pressed back into its original form.

Replacement of Stud Assembly

21 When replacing a stud assembly, compress the spring of the stud assembly with pliers and enter the stud through the grommet. Camloc pliers No. 4P4 are convenient for this operation. Any pliers may be ground to a similar shape or an improvised metal extractor may be used. Use the shortest stud assembly that will lock and unlock without binding.

AIRLOC FASTENERS

General

22 The airloc fastener, (see Figure 7-9), consists a stud, cross pin and receptacle. They are manufactured in three sizes; No. 7, No. 5 and No. 2, (see Figure 7-10).

Stud

23 The stud is of steel, casehardened to eliminate excessive wear. The cross pin hole is reamed to close tolerance with a press fit of the pin in the stud. Head styles available are flush, oval and wing.

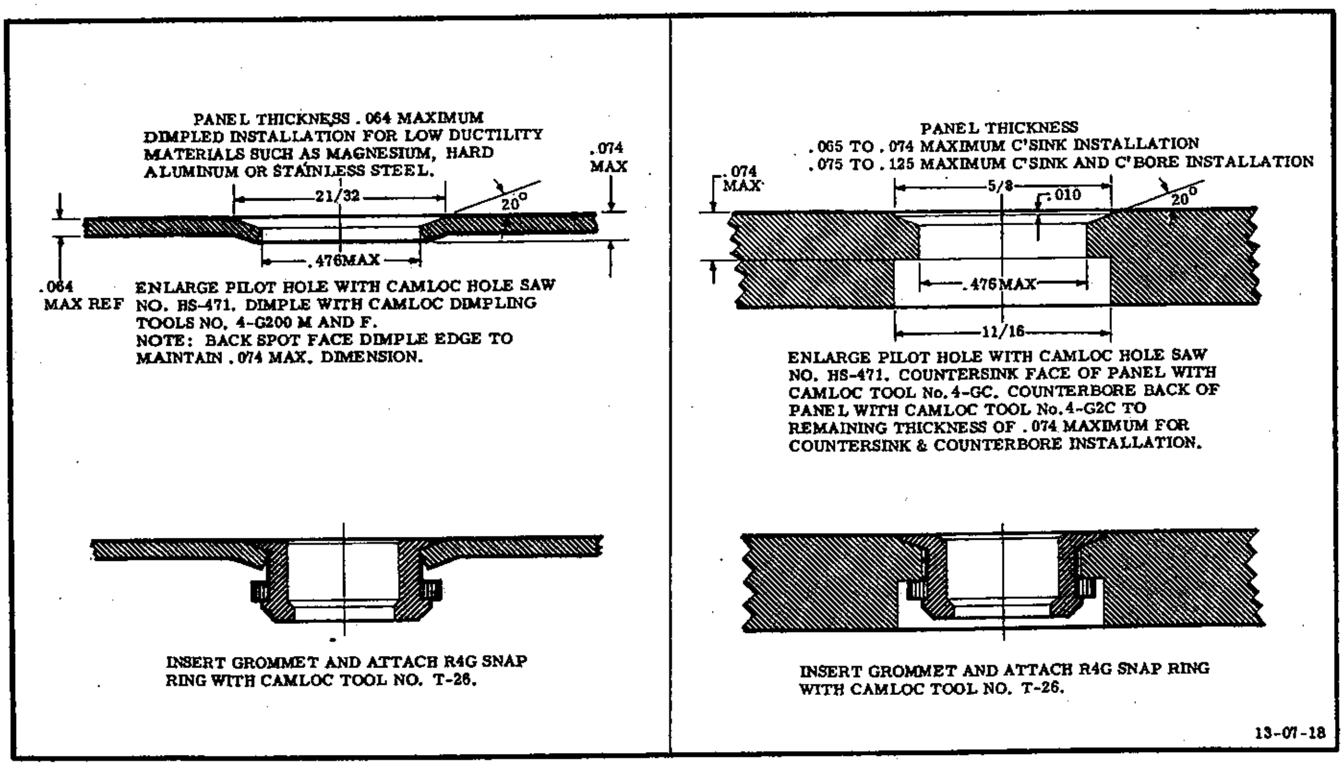


Figure 7-8 Camloc Grommet Installation

Cross Pin

24 The cross pin is of chrome-vanadium steel, heat-treated to provide maximum strength, wear and holding power. It is held to close tolerance.

Stud Receptacle

25 Two types of sheet spring receptacles are available; the rigid type and the floating type. Both are of high carbon, heat-treated steel. An upper wing provides ejection of the stud when the fastener is unlocked and enables the cross pin to be held in a locked position between the upper wing, the cam, the stop and the wing indenture without regard to the tension which the stud places on the receptacle.

Dimpling

26 Use standard hand tools provided. For full instructions regarding dimpling, refer to Part 5, preceding.

Replacement of Receptacle

27 Remove old receptacle by drilling out rivets. Do not damage the sheet. Rivet recept-

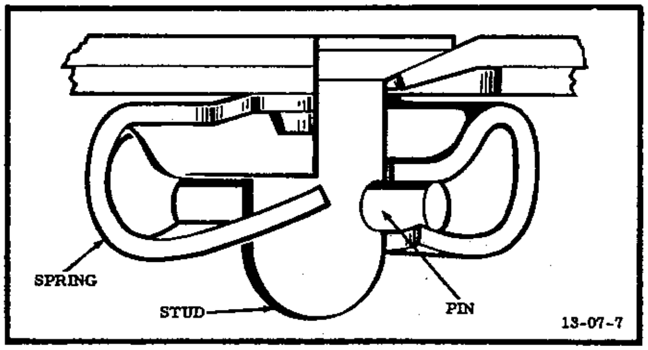


Figure 7-9 Airloc Fastener

Size	Rivet Centre Distance	Stud Shank Diameter	Stud Cross Pin Length
No.7	1-3/8	5/16	.600
No.5	1	17/64	.453
No.2	3/4	11/64	.313

Figure 7-10
Airloc Fastener Size Designations

NUMBER 7

Outer Sheet

Dimpled, drill 11/32 inch.

Dimple diameter, 49/64 inch.

Protruding head, drill 3/8 inch.

Inner Sheet

Drill 13/16 inch.

Floating receptacle, drill 31/32 inch.

Rivet centres 1-3/8 inch, use 1/8 inch rivets.

NUMBER 5

Outer Sheet

Dimpled, drill 9/32 inch.

Dimple diameter, 5/8 inch.

Protruding head, drill 21/64 inch.

Inner Sheet, drill 5/8 inch.

Floating receptacle,
If 1/8 inch rivets are used, drill 5/8 inch.
If 3/32 inch rivets are used, drill 11/16 inch.

Rivet centres 1 inch.

NUMBER 2

Outer Sheet

Dimpled, drill 3/16 inch.

Dimple diameter, 7/16 inch.

Protruding head, drill 3/16 inch.

Inner Sheet, drill 7/16 inch.

Rivet centres 3/4 inch, use 3/32 inch rivets.

Figure 7-11
Hole Sizes for Airloc Fastener Receptacles

acles to the inner surface of the inner sheet. Rivets must be flush with the outer surface of the inner sheet. For hole sizes, see Figure 7-11. Receptacles with plain rivet holes can be replaced by receptacles with countersunk rivet holes.

Insertion of Cross Pin

28 Use standard hand tools provided for the size of fastener being replaced. Observe the following precautions:

(a) Be sure the stud cross pin is centered in the stud as this will assure satisfactory operation of the fastener.

(b) Do not re-use cross pins or studs. Only new parts will be sufficiently tight.

Servicing Airloc Fasteners

29 Airloc studs come in lengths varying ten-thousandths of an inch. To determine proper stud length to be used, proceed as follows:

(a) Select type-flush head, roundhead, or wing.

(b) Determine total application thickness. Add thickness of inner (structure) and outer (panel, doors, and the like) sheets, including gaskets and reinforcements in thousandths of an inch, plus .010 inch to allow for wrinkling, warpage, etc. Take the nearest even .010 inch above this total.

(c) When selecting studs for No. 2 floating receptacle, an additional .020 inch must be added to the above. For the No. 5 and No. 7 floating receptacles an additional .030 must be added. For grip lengths, see Figure 7-1. Select a stud with this number stamped on the head.

SHAKEPROOF FASTENERS

General

30 Shakeproof fasteners (Item 4) are similar to the Airlock fastener and instructions for installation, removal and servicing are to be followed as detailed in Paragraphs 27, 28 and 29, preceding.

PANELOC-ZAHODIAKIN AIRCRAFT FASTENER

General

31 The Paneloc fastener (Item 5) is a quick release fastener manufactured by the Scovill Mfg. Co., under patents of the Zahodiakin Research Corp. (See Figure 7-12.) It consists of a stud, a retaining ring and a receptacle. Ejector spring, reinforcing grommet, pressure

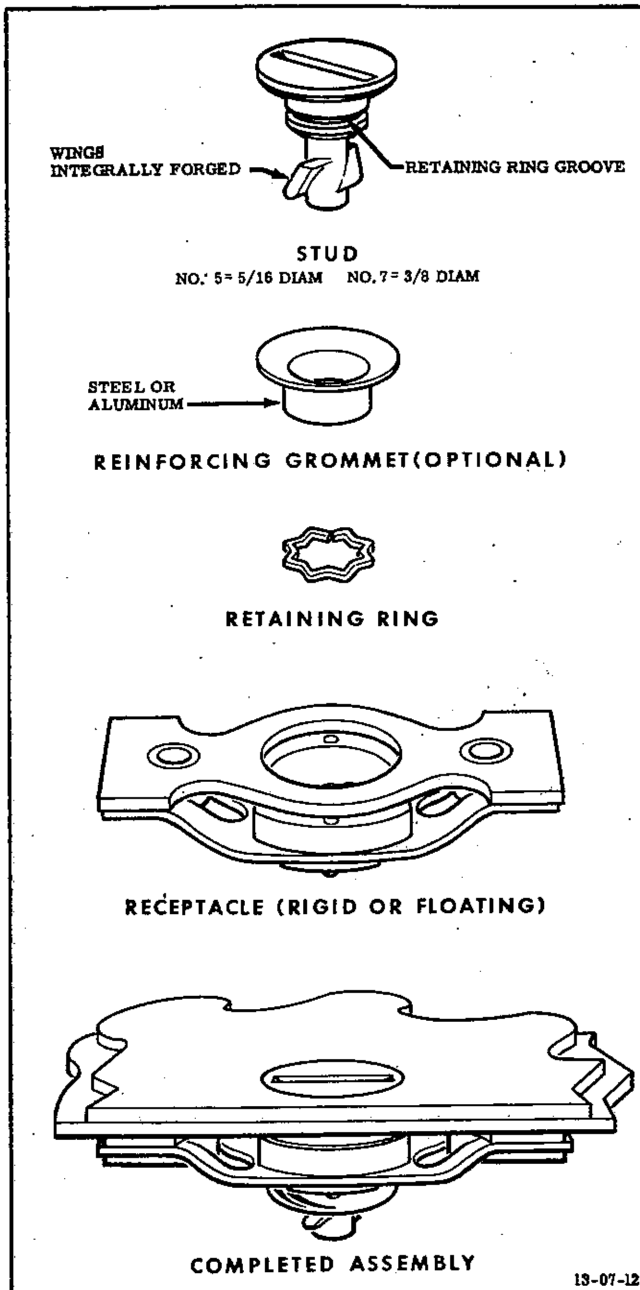


Figure 7-12 Paneloc Zahodiakin Fastener

seal gasket and shear washer are optional. They are available in two sizes: No. 5 and No. 7.

Stud

32 The studs are made of cadmium-plated steel and have wings integrally forged from the shank. They are available with flush heads, oval heads and wing heads. The stud is held in position by a retaining ring.

Retaining Ring

33 The retaining ring is made of cadmium-plated steel, and locks into a groove in the stud. No special installation tools are required.

Receptacle

34 The receptacle is mounted on the inside sheet by means of two rivets. There are two types of receptacle, rigid and floating.

Reinforcing Grommet

35 To strengthen the bearing area, the reinforcing grommet may be installed in the dimpled sheet before inserting the stud. The grommets are made of corrosion resistant steel and aluminum, the latter being used for soft material to protect the sheet from scoring.

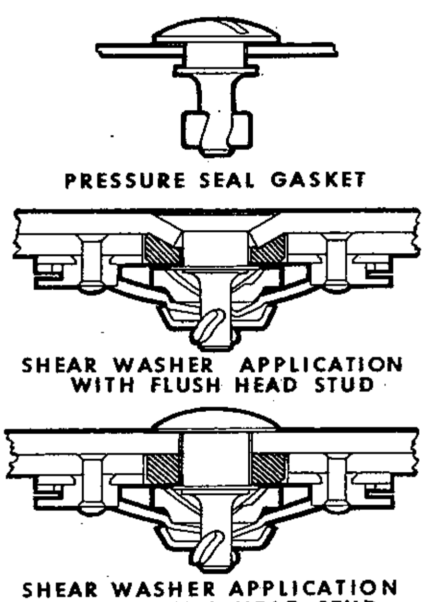


Figure 7-13 Pressure Seal Gasket and Shear Washer Application

Pressure Seal Gaskets

36 Pressure seal gaskets, made of non-metallic material, (see Figure 7-13), are used under the head of the studs to achieve fluid tightness.

Shear Washers

37 A shear washer is applied when it is necessary to reduce sheet deflection, especially in case of oval head studs. The washer, being closely fitted in the inner sheet, carries the shear load directly into the stud. Shear washers are made for oval and flush head studs.

Part Number Coding

38 For part number coding for Paneloc fasteners, see Figure 7-14.

Installation

39 Paneloc fasteners are installed as follows:

(a) To install studs (Item 5) drill holes, (see Figure 7-15), in the outer sheet, insert the stud and secure with a retaining ring.

(b) Install all receptacles using two 1/8 inch rivets. For hole sizes see Figure 7-16. Use countersunk receptacle where the skin rivet holes are dimpled, and non-countersunk receptacle where the skin holes are machine countersunk. To determine the grip length add to total sheet thickness 0.144 inch for No. 5 receptacle, and add 0.175 inch for No. 7 receptacle.

(c) Close and secure reinforcing grommets with standard grommet tools. Use the irregularly pierced holes where a non-turning grommet is required, (see Figure 7-16).

(d) To install ejector spring, drill outer sheet as specified to accommodate stud dimple and allow for the arc of the stud. Install stud in ejector spring and lock stud in receptacle. Use rivet holes in spring as template and drill top sheet for two 1/8 inch rivets.

(e) Install pressure seal gasket between the head of the stud and the outer sheet. No reinforcing grommet is used with this installation.

(f) Where shear washers are used, install underneath the outer sheet and secure with retaining ring. Drill holes in inner sheet, (see Figure 7-15), to accommodate the washer. With the -68 and -79 shear washers, use special receptacles with oversize holes in the base plate corresponding to outside diameter of the washer.

LION FASTENERS

General

40 Lion fasteners (Item 6) consist of a stud, grommet and receptacle. The fasteners are manufactured in three sizes: Hi-Strength, corresponding to 3/8 inch diameter; No. 5 corresponding to 5/16 inch diameter; and No. 2 corresponding to 1/4 inch diameter. (See Figures 7-17, 7-18 and 7-19.)

Stud

41 The one-piece studs, made of mild steel are available in the following head styles: Flush, oval, wing (5-W - and 5-WA-), ring (5-RA-and 5-RB), notched (5-N-), key (5-N-) and knurled (5-K-). The stud of the Hi-Strength type is held in position by means of a ring which locks into holes in the stud. The studs of the remaining types are retained in the panels with grommets.

Grommet

42 Grommets are used for No. 5 and No. 2 fasteners only. They are made of aluminum alloy and mild steel. In addition, rubber grommets (neoprene) are available to allow for hand removal of stud. They are made for No. 5 studs only.

EXAMPLES OF PART NO. CODING			
S2000-F-13	No.5 Flush Head Stud, grip length from 0.121 inch to 0.130 inch.	AG4000-F-46	No.7 Aluminum Alloy Grommet, for flush head stud, for outer sheet thickness from 0.040 inch to 0.060 inch.
S2000-R-15	No.5 Oval Head Stud, grip length from 0.141 inch to 0.150 inch.	SG4000-F-68	No.7 Corr. Res. Steel Grommet, for flush head stud, for outer sheet thickness from 0.060 inch to 0.080 inch.
S4000-W-18	No.7 Wing Head Stud, grip length from 0.171 inch to 0.180 inch.	E4000-D	No.7 Ejector Spring, dimpled.
L2000	No.5 Retaining Ring.	E2000-ND	No.5 Ejector Spring, non-dimpled.
L4000	No.7 Retaining Ring.	PS2000	No.5 Pressure Seal Gasket, for use with flush, oval and wing head studs.
R2000-Z-C	No.5 Floating Type Receptacle, countersunk rivet holes	AW2000-43-4	No. 5 Aluminum Alloy Shear Washer, 0.430 inch outside diameter, for sheet thickness up to 0.040 inch.
R4000-NZ-NC	No.7 Rigid Type Receptacle, non-countersunk rivet holes.	SW4000-79-5	No.7 Steel Shear Washer, 0.798 inch outside diameter, for sheet thickness up to 0.051 inch.
AG2000-F-25	No. 5 Aluminum Alloy Grommet, for flush head stud, for outer sheet thickness from 0.020 inch to 0.050 inch.		
SG2000-F-57	No.5 Corr. Res. Steel Grommet, for flush head stud, for outer sheet thickness from 0.050 inch to 0.070 inch.		

Figure 7-14. Paneloc Part Number Coding

Receptacle

43 A floating assembly made of mild steel allows for misalignment up to 0.153 inch on No. 5 fastener, and for a wide range tolerance of sheet thickness. Hi-Strength and No. 5 receptacles are attached with 1/8 inch and No. 2 receptacle with 3/32 inch flush head rivets. The No. 5 receptacle is also manufactured for spot-welding to the inner sheet (Part No. 5-296).

Coding

44 For part number coding, see Figure 7-20.

Installation of Lion Fasteners

45 Use special tools for sheet dimpling and closing of metal grommets. Employ flush head rivets for attaching receptacles. After riveting, ensure that the receptacle spring floats in the base. Immobilization of the spring will limit the range of misalignment.

Hi-Strength Fastener

46 To install a Hi-Strength fastener, proceed as follows: (See Figure 7-17.)

(a) Drill a 3/8 inch hole in the outer sheet, insert the stud and secure it with retaining ring. No special tools are required.

(b) In the inner sheet, drill two No. 30 rivet holes to 1 inch centres and countersink. Drill a 15/32 inch centre hole and countersink the side of the sheet to which the receptacle is to be attached to 82° and to a depth of 0.044 inch. The manufacturer's tool for drilling and countersinking is No. HT-1.

NUMBER 7 STUD	NUMBER 5 STUD
Outer Sheet	**Outer Sheet**
Flush head stud: Before dimpling, drill 11/32 inch hole. Final hole 3/8 (±.010 inch). Dimple diameter: .700 inch to .720 inch. Angle 118° to 120°. Oval and wing heads: Final hole size 3/8 (±.010 inch). For ejector spring: Drill .812 (±.010 inch). For reinforcing grommet: See Figure 7-16.	Flush head stud: Before dimpling, drill 19/64 inch hole. Final hole size 5/16 (±.010 inch). Dimple diameter: .630 inch to .650 inch. Angle 118° to 120°. Oval and wing head studs: Final hole size 5/16 (±.010 inch). For ejector spring: Drill .703 (±.010 inch) hole. For reinforcing grommet: See Figure 7-16.
Inner Sheet	**Inner Sheet**
For receptacle holes: See Figure 7-16. For shear washers: Drill .500 inch to .505 inch hole for dash No. 49. .802 inch to .822 inch hole for dash No. 79.	For receptacle holes: See Figure 7-16. For shear washers: Drill .435 inch to .440 inch hole for dash No. 43. .693 inch to .713 inch hole for dash No. 68.

Figure 7-15 Paneloc Sheet Hole Sizes

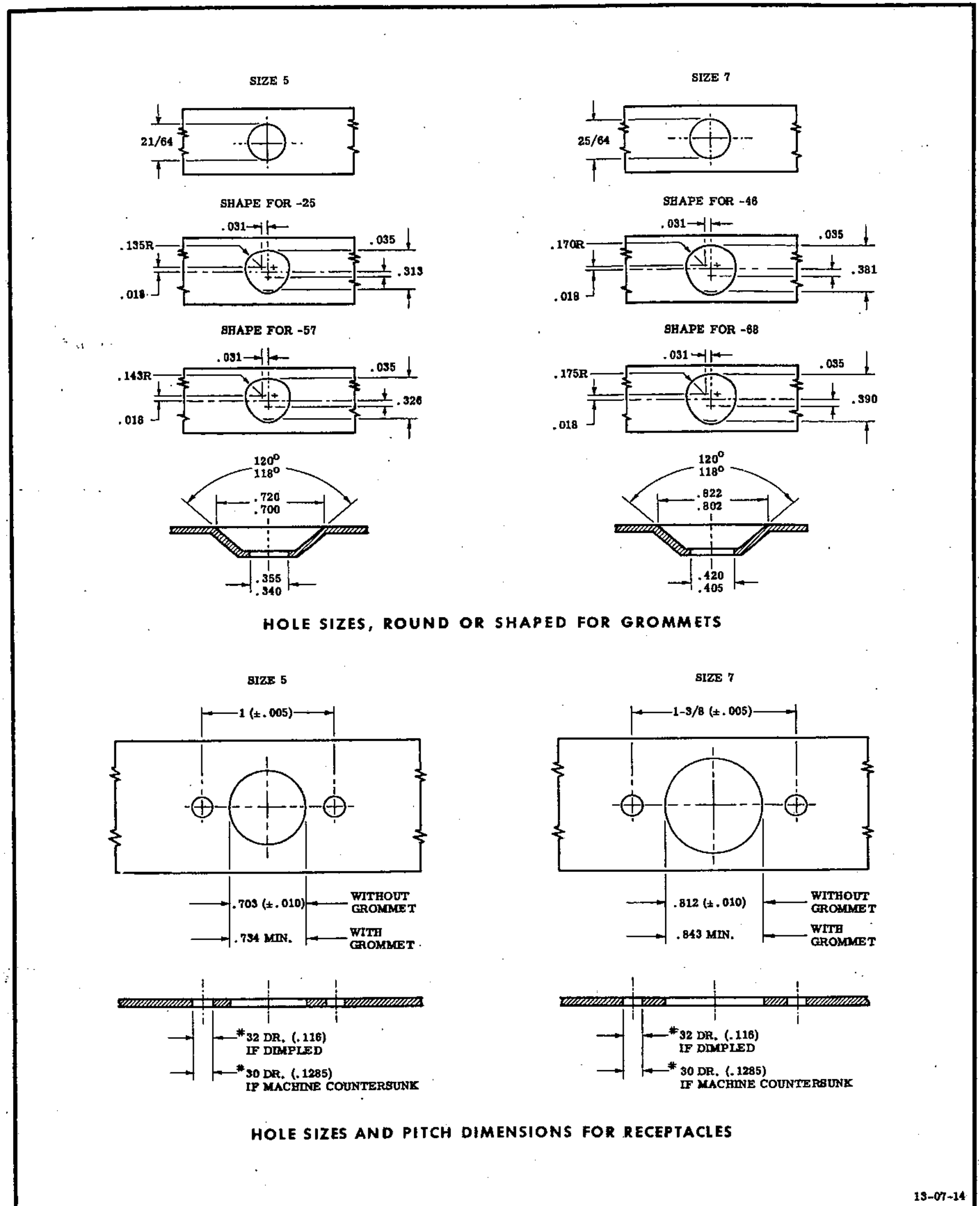


Figure 7-16 Installation Dimension for Receptacles and Grommets

NOTE

The minimum thickness of the inner sheet for a Hi-Strength receptacle is 0.062 inch.

No. 5 Fastener

47 To install a flush head No. 5 fastener, using a GF grommet in the outer sheet proceed as follows:

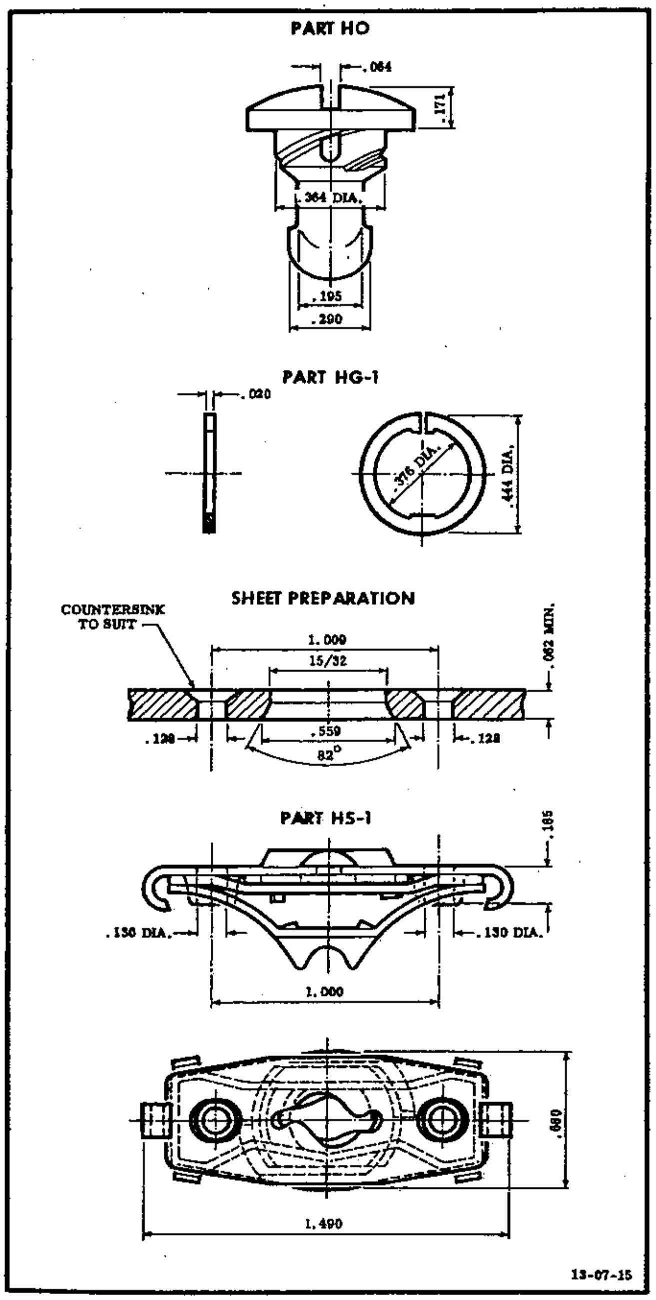


Figure 7-17 Lion High Strength HO Fastener

(a) Drill a 11/32 inch hole and insert stud and grommet. Curl grommet, using the flat end of tool No. 5-FD-3. Employ the countersunk end of tool to close the grommet and dimple the sheet.

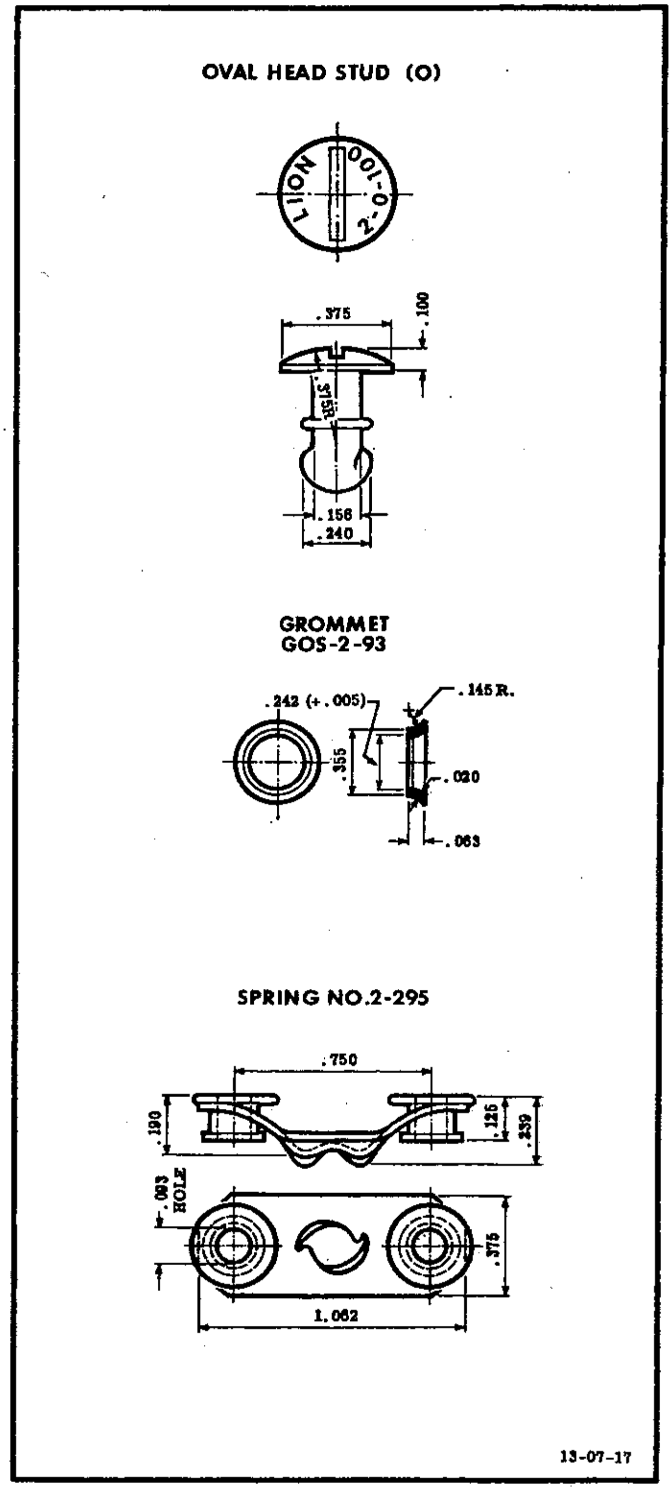


Figure 7-18 Lion No. 2 Fastener

(b) For thicknesses from 0.095 inch to 0.120 inch, drill 11/32 inch hole. Countersink to provide proper conditions for closing the grommet and dimpling. For thicknesses over 0.120 inch, drill 5/16 inch hole, countersink and use GOS-5-93 grommet.

48 To install an oval head No. 5 fastener, drill a 5/16 inch hole, insert stud and slip grommet on with the larger opening towards the head. Tap tool (Punch 5-OP-1; Die 5-OD-1) lightly to centre the grommet and then set the grommet.

No. 5 Receptacle

49 To install a No. 5 receptacle with flush head stud, proceed as follows:

(a) Drill 1/2 inch hole in the inner sheet and dimple, using Punch No. 5-SP-1 and Die No. 5-SD-1.

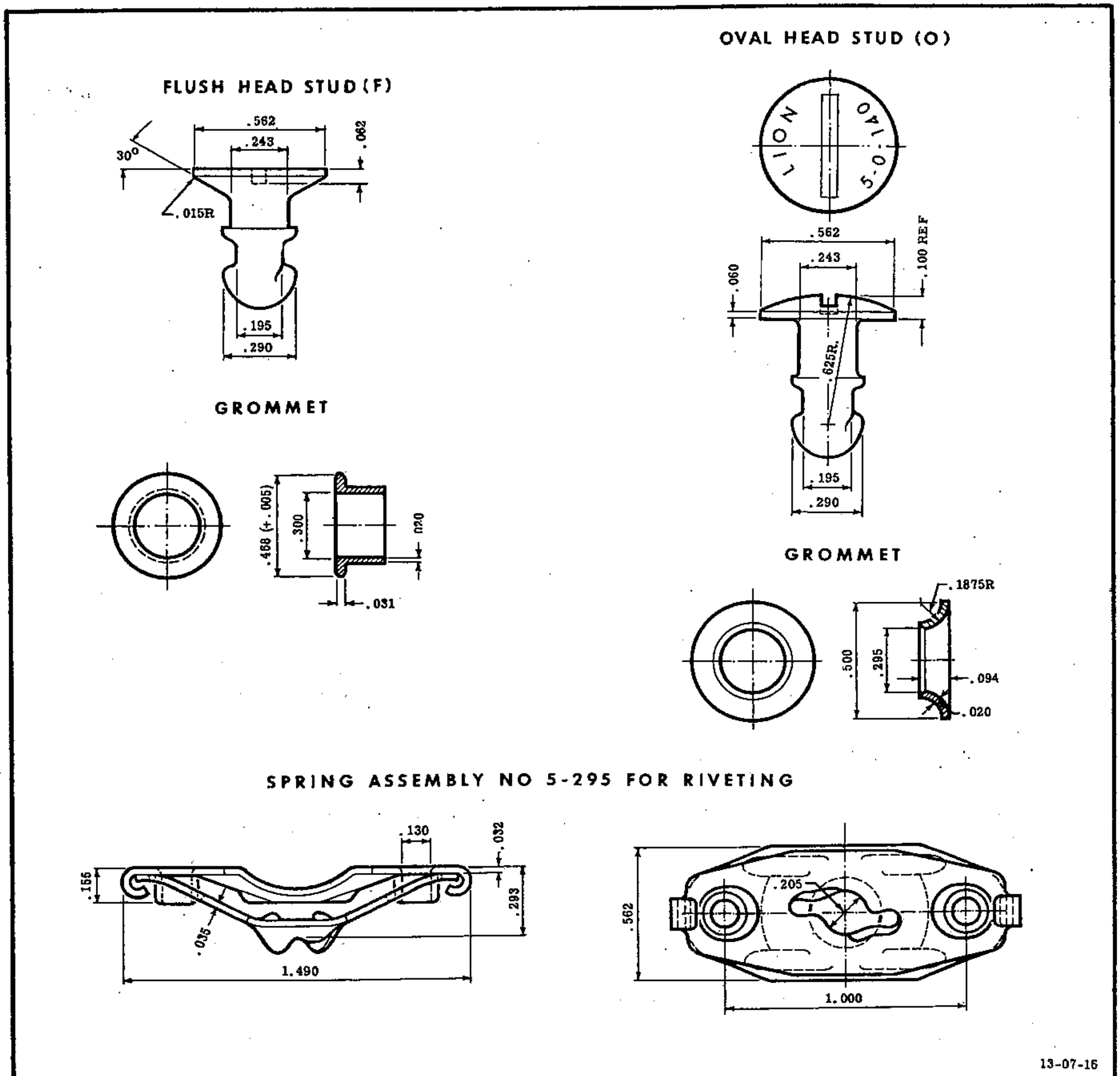


Figure 7-19 Lion No. 5 Fastener

(b) For No. 5 receptacle with oval head stud only, drill a 9/16 inch hole.

(c) For both types, drill two No. 30 (0.128 inch) holes on 1 inch centres for 1/8 inch rivets and dimple if the thickness of the sheet is 0.040 inch or less. If the thickness is over 0.040 inch, cut countersink.

No. 2 Fastener

50 Install No. 2 stud in the outer sheet in the same manner as No. 5 oval head type, drilling 1/4 inch hole.

51 To attach receptacle to the inner sheet, drill 15/32 inch centre hole, and two No. 41 (0.096 inch) holes on 3/4 inch centres for 3/32 inch rivets.

ODDIE FASTENERS

General

52 Each Oddie fastener (Item 7) consists of a central pin, a coil spring or rubber washer and a two-legged spring clip. The spring clip is rivetted to the underside of the structure at the point where the fastening is to be made. (See Figure 7-21.)

Description

53 The central stud is made of mild steel with a rustproof coating and is available in standard and midget sizes, each in several lengths and with flush, oval or wing types of head. The stud is undercut below the head to

EXAMPLES OF PART NO.CODING			
HO-140	Hi-Strength stud, grip length 0.130 inch to 0.150 inch. (Grip length available from 0.130 inch (Dash No.140) to 0.430 inch (Dash No.410) Increments in 0.030 inch.)	GF-130	No.5 Aluminum alloy flush head type grommet. (The range of sheet thickness up to 0.020 inch (Dash No.130) to 0.120 inch (Dash No.250). NOTE: For sheet thickness over 0.120 inch use GOS-5-93 grommet.
5-F-60	No.5 Flush head stud, grip length from 0.050 inch to 0.069 inch.		
5-0-80	No. 5 Oval head stud, grip length from 0.070 inch to 0.089 inch. (The range of grip for Flush and Oval head studs from 0.050 inch (Dash No. 60) to 1.009 inch (Dash No. 1000). Increments in 0.020 inch.)	GOS-5-93	No.5 Steel oval and flush head type grommet.
		GO-5-93	No.5 Aluminum alloy oval-head type grommet.
2-0-80	No.2 Oval head stud, grip length from 0.070 inch to 0.089 inch.	GR-1	No.5 Rubber grommet.
		GOS-2-93	No.2 Steel oval head type grommet.
2-W-100	No.2 Wing head stud, grip length from 0.090 inch to 0.109 inch. (The range of grip from 0.070 inch (Dash No.80) to 0.250 inch (Dash No.240). Increments in 0.020 inch.	GO-2-93	No.2 Aluminum alloy oval-head type grommet.
		HS-1	Hi-Strength receptacle.
		5-295	No.5 Receptacle for rivetting.
HG-1	Hi-Strength retaining ring.	2-295	No.2 Receptacle.

Figure 7-20 Lion Part Number Coding

accommodate the rubber washer or coiled spring which retains the stud in the panel. The bullet-shaped end of the stud is recessed at each side to mesh with the spring legs when in the locked position.

NOTE

The resilient watertight rubber washer is spaced between the panel and the mounting and is necessary to reduce vibration and chattering to a minimum. The coiled spring is intended for positions where excessive heat is expected to be encountered.

Spring Clips

54 The spring clips, held in position by two light alloy rivets, are made from spring steel and are corrosion resistant. The spring clip legs engage with the flats on the stud, the leading ends of the spring acting as a guide on the bullet end of the stud.

Installation

55 All installation data and dimensions, (see Figure 7-22), must be adhered to in order that the correct functioning of the fasteners is ensured. It is essential that the correct alignment is obtained between the stud and spring clip. Note the following points:

(a) Do not exceed the maximum dimensions given on the various assemblies, between the top or outer face of the panel, i.e. the grip length. Keep on the minus side of these dimensions to obtain secure engagement of the studs in the spring clips.

(b) It should always be possible to engage the fasteners by finger-pressure only, and there must be a definite and audible click as the fastener engages, indicating that it is locked. If the click is not heard, then the installation is incorrect and the condition should be rectified.

(c) The edge of a washer or similar device may be used to unlock the fastener by turning the head through 90°. When unlocked, it is advisable to turn the head 90° to its original position, ready for assembly.

Removal of Fasteners

56 Remove the rubber washer at the inner side of the panel to remove the stud from its mounting. To remove the spring clip, drill out the rivets in the structure. Fit new rivets and spring clips, using the same rivet holes, when replacing.

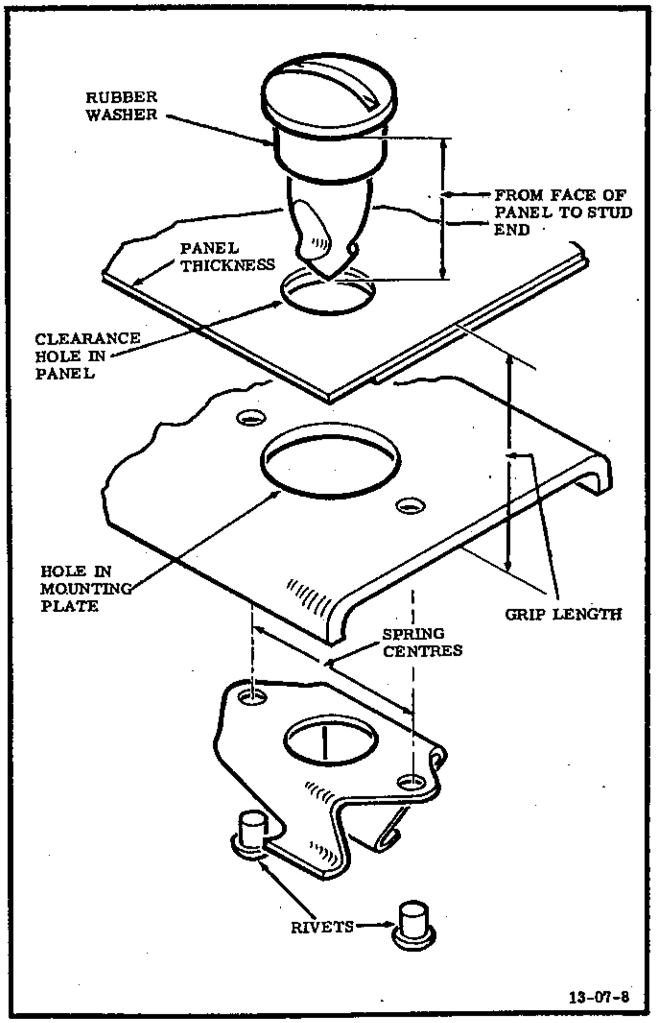


Figure 7-21 Oddie Fastener - Exploded View

Description	Atom	Midget		Standard	
	Dome head	Dome head	Flush head	Dome head	Flush head
Panel thickness	.065	.065	.065 dimpled .10 max.	.10	.10 dimpled .15 max.
Clearance hole in panel	3/16 dia.	1/4 dia.	1/4 dia.	3/8 dia.	3/8 dia.
Hole in mounting plate	5/16 dia.	15/32 dia.	15/32 dia.	5/8 dia.	5/8 dia.
Grip Length	.15 max.	.17 max.	.24 max.	.26 max.	.34 max.
Dia. of light alloy rivets for spring clip	1/16	3/32	3/32	1/8	1/8
Recommended pitch of fasteners per inch run	1 to 2	2 to 4	2 to 4	6 to 10	6 to 10
Distance from top face of panel to end of stud	.475	.70	.77	.95	1.04
Distance of rivet hole centres on clips	.50	.69	.69	1.000 min. 1.062 max.	1.000 min. 1.062 max.

Figure 7-22 Oddie Fastener Installation Data

PART 7 SECTION 2

VIBRATION INSULATORS

PLATE VIBRATION INSULATORS

General

1 Vibration insulators used on aircraft in the installation of instruments, instrument panels, and other equipment requiring plate type vibration insulator mounting, consist of three essential parts; the mounting plate, the elastic medium (or element made of natural rubber) and the centre sleeve of metal. These mounts are manufactured in three types; the square plate, the cupped-outside load and the cupped-inside load. A cross-reference of manufacturers' and AN part numbers is shown in Figure 7-23.

Mounting Plate

2 The mounting plate, either flat or cupped, is fabricated from aluminum alloy and is protected with an anodic film. The metal of the plate is of sufficient strength to withstand 15 times rated load without distortion.

Centre Sleeve

3 The centre sleeve is fabricated of the same metal as the plate, the dimensions of which are listed in Figure 7-23. It is moulded into the rubber element or pressed into place and held in position by crimped washers. The side that protrudes above the plate the greater distance when it is not supporting a load is designated as the load side, and is shown in Figure 7-24.

Elastic Element

4 The elastic element is constructed of natural rubber only, and will retain its proper vibration characteristics to -54°C (-65°F). The rubber element, either bonded or clamped to the metal depending on the manufacturing design, (see Figure 7-25), is designed to give the proper deflection characteristics for both radial and axial loads. The design, in either case, is provided with a cushioned stop to prevent contact between vibration insulators or between the supported and supporting structures when more than the rated load is applied. The elastic element is so designed that when the rated load is applied axially on the load carrying side of the insulator centre sleeve, the deflection of the centre sleeve with respect to the plate will be 0.062 (± 0.009) inch.

Installation

5 When it is necessary to install or to modify equipment requiring vibration insulator mounting in a specific type aircraft, mounting instructions will be included with the instructions directing the required work.

6 Vibration insulators have been made a design requirement on all aircraft instrument panels. Vibration insulators are mounted in pairs with their axes vertical in a plane parallel to the instrument board through the centre of gravity of the instrument board complete with instruments. The number, size, rating and location of vibration insulating units are such that a total deflection of 1/8 (± 1/64) inch is produced on each pair of units. The rating of each single unit is the load required to deflect it 1/16 inch.

Insulating Unit Size

7 For instrument board, complete with instruments, weighing less than 24 pounds, Size 1 units (1 inch diameter) will be used. For instrument boards weighing more than 24 pounds, Size 2 units (1-1/2 inch diameter) or Size 3 units (2 inch diameter) will be used.

NOTE

These installations provide equal flexibility in all directions. If an instrument board weighs 16 pounds, four pairs of 4-pound units will produce a static deflection of 1/8 inch. The same deflection (± 1/64 inch) may be obtained with five pairs of 3-pound units.

Mounting Brackets

8 All members or brackets to which vibration insulating units are attached are designed with sufficient rigidity to prevent any appreciable flexing in themselves or in their attachment to adjacent members. Supporting brackets must not be mounted on the cowling or any other member subject to vibration from the flow of air unless adequate provisions for rigid support are made.

Snubbing

9 Suitable means are provided to prevent excessive deflection of insulating units, and to absorb shock due to catapulting, arrested

Size	Shape	AN Part Number	Manufacturers Part Number				Load Rating Pounds Per 1/16 Inch Deflection
			Lord Mfg. Co. Erie, Pa.	Harris Products Co. Cleveland, Ohio.	M.B. Mfg. Co., Inc. 1060 State St. New Haven 11, Conn.	General Tire and Rubber Co. Wabash, Ind.	
1	Square Plate	AN8008D0					1/2
		AN8008D1	100PL-1			10059	1
		AN8008D2	100PL-2	1022-1D-2	171.32	10060	2
		AN8008D3	100PL-3	1022-1D-3	171.46		3
		AN8008D4			171.68		4
2		AN8008D5	150PL-2	1022-2D-2	172.32		2
		AN8008D6	150PL-4			10073	4
		AN8008D7	150PL-6	1022-2D-6	1721.0	10074	6
		AN8008D8	150PL-8	1022-2D-8		10075	8
		AN8008D9	150PL-10		1721.5	10076	10
		AN8008D10	150PL-12		1721.8	10077	12
3		AN8008D11	200PL-10		1731.5	10380	10
		AN8008D12	200PL-15			10381	15
		AN8008D13	200PL-20	1022-3D-20	1733.2	10382	20
		AN8008D14	200PL-25		1733.8		25
		AN8008D15	200PL-35		1735.6		35
		AN8008D16		1022-3D-45	1736.8		45

Figure 7-23 (Sheet 1 of 3) Vibration Insulator Cross-reference Table

landing or rough field landing. Snubbing is accomplished as shown in Figures 7-24 and 7-25.

Clearance

10 Adequate clearance is provided for mounted unit in all directions when vibration insulators are used.

NOTE

Clearance is necessary to prevent instrument panels and instruments or similarly mounted equipment from coming in contact with any part of the aircraft, both under normal vibration conditions and shock due to landing.

Size	Shape	AN Part Number	Manufacturers Part Number				Load Rating Pounds Per 1/16 Inch Deflection
			Lord Mfg. Co. Erie, Pa.	Harris Products Co. Cleveland, Ohio.	M. B. Mfg. Co., Inc. 1060 State St. New Haven 11, Conn.	General Tire and Rubber Co. Wabash, Ind.	
1	Cupped Outside Load	AN8008D20					1/2
		AN8008D21				10313	1
		AN8008D22	100PHL-2			10314	2
		AN8008D23		1022-4D-3			3
		AN8008D24		1022-4D-4			4
2		AN8008D25	150PHL-2	1022-5D-25			2
		AN8008D26	150PHL-4			10187	4
		AN8008D27	150PHL-6	1022-5D-6		10188	6
		AN8008D28	150PHL-8	1022-5D-28		10089	8
		AN8008D29	150PHL-10			10090	10
		AN8008D30	150PHL-12			10091	12
3		AN8008D31	200PHL-10				10
		AN8008D32	200PHL-15				15
		AN8008D33	200PHL-20	1022-6D-20			20
		AN8008D34	200PHL-25				25
		AN8008D35	200PHL-35				35
		AN8008D36		1022-6D-45			45

Figure 7-23 (Sheet 2 of 3) Vibration Insulator Cross-reference Table

Inspection

11 At the periodic inspection nearest to 100 hours, mounted vibration insulators must be inspected as follows:

(a) Move the instrument panel and all vibration mounted instruments or equipment to extreme positions in every direction to determine if insulators have sagged or any looseness of rivets has developed.

(b) Check rubber part of units for cracks

(c) Check centre sleeve for looseness.

(d) Check mounting plates and rivets.

Size	Shape	AN Part Number	Manufacturers Part Number				Load Rating Pounds Per 1/16 Inch Deflection
			Lord MFG. Co. Erie, Pa.	Harris Products Co. Cleveland, Ohio.	M.B. Mfg. Co., Inc. 1060 State St. New Haven 11, Conn.	General Tire and Rubber Co. Wabash, Ind.	
1	Cupped Inside Load	AN8008D40					1/2
		AN8008D41	100PHUL-1			10340	1
		AN8008D42				10341	2
		AN8008D43	100PHUL-3	1022-7D-3		10342	3
		AN8008D44	100PHUL-4				4
2		AN8008D45	150PHUL-2	1022-8D-2			2
		AN8008D46	150PHUL-4			10172	4
		AN8008D47	150PHUL-6	1022-8D-6		10173	6
		AN8008D48	150PHUL-8	1022-8D-8		10174	8
		AN8008D49	150PHUL-10			10175	10
		AN8008D50	150PHUL-12			10176	12
3		AN8008D51	200PHUL-10				10
		AN8008D52	200PHUL-15				15
		AN8008D53	200PHUL-20	1022-9D-20			20
		AN8008D54	200PHUL-25				25
		AN8008D55	200PHUL-35				35
		AN8008D56	200PHUL-45	1022-9D-45			45

Figure 7-23 (Sheet 3 of 3) Vibration Insulator Cross-reference Table

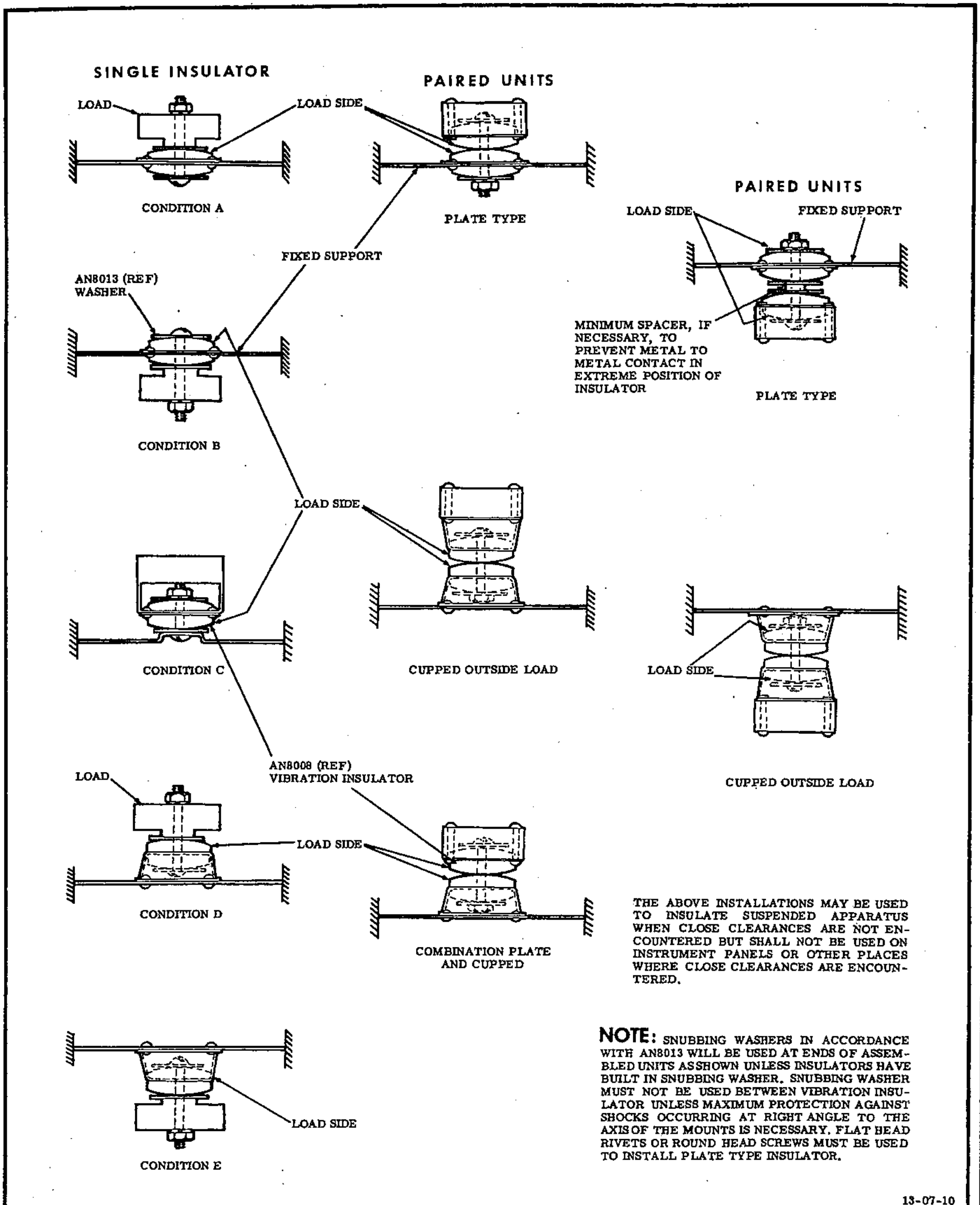


Figure 7-24 Loading Instructions - Vibration Dampeners

(e) If any defective part is found, replace the vibration insulator with a serviceable insulator of proper size and type.

(f) If mounts have collected oil or grease, clean thoroughly by washing insulator in warm water containing detergent (Item 9).

Replacement

12 Replacement of vibration insulators is accomplished as follows:

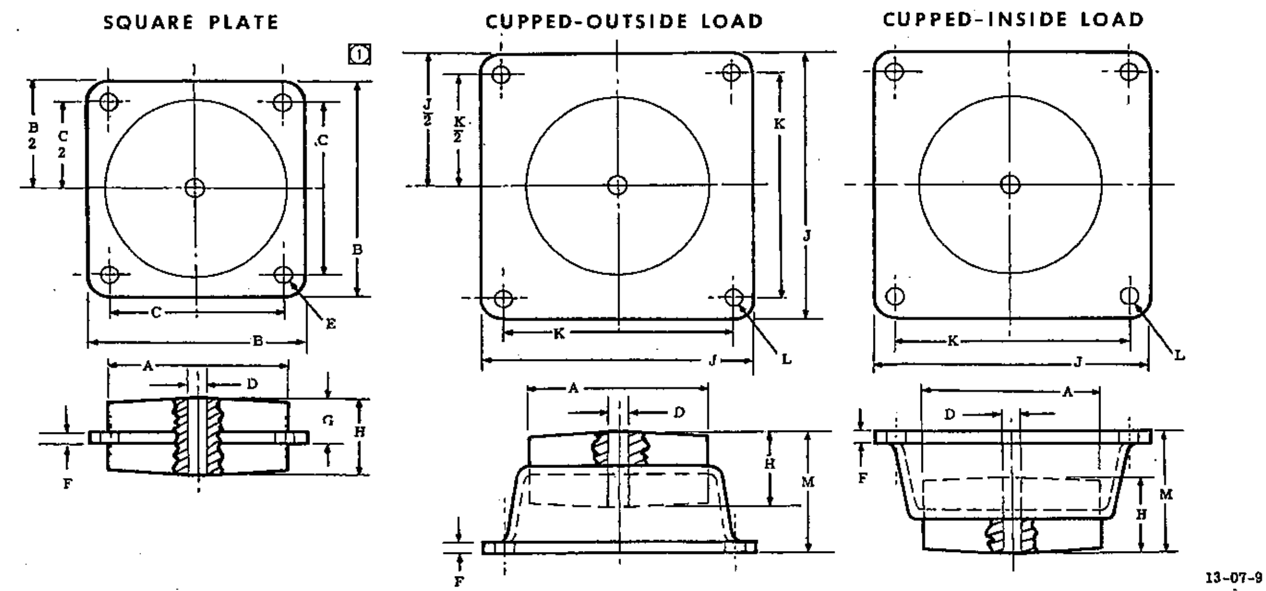
(a) Consult Figures 7-23 and 7-25 for size and type insulator to be used.

(b) Install to conform to Figure 7-24.

Material Specifications

13 For table showing item numbers, materials, specifications and manufacturers called in this Part, see Figure 7-26.

AN PART NUMBER SHOWN ON LOAD CARRYING SIDE OF INSULATOR, POSITION OPTIONAL. HOLE D IS CENTERED WITHIN 0.010. DIMENSIONS ARE SHOWN WITH INSULATOR UNDER RATED LOAD.



Size	A Dia. Max.	B	C	D Dia.	E Dia. +.003 -.002	F	G	H ±.008	J	K	L Dia. +.003 -.002	M	Weight lbs. Max. Square Plate D	Weight lbs. Max. Cupped Plate D
1	1.005	1-1/4	1.000	.166 +.005 -.000	.141	.100 / .025	.235	.406	1-11/16	1.375	.141	.719	.015	.033
2	1.505	1-3/4	1.375	.257 +.008 -.000	.166	.160 / .032	.337	.625	2-3/8	1.937	.196	1.063	.048	.090
3	2.005	2-1/4	1.750	.391 +.008 -.000	.196	.250 / .037	.529	1.000	3	2.500	.257	1.500	.180	.290

Figure 7-25 (Sheet 1 of 2) Plate Vibration Insulators

Load Rating Lbs. Per 1/16 Deflection	Square Plate		Cupped - Outside Load		Cupped - Inside Load	
	Dash No.	Size	Dash No.	Size	Dash No.	Size
1/2	0	1	20	1	40	1
1	1	1	21	1	41	1
2	2	1	22	1	42	1
3	3	1	23	1	43	1
4	4	1	24	1	44	1
2	5	2	25	2	45	2
4	6	2	26	2	46	2
6	7	2	27	2	47	2
8	8	2	28	2	48	2
10	9	2	29	2	49	2
12	10	2	30	2	50	2
10	11	3	31	3	51	3
15	12	3	32	3	52	3
20	13	3	33	3	53	3
25	14	3	34	3	54	3
35	15	3	35	3	55	3
45	16	3	36	3	56	3

NOTE

Dimensions in inches. Unless otherwise specified, tolerances on fractions ± 1/64, decimals ±.010.

Metal used is denoted by letter; Aluminum (D).

Example of AN part No. AN8008D7 indicates Aluminum, square plate insulator, Size 2, Load Rating: 6 pounds per 1/16 deflection.

Figure 7-25 (Sheet 2 of 2) Plate Vibration Insulators

Item No.	Material	RCAF Ref.	Specification	Manufacturer
1	Fastener, Dzus	28NS/	MIL-F-5591A	Dzus Fastener Co., P.O. Box 185, Babylon, New York.
2	Fastener, Camloc	28NS/	MIL-F-5591A	Camloc Fastener Corp., 22 Spring Valley Road, Paramus, New Jersey.
3	Fastener, Airloc	28NS/	MIL-F-5591A	United-Carr Fastener Corp., 31 Ames St., Cambridge, Mass.
4	Fastener, Shakeproof	28NS/	MIL-F-5591A	Shakeproof Inc., 2501 N Keeler Avenue, Chicago, Ill.
5	Fastener, Panelock-Zahodiakin	28NS/	MIL-F-5591A	Scovill Mfr. Co., Waterbury, Conn.
6	Fastener, Lion	28NS/	MIL-F-5591A	South Chester Corp., Lester, Penn.
7	Fastener, Oddie	28NS/	MIL-F-5591A	Brown Bros. (Aircraft) Ltd., Bedford Rd., Northampton, Eng.
8	Insulator, Vibration, AN8008	27LM/	MIL-I-5432A	Lord Mfr., 1635 W 12th St., Erie, Penn.
9	Detergent, (General Purpose)	33C/667	2-GP-103	

Figure 7-26 Table of Material Specifications

PART 8

SAFETYING MEDIA

PART 8

SAFETYING MEDIA

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

PART 8

SAFETYING MEDIA

Safety Wiring Methods

1 For general instructions regarding the use and application of safety wire, refer to EO 05-1-2AQ.

Cable Quick-disconnect Installation

2 Instructions for installation of control cable quick-disconnects are shown in Figure 8-1.

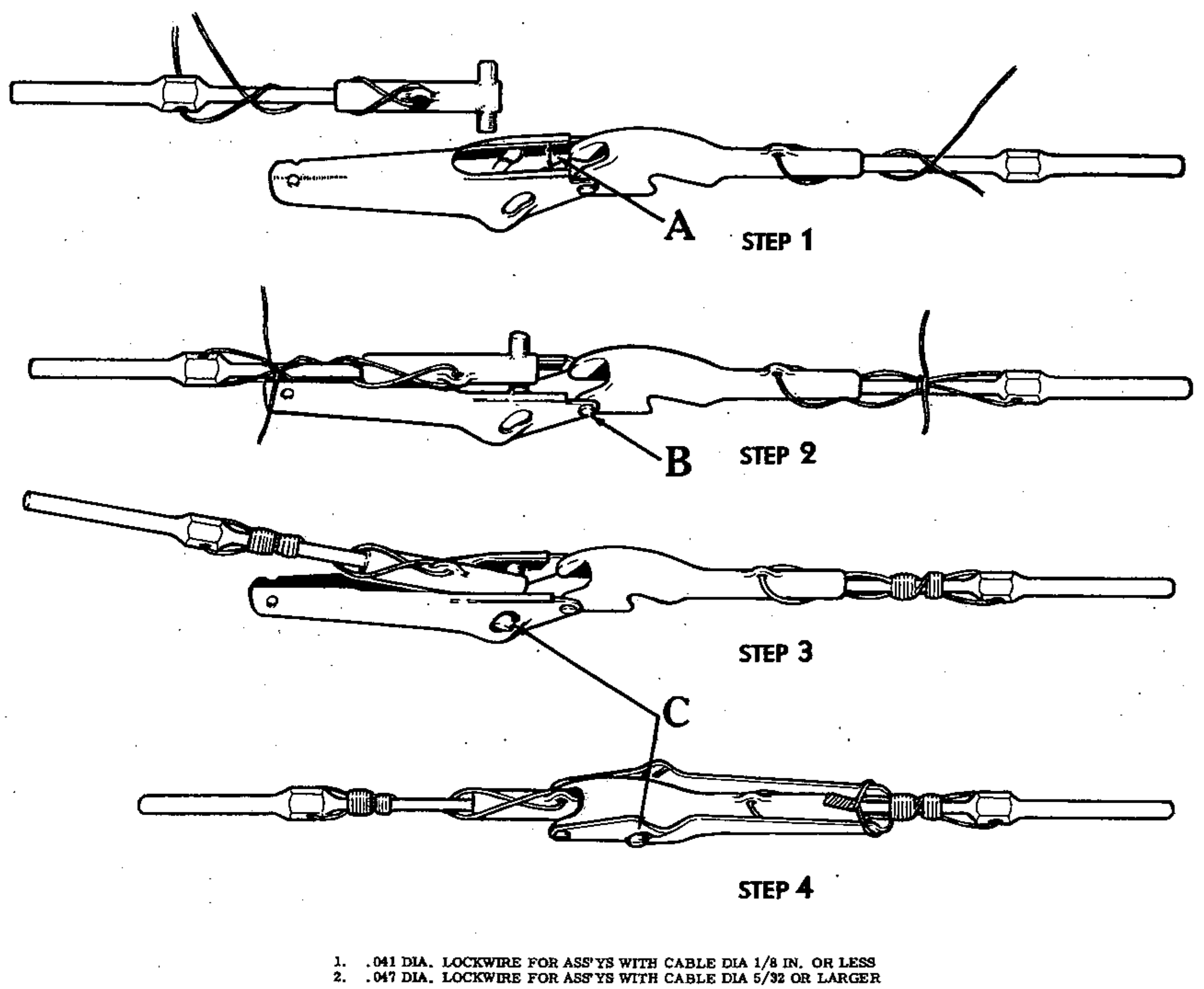


Figure 8-1 Quick-disconnect Assembly Details

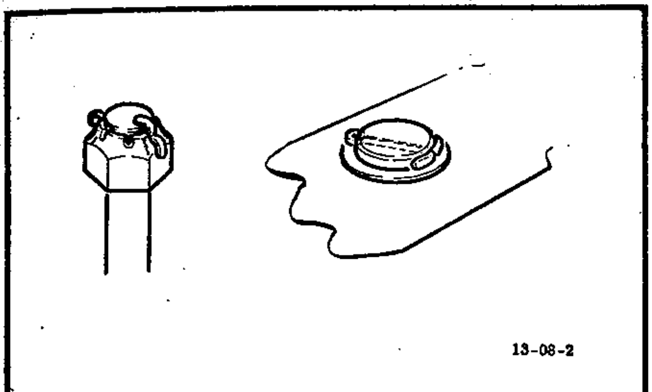


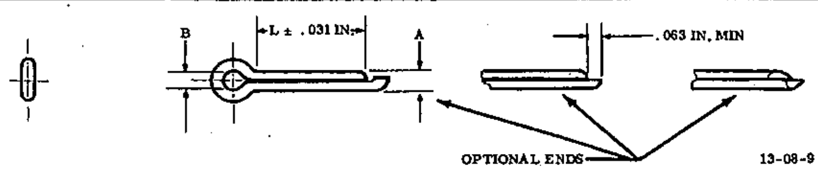
Figure 8-2 Cotter-pin Installation

Installation Inspection

3 Carry out the following inspections during installation:

(a) The lips at the open end of the locking handle (A) must be parallel. If they are not parallel, the handle has been warped by improper installation of the unit and the unit must be replaced.

(b) On units having the peened hinge pin (B) inspect the peened head for fullness. If the head is not fully flattened outside the surface of the sheet-metal locking handle, replace the unit.



Nom Dia	A Dia	B Min	Hardness Rockwell 15-N	Recommended Drill Hole Dia +.005 -.002
1/32	$.030^{+.000}_{-.003}$	.032	65 TO 75	.035
1/16	$.061^{+.000}_{-.003}$	.063		.067
3/32	$.090^{+.000}_{-.004}$	.094	60 TO 70	.096
1/8	$.122^{+.000}_{-.004}$	.125	55 TO 67	.129
5/32	$.150^{+.000}_{-.004}$	.156		.161
3/16	$.176^{+.000}_{-.004}$	.188		.188
7/32	$.207^{+.000}_{-.005}$	.219		.219
1/4	$.225^{+.000}_{-.005}$	.250		.238
5/16	$.280^{+.000}_{-.005}$	.313		.295

Prong of pin shall withstand bending flat on itself without cracking. Flat of prong shall form outside of bend.

Material: corrosion resisting steel.

Finish: passivate.

Example of Part No: AN381-2-10 - 1/6 (2/32) Nom. Dia Cotter Pin .625 inches long.

Note: Cotter Pins shall be free from burrs.

Figure 8-3 (Sheet 1 of 4) Cotter-pins - AN381

(c) Check the T-ends on the male part of the unit carefully during the mating of the cable. Both ends must extend beyond the surface of the locking handle through the slotted holes (C). If the cross is not seated properly in the slotted holes before the locking handle is closed, closing the handle may jam the cross against the body casting, which warps the locking handle by spreading the sides and may damage the hinge pin. Check for correct positioning of the T-ends before and after the locking handle is closed as shown in Figure 8-1.

(d) Exercise caution to prevent warping the locking handle by extending the unlocking action beyond approximately 200 degrees. Further extension of the unlocking movement may force the parallel lips on the handle (A) over the body casting, thus warping the open end of the handle.

Length L	Dash Numbers								
	1/32	1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16
.313		2-5							
.375	1-6	2-6							
.438		2-7							
.500	1-8	2-8	3-8	4-8	5-8				
.625		2-10	3-10						
.750	1-12	2-12	3-12	4-12	5-12				
.875		2-14	3-14	4-14					
1.000	1-16	2-16	3-16	4-16	5-16				
1.125			3-18	4-18	5-18				
1.250		2-20	3-20	4-20	5-20				
1.375			3-22	4-22	5-22				
1.500		2-24	3-24	4-24	5-24	6-24			
1.625			3-26	4-26	5-26	6-26			
1.750		2-28	3-28	4-28	5-28	6-28			
2.000		2-32	3-32	4-32	5-32	6-32	7-32	8-32	10-32
2.250				4-36	5-36	6-36	7-36	8-36	10-36
2.500					5-40	6-40	7-40	8-40	10-40
3.000						6-48		8-48	
3.500								8-56	
4.000								8-64	

Figure 8-3 (Sheet 2 of 4) Cotter-pins - AN381

Dia.	AN381 Current Length	AN381 Current Dash No.	AN381 Current RCAF Ref	AN380 Obsolescent Length	AN380 Obsolescent Dash No.	AN380 Obsolescent RCAF Ref	AGS784 Obsolescent Dash No.	AGS166 Obsolescent Dash No.
1/32	.375	-1-6	6025	3/8	-1-1	19560		-1C
1/32	.500	-1-8	6026	1/2	-1-2	18590		-2C
1/32	.750	-1-12	6027	3/4	-1-3	19561		-3C
1/32	1.000	-1-16		1	-1-4	19562		
1/16	.313	-2-5						
1/16	.375	-2-6	6028	3/8	-2-1	18123		
1/16	.438	-2-7						
1/16	.500	-2-8	5945	1/2	-2-2	11183	-2	-2
1/16	.625	-2-10						
1/16	.750	-2-12	5946	3/4	-2-3	11254	-3	-3
1/16	.875	-2-14						
1/16	1.000	-2-16	5947	1	-2-4	11255	-4	-4
1/16	1.250	-2-20	5948	1-1/4	-2-5	13310	-5	-5
1/16	1.500	-2-24	5949	1-1/2	-2-6	14926		
1/16	1.750	-2-28	5950	1-3/4	-2-7	14928	-6	-6
1/16	2.000	-2-32	5951	2	-2-8	11322		
3/32	.500	-3-8	5952	1/2	-3-2	11256	-10	-10
3/32	.625	-3-10						
3/32	.750	-3-12	5953	3/4	-3-3	11257	-11	-11
3/32	.875	-3-14						
3/32	1.000	-3-16	5954	1	-3-4	11258	-12	-12
3/32	1.125	-3-18						
3/32	1.250	-3-20	5955	1-1/4	-3-5	11259	-13	-13
3/32	1.375	-3-22						
3/32	1.500	-3-24	5956	1-1/2	-3-6	11253		
3/32	1.625	-3-26						
3/32	1.750	-3-28	5957	1-3/4	-3-7	14299	-14	-14
3/32	2.000	-3-32		2	-3-8	14938		
1/8	.500	-4-8	5959	1/2	-4-2	14300	-18	-18
1/8	.750	-4-12	5960	3/4	-4-3	13311	-19	-19
1/8	.875	-4-14						
1/8	1.000	-4-16	5961	1	-4-4	11260	-20	-20
1/8	1.125	-4-18						
1/8	1.250	-4-20	5962	1-1/4	-4-5	12714	-21	-21

AGS784 Obsolescent: AGS Lengths are Overall Lengths whereas AN Pins are measured below head. NO RCAF REFERENCE

AGS166 Obsolescent: All Lengths on this Chart are based on Length as specified for AN Pins. NO RCAF REFERENCE

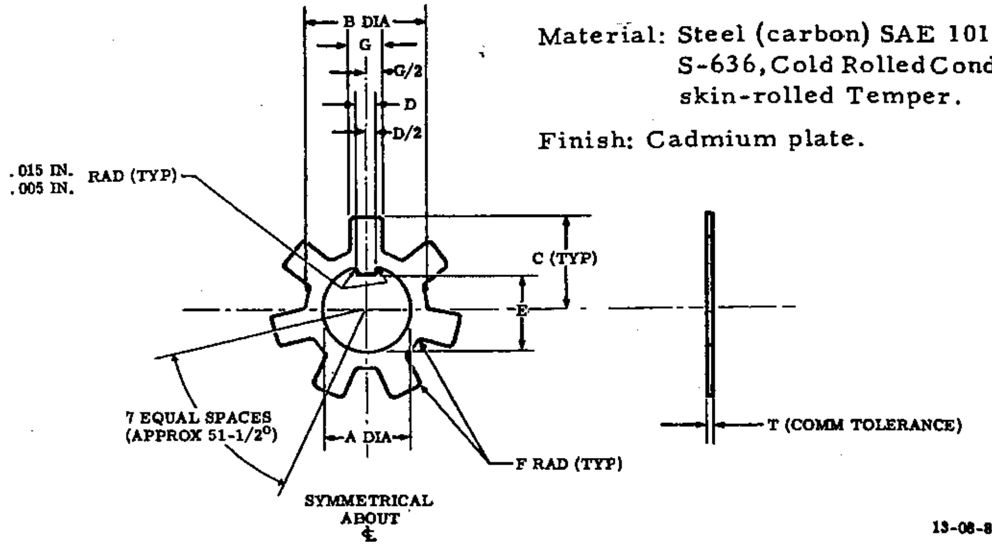
Figure 8-3 (Sheet 3 of 4) Cotter-pins - Interchangeability Table

Dia.	AN381 Current			AN380 Obsolescent			AGS784 Obsolescent	AGS166 Obsolescent
	Length	Dash No.	RCAF Ref	Length	Dash No.	RCAF Ref	Dash No.	Dash No.
1/8	1.375	-4-22		1-1/4				
1/8	1.500	-4-24	5963	1-1/2	-4-6	11184		
1/8	1.625	-4-26						
1/8	1.750	-4-28	5964	1-3/4	-4-7	14301	-22	-22
1/8	2.000	-4-32	5965	2	-4-8	11708	-23	-23
1/8	2.250	-4-36	6049	2-1/2	-4-10	11708	-24	-24
5/32	.500	-5-8	5967	1/2	-5-2	14302	-26	-26
5/32	.750	-5-12	5968	3/4	-5-3	16759	-27	-27
5/32	1.000	-5-16	5969	1	-5-4	13314	-28	-28
5/32	1.125	-5-18						
5/32	1.250	-5-20	5070	1-1/4	-5-5	14433	-29	
5/32	1.375	-5-22						
5/32	1.500	-5-24	5971	1-1/2	-5-6	14519		
5/32	1.625	-5-26						
5/32	1.750	-5-28	5972	1-3/4	-5-7	14303	-30	-30
5/32	2.000	-5-32	5973	2	-5-8	12987	-31	-31
5/32	2.250	-5-36	6055	2-1/2	-5-10	16106		
3/16	1.500	-6-24	5975	1-1/2	-6-6	18125		-37
3/16	1.625	-6-26						
3/16	1.750	-6-28	6059				-38	-38
3/16	2.000	-6-32	5976	2	-6-8	18126	-39	-39
3/16	2.250	-6-36	6060					
3/16	2.500	-6-40	5977	2-1/2	-6-10	18127	-40	-40
3/16	3.000	-6-48	5978	3	-6-12	18128		
7/32	2.000	-7-32						
7/32	2.250	-7-36						
7/32	2.500	-7-40						
1/4	2.000	-8-32	5979	2	-8-8	18129	-47	-47
1/4	2.250	-8-36	6066					
1/4	2.500	-8-40	5980	2-1/2	-8-10	18130	-48	-48
1/4	3.000	-8-48	5981	3	-8-12	18131		
1/4	3.500	-8-56	5982	3-1/2	-8-14	14304		
1/4	4.000	-8-64	5983	4	-8-16	14305		
5/16	2.250	-10-36						
5/16	2.500	-10-40						

AGS784: AGS Lengths are Overall Lengths whereas AN Pins are measured below head. NO RCAF REFERENCE

AGS166: All Lengths on this Chart are based on Length as specified for AN Pins. NO RCAF REFERENCE

Figure 8-3 (Sheet 4 of 4) Cotter-pins - Interchangeability Table



Material: Steel (carbon) SAE 1010, Spec. QQ-S-636, Cold Rolled Condition 4, Soft-skin-rolled Temper.

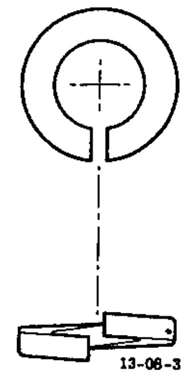
Finish: Cadmium plate.

Part Number	A ±.005	B	C	D ±.005	E ±.005	F	G	T
NAS460-416	.256	.374	.317	.055	.223	.032	.094	.030
NAS460-516	.319	.436	.364	.055	.286	.032	.116	.030
NAS460-616	.381	.499	.411	.086	.333	.032	.140	.030
NAS460-716	.444	.560	.458	.086	.396	.032	.164	.030
NAS460-816	.506	.684	.546	.117	.442	.032	.188	.030
NAS460-916	.569	.773	.626	.117	.505	.050	.210	.048
NAS460-1016	.631	.896	.705	.148	.551	.050	.234	.048
NAS460-1216	.756	1.019	.798	.180	.661	.050	.280	.048
NAS460-1416	.881	1.206	.934	.180	.786	.050	.328	.048
NAS460-1616	1.006	1.367	1.057	.242	.880	.062	.374	.060
NAS460-1816	1.131	1.517	1.211	.242	1.005	.062	.422	.060
NAS460-2016	1.256	1.698	1.361	.305	1.097	.062	.468	.060
NAS460-2216	1.381	1.880	1.487	.305	1.222	.062	.516	.060
NAS460-2416	1.506	2.029	1.623	.367	1.316	.078	.562	.075
NAS460-2816	1.756	2.392	1.875	.430	1.534	.078	.656	.075
NAS460-3216	2.006	2.754	2.127	.492	1.753	.078	.750	.075

Figure 8-4 (Sheet 1 of 2) Table of NAS460 Tab Washers

(Reference Only)				
Eyebolt Thread	Eyebolt Keyway Width	Eyebolt Keyway Depth	Aircraft Check Nut AN316	Regular Jam Nut SAE
1/4-28	.0625 .0615	.0342 .0327	-4	
5/16-24	.0625 .0615	.0342 .0327	-5	
3/8-24	.0937 .0927	.0499 .0484	-6	
7/16-20	.0937 .0927	.0499 .0484	-7	
1/2-20	.1250 .1240	.0655 .0640	-8	
9/16-18	.1250 .1240	.0655 .0640	-9	
5/8-18	.1562 .1552	.0811 .0796	-10	
3/4-16	.1875 .1865	.0968 .0953	-12	
7/8-14	.1875 .1865	.0968 .0953	-14	
1-14	.2500 .2490	.1280 .1265	-16	
1-1/8-12	.2500 .2490	.1280 .1265		1-1/8
1-1/4-12	.3125 .3115	.1615 .1590		1-1/4
1-3/8-12	.3125 .3115	.1615 .1590		1-3/8
1-1/2-12	.3750 .3740	.1930 .1905		1-1/2
1-3/4-12	.4375 .4365	.2242 .2217		1-3/4
2-12	.5000 .4990	.2555 .2530		2

Figure 8-4 (Sheet 2 of 2)
Table of NAS460 Tab Washers



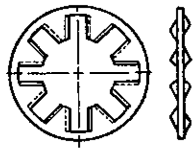
Dash Numbers		Bolt Size
Regular	Light	
2	2L	No. 2(.086)
4	4L	No. 4(.112)
6	6L	No. 6(.138)
8	8L	No. 8(.164)
10	10L	No.10(.190)
416	416L	1/4
516	516L	5/16
616	616L	3/8
716	716L	7/16
816	816L	1/2
916	916L	9/16
1016	1016L	5/8
1216	1216L	3/4

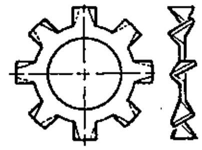
Examples of Part Numbers:
AN935-10 - Washer for No. 10 bolt, regular.

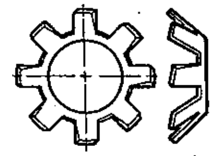
AN935-10L - Washer for No. 10 bolt, light.

Material: Steel.

Figure 8-5 Table of AN935 Lock Washers


13-08-4

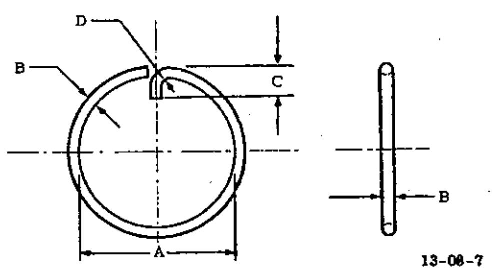

13-08-5


13-08-6

Size	Internal Teeth		External Teeth		Countersunk Teeth	
	Dash Number		Dash Number		Dash Number	
	Steel	Bronze	Steel	Bronze	Steel	Bronze
#2	A2					
#3	A3					
#4	A4	A4B	B4	B4B		
#6	A6	A6B	B6	B6B	C6	C6B
#8	A8	A8B	B8	B8B	C8	C8B
#10	A10	A10B	B10	B10B	C10	C10B
1/4	A416	A416B	B416	B416B	C416	C416B
	A416H					
5/16	A516	A516B	B516	B516B	C516	C516B
3/8	A616	A616B	B616	B616B	C616	C616B
7/16	A716	A716B	B716	B716B	C716	C716B

Example of Part Number: AN936B416B - Washer, external teeth, for 1/4-inch bolt, bronze.
Material: Steel, bronze.

Figure 8-6 Table of AN936 Lock Washers



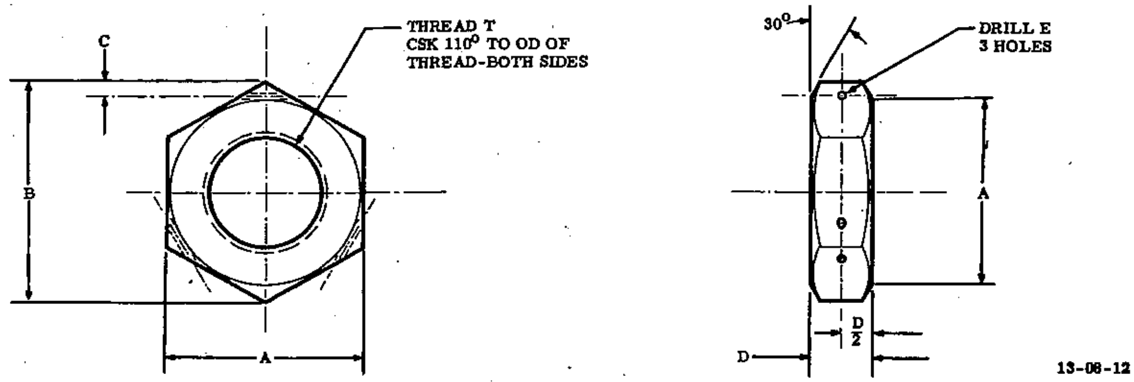
13-08-7

Example of Part Number:
AN996-8 - Lock Ring; with 1/2 inch I.D.
Material: Steel, Spring temper.
Specification AN-QQ-W-441.
Finish: Cadmium Plate, or Zinc Plate.

Dash Nos.	A	B	C	D
8	1/2	.063	5/16	1/16
10	5/8	.063	5/16	1/16
12	3/4	.063	5/16	1/16
14	7/8	.063	5/16	1/16
16	1	.063	5/16	1/16
18	1-1/8	.063	5/16	1/16

Dash No.	A	B	C	D
20	1-1/4	.063	5/16	1/16
22	1-3/8	.063	5/16	1/16
24	1-1/2	.063	5/16	3/32
26	1-5/8	.080	5/16	3/32
28	1-3/4	.080	5/16	3/32
30	1-7/8	.080	5/16	3/32
32	2	.080	5/16	3/32
34	2-1/8	.080	1/2	3/32
36	2-1/4	.080	1/2	3/32
38	2-3/8	.080	1/2	3/32
40	2-1/2	.080	1/2	3/32
44	2-3/4	.090	1/2	3/32
48	3	.090	1/2	3/32
52	3-1/4	.090	1/2	3/32
56	3-1/2	.090	1/2	3/32
60	3-3/4	.090	1/2	3/32
64	4	.090	1/2	3/32
68	4-1/4	.090	1/2	3/32

Figure 8-7 Table of AN996 Lock Rings

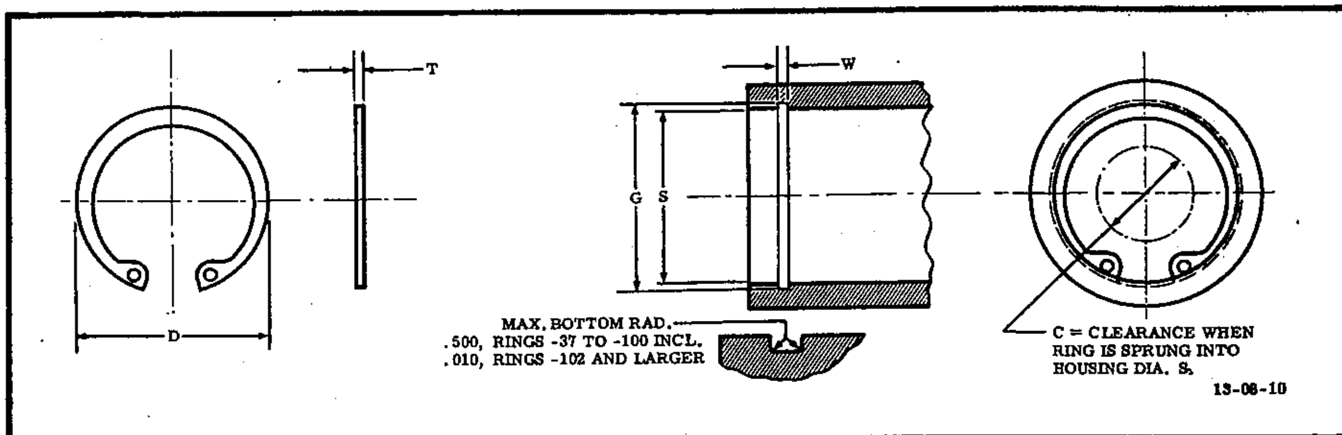


Dash No.	Thread T	A	B Approx	C	D	Drill E. No.
4	1/4-28UNF-3B	.438 +.002 -.010	.50	.093	.188	56(.046)
5	5/16-24UNF-3B	.500 +.002 -.010	.58	.093	.219	56(.046)
6	3/8-24UNF-3B	.563 +.002 -.010	.66	.093	.250	56(.046)
7	7/16-20UNF-3B	.625 +.002 -.010	.72	.093	.281	56(.046)
8	1/2-20UNF-3B	.750 +.002 -.010	.88	.093	.313	56(.046)
9	9/16-18UNF-3B	.875 +.002 -.012	1.02	.093	.375	56(.046)
10	5/8-18UNF-3B	1.000 +.002 -.014	1.16	.093	.406	56(.046)
12	3/4-16UNF-3B	1.125 +.002 -.016	1.30	.125	.469	50(.070)
14	7/8-14UNF-3B	1.313 +.002 -.017	1.52	.125	.500	50(.070)
16	1 -14NF-3B	1.500 +.002 -.019	1.73	.125	.500	50(.070)
18	1- 1/8-12UNF-3B	1.625 +.002 -.020	1.88	.125	.531	50(.070)
20	1- 1/4-12UNF-3B	1.750 +.002 -.022	2.02	.125	.563	50(.070)
22	1- 3/8-12UNF-3B	1.875 +.002 -.024	2.16	.125	.594	50(.070)
24	1- 1/2-12UNF-3B	2.000 +.002 -.025	2.31	.125	.625	50(.070)
26	1- 5/8-12N-3B	2.125 +.002 -.027	2.45	.125	.656	50(.070)
28	1- 3/4-12UN-3B	2.250 +.002 -.028	2.60	.125	.688	50(.070)
30	1- 7/8-12N-3B	2.375 +.002 -.030	2.74	.125	.719	50(.070)
32	2 -12UN-3B	2.625 +.002 -.030	3.04	.125	.750	50(.070)
34	2- 1/8-12N-3B	2.750 +.002 -.031	3.18	.125	.781	50(.070)
36	2- 1/4-12UN-3B	2.875 +.002 -.032	3.32	.125	.812	50(.070)

Code: Dash number designates thread size as noted in the above table.
Example: NAS509-4 = Jam nut with 1/4-28UNF-3B right hand thread.
Material: Steel, SAE 4130
Heat-treat: Rockwell C33-38 (150,000 psi min TS)
Tolerances: Unless otherwise specified, decimals, ±.010; angles, ±1°.

Finish: Cadmium plate, see Part 20.
Notes:
1. This nut is intended for use with the NAS513 keyed washer for positive locking of rod end terminals to hydraulic piston rods.
2. All machined surfaces 250.
3. Parts shall be magnafluxed.
4. Remove all burrs and sharp edges.
5. Surface to be square with thread within .003 inches per inch diameter.

Figure 8-8 Table of NAS509 Drilled Jam Nuts



Dash No.	Housing		Ring Dimensions					Engineering Information			
	Diameter		Free Diam.		Thickness		C	Groove Diam.		Groove Width	
	S In.	S Mm.	D In.	Tol. In.	T In.	Tol. In.	Max.In.	G In.	Tol. In.	W In.	Tol. In.
37	.375	9.5	.403	+.005 -.002	.025	±.0016	.19	.397		.028	
43	.438	11	.468		.025		.22	.461	±.002	.028	
50	.500	13	.533		.035		.23	.524		.039	
56	.562	14.5	.607		.035		.27	.592		.039	
62	.625	16	.675		.035		.33	.659		.039	
68	.688	17.5	.742		.035		.37	.724		.039	+.003 -.000
75	.750	19	.808	+.010 -.005	.035		.43	.790	±.003 .002 T.I.R.	.039	
77	.777	20	.836		.042		.45	.819		.046	
81	.812	21	.877		.042		.47	.857		.046	
87	.875	22	.944		.042		.51	.922		.046	
90	.901	23	.970		.042		.52	.950		.046	
93	.938	24	1.015		.042		.54	.989		.046	
100	1.000	25.5	1.081		.042	±.002	.59	1.055		.046	
102	1.023	26	1.106		.042		.60	1.079		.046	
106	1.062	27	1.150		.050		.65	1.120		.056	
112	1.125	28.5	1.217		.050		.71	1.185		.056	
118	1.188	30	1.283		.050		.77	1.250		.056	
125	1.250	32	1.351	+.015 -.010	.050		.82	1.320	±.004 .003 T.I.R.	.056	
131	1.312	33	1.418		.050		.87	1.385		.056	+.004 -.000
137	1.375	35	1.486		.050		.92	1.450		.056	
143	1.438	36.5	1.552		.050		.98	1.515		.056	
145	1.456	37	1.572		.050		1.00	1.535		.056	
150	1.500	38	1.622		.050		1.04	1.580		.056	
156	1.562	40	1.688		.062		1.09	1.647		.068	
162	1.625	41	1.756		.062		1.14	1.715		.068	
165	1.653	42	1.786		.062		1.16	1.745	±.005 .003 T.I.R.	.068	
168	1.688	43	1.823	+.020 -.013	.062	±.003	1.20	1.780		.068	
175	1.750	44.5	1.891		.062		1.26	1.845		.068	
181	1.812	46	1.958		.062		1.31	1.910		.068	
185	1.850	47	1.998		.062		1.34	1.949		.068	

Figure 8-9 (Sheet 1 of 2) Table of NAS50 Internal Retainer Rings

Dash No.	Housing Diameter		Ring Dimensions					Engineering Information			
			Free Diam.		Thickness		C	Groove Diam.		Groove Width	
	S In.	S Mm.	D In.	Tol. In.	T In.	Tol. In.	Max. In.	G In.	Tol. In.	W In.	Tol. In.
187	1.875	47.5	2.025	+.020 -.013	.062	±.003	1.36	1.975	±.005 .003 T.I.R.	.068	+.004 -.000
193	1.938	49	2.095		.062		1.41	2.040		.068	
200	2.000	51	2.160		.062		1.47	2.110		.068	
206	2.062	52.5	2.225	+.025 -.015	.078		1.54	2.175	±.006 .004 T.I.R.	.086	+.005 -.000
212	2.125	54	2.295		.078		1.58	2.240		.086	
218	2.188	55.5	2.365		.078		1.63	2.305		.086	
225	2.250	57	2.435		.078		1.69	2.370		.086	
231	2.312	59	2.500		.078		1.75	2.440		.086	
237	2.375	60.5	2.567		.078		1.81	2.505		.086	
244	2.440	62	2.634		.078		1.86	2.570		.086	
250	2.500	63.5	2.700		.078		1.91	2.635		.086	
253	2.531	64.5	2.733	+.030 -.020	.078		1.93	2.668		.086	
256	2.562	65	2.760		.093		1.96	2.700		.103	
262	2.625	66.5	2.840		.093		2.02	2.765		.103	
268	2.688	68	2.907		.093		2.09	2.834		.103	
275	2.750	70	2.975		.093		2.16	2.900		.103	
281	2.813	71.5	3.040		.093		2.20	2.965		.103	
283	2.834	72	3.063		.093		2.22	2.987		.103	
287	2.875	73	3.105		.093		2.24	3.030		.103	
300	3.000	76	3.245		.093		2.35	3.165		.103	
306	3.062	78	3.310		.109		2.41	3.230		.120	
312	3.125	79.5	3.377		.109		2.46	3.295		.120	
315	3.156	80	3.408		.109		2.53	3.328		.120	
325	3.250	82.5	3.509		.109		2.59	3.426		.120	
334	3.346	85	3.611		.109		2.67	3.525		.120	
347	3.469	88	3.746		.109		2.75	3.657		.120	
350	3.500	89	3.780		.109		2.79	3.690		.120	
354	3.543	90	3.826		.109		2.82	3.735		.120	
356	3.562	90.5	3.850		.109		2.84	3.756		.120	
375	3.750	95	4.060		.109		3.00	3.955		.120	
387	3.875	98.5	4.205		.109		3.11	4.087		.120	
393	3.938	100	4.283		.109		3.18	4.150		.120	
400	4.000	102	4.350		.109		3.23	4.220		.120	

Part Number Example: NAS 50-306N: Ring for 3.062 nom. dia. bore, oiled or greased only, no plating. Dash number indicates bore nom. dia. in hundredths.

Material: Steel, S.A.E. 1065-1090, H. T. 238,000 - 280,000 psi, tensile.

Installation: Use long-nose or installation pliers.

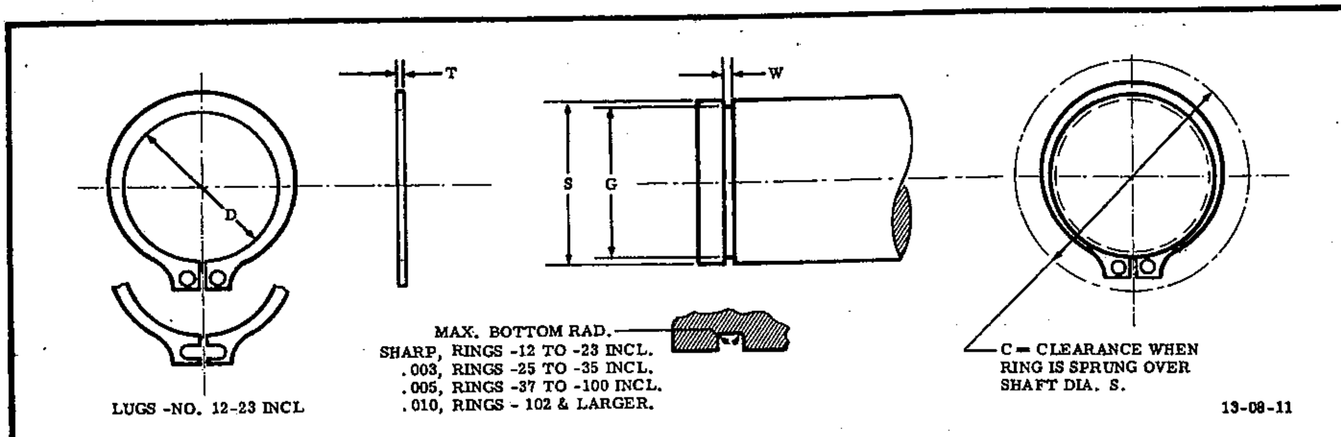
Corrosion Protection:

Unplated: Coat with corrosion prevention compound, specification AN-C-52, suffix N to dash number.

Parkerize: Suffix P to dash number.

Cadminum Plate: No suffix to dash number.

Figure 8-9 (Sheet 2 of 2) Table of NAS50 Internal Retainer Rings



Dash No.	Shaft		Ring Dimensions					Engineering Information			
	Diameter		Free Diam.		Thickness		C	Groove Diam.		Groove Width	
	S In.	S mm	D In.	Tol. In.	T In.	Tol. In.	Min. In.	G In.	Tol. In.	W In.	Tol. In.
12	.125	3.2	.112	+.002 -.004	.010	±.0005	.40	.117	±.0015 .0015 T.I.R.	.012	+.002 -.000
15	.156	4	.140		.010		.44	.146		.012	
18	.188	4.7	.168		.015		.47	.175		.017	
19	.197	5	.179		.015	±.001	.48	.185		.017	
21	.219	5.5	.196		.015		.50	.205		.017	
23	.236	6	.215		.015		.52	.222		.017	
25	.250	6.5	.225		.025	±.0015	.54	.230		.028	+.003 -.000
27	.275	7	.250	+.002 -.005	.025		.56	.255	±.002 .002 T.I.R.	.028	
31	.312	8	.281		.025		.61	.290		.028	
35	.354	9	.320		.025		.66	.330		.028	
37	.375	9.5	.338		.025		.68	.352		.028	
39	.393	10	.354		.025		.70	.369		.028	
40	.406	10.5	.366		.025		.71	.382		.028	
43	.438	11	.395		.025		.75	.412		.028	
46	.469	12	.428		.025		.77	.443		.028	
50	.500	13	.461		.035	±.002	.80	.474		.039	
55	.551	14	.509	+.005 -.010	.035		.87	.524	±.003 .002 T.I.R.	.039	
56	.562	14.5	.521		.035		.89	.535		.039	
59	.594	15	.550		.035		.93	.565		.039	
62	.625	16	.579		.035		.97	.596		.039	
66	.669	17	.618		.035		1.00	.638		.039	
68	.688	17.5	.635		.042		1.03	.655		.046	
75	.750	19	.693		.042		1.10	.715		.046	
78	.781	20	.722		.042		1.14	.745		.046	
81	.812	21	.751		.042		1.16	.776		.046	
87	.875	22	.810		.042		1.24	.835		.046	
93	.938	24	.867		.042		1.31	.894		.046	

Figure 8-10 (Sheet 1 of 2) Table of NAS51 External Retainer Rings

Dash No.	Shaft Diameter		Ring Dimensions Free Diam.		Thickness		C	Engineering Information Groove Diam.		Groove Width	
	S In.	S mm.	D In.	Tol. In.	T In.	Tol. In.	Min. In.	G In.	Tol. In.	W In.	Tol. In.
98	.984	25	.910	+.005 -.010	.042	±.002	1.36	.940	±.003 .002 T.I.R.	.046	+.003 -.000
100	1.000	25.5	.925		.042		1.38	.955		.046	
102	1.023	26	.946	+.010 -.015	.042		1.41	.977	±.004 .003 T.I.R.	.046	+.004 -.000
106	1.062	27	.982		.050		1.45	1.015		.056	
112	1.125	28.5	1.041		.050		1.52	1.075		.056	
118	1.188	30	1.098		.050		1.63	1.135		.056	
125	1.250	32	1.156		.050		1.73	1.195		.056	
131	1.312	33	1.214		.050		1.80	1.250		.056	
137	1.375	35	1.272		.050		1.87	1.310		.056	
143	1.438	36.5	1.333		.050		1.94	1.370		.056	
150	1.500	38	1.387		.050		2.00	1.430		.056	
156	1.562	40	1.446	+.013 -.020	.062	±.003	2.08	1.490	±.005 .003 T.I.R.	.068	
162	1.625	41	1.503		.062		2.14	1.550		.068	
175	1.750	44.5	1.618		.062		2.28	1.670		.068	
177	1.771	45	1.637		.062		2.33	1.689		.068	
181	1.812	46	1.675		.062		2.34	1.730		.068	
187	1.875	47.5	1.735		.062		2.41	1.790		.068	
196	1.969	50	1.819		.062		2.50	1.879		.068	
200	2.000	51	1.850		.062		2.54	1.910		.068	
206	2.062	52.5	1.906	+.015 -.025	.078	±.003	2.62	1.970	±.006 .004 T.I.R.	.086	+.005 -.000
212	2.125	54	1.964		.078		2.68	2.027		.086	
215	2.156	55	1.993		.078		2.72	2.057		.086	
225	2.250	57	2.081		.078		2.82	2.145		.086	
231	2.312	59	2.139		.078		2.88	2.205		.086	
237	2.375	60.5	2.197		.078		2.95	2.265		.086	
250	2.500	63.5	2.313		.078		3.08	2.385		.086	
255	2.559	65	2.377	+.020 -.030	.078		3.16	2.451		.086	
262	2.625	66.5	2.428		.078		3.21	2.505		.086	
275	2.750	70	2.543		.093		3.35	2.625		.103	
287	2.875	73	2.659		.093		3.48	2.742		.103	
293	2.938	74.5	2.717		.093		3.55	2.801		.103	
300	3.000	76	2.775		.093		3.62	2.860		.103	

Part Number Example: NAS 51-231N: Ring for 2.312 nom. dia. shaft, oiled or greased only, no plating. Dash No. indicates shaft nom. dia. in hundredths.

Installation: Use long-nose or installation pliers.

Material: Sizes dash 12 to dash 23 incl. only, beryllium copper, H. T. 180,000 - 200,000 psi tensile. Note: these sizes were formerly steel and are interchangeable. Sizes dash 25 and larger. steel, S. A. E. 1065 - 1090, H. T. 238,000 - 280,000 psi tensile.

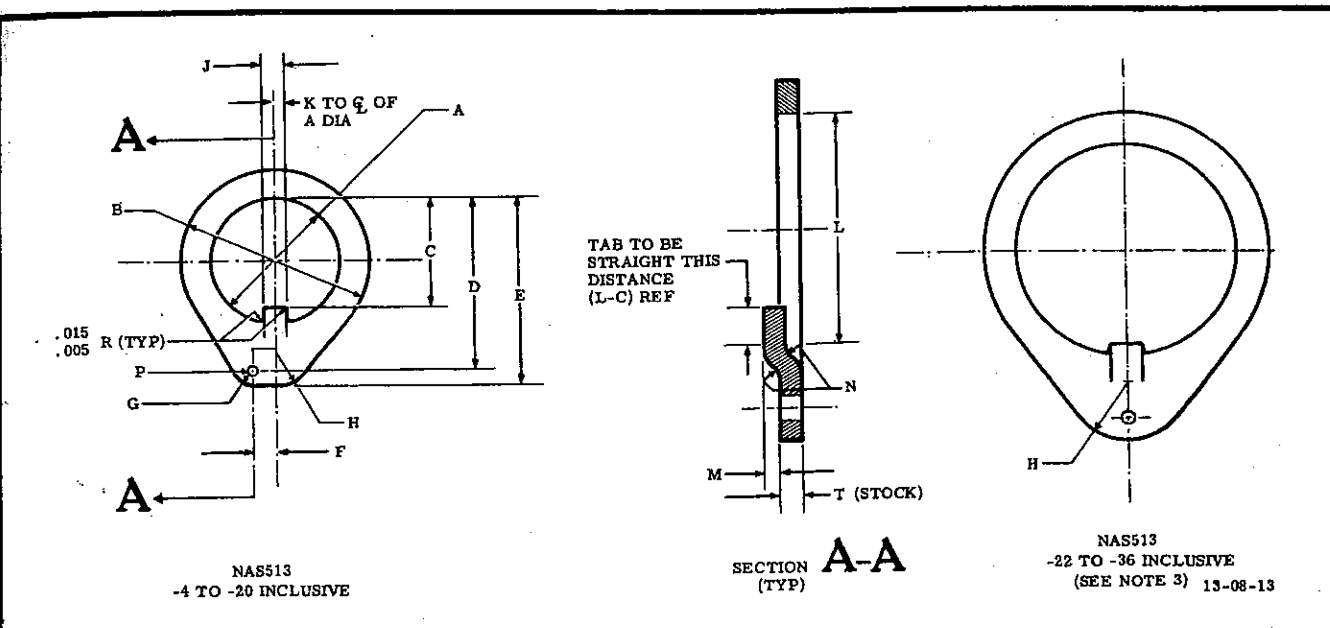
Corrosion Protection:

Unplated: Coat with corrosion prevention compound, specification AN-C-52. Suffix N to dash number.

Parkerize: Suffix P to dash No.

Cadmium Plate: No suffix to dash No.

Figure 8-10 (Sheet 2 of 2) Table of NAS51 External Retainer Rings



Dash No.	Terminal Thread Size (Ref)	A Dia.	B Dia. +.02 -.00	C	D ±.016	E ±.016
4	1/4 -28UNF-3A	.272±.005	.44	.214±.005	.406	.500
5	5/16-24UNF-3A	.334±.005	.50	.273±.005	.484	.578
6	3/8 -24UNF-3A	.396±.008	.56	.327±.008	.562	.636
7	7/16-20UNF-3A	.459±.008	.63	.386±.008	.625	.719
8	1/2 -20UNF-3A	.520±.008	.75	.450±.008	.719	.813
9	9/16-18UNF-3A	.583±.008	.88	.496±.010	.812	.906
10	5/8 -18UNF-3A	.647±.010	1.00	.559±.010	.937	1.031
12	3/4 -16UNF-3A	.772±.010	1.12	.681±.010	1.062	1.158
14	7/8 -14UNF-3A	.897±.010	1.31	.795±.010	1.250	1.344
16	1 -14NF-3A	1.022±.010	1.50	.918±.010	1.422	1.516
18	1-1/8 -12UNF-3A	1.147±.010	1.62	1.028±.010	1.547	1.656
20	1-1/4 -12UNF-3A	1.272±.010	1.75	1.154±.010	1.687	1.796
22	1-3/8 -12UNF-3A	1.397±.010	1.88	1.254±.010	1.859	1.969
24	1-1/2 -12UNF-3A	1.518±.010	2.00	1.379±.010	1.969	2.078
26	1-5/8 -12N-3A	1.643±.010	2.12	1.495±.010	2.109	2.249
28	1-3/4 -12UN-3A	1.766±.010	2.29	1.607±.010	2.266	2.375
30	1-7/8 -12N-3A	1.891±.010	2.38	1.732±.010	2.375	2.484
32	2 -12UN-3A	2.016±.010	2.63	1.857±.010	2.594	2.703
34	2-1/8 -12N-3A	2.141±.010	2.75	1.973±.010	2.750	2.860
36	2-1/4 -12UN-3A	2.266±.010	2.88	2.098±.010	2.875	2.984

Figure 8-11 (Sheet 1 of 2) Table of NAS513 Rod End Locking Washers

Dash No.	F ±.031	G Rad	H Rad	J ±.005	K	L ±.031	M ±.005	N Rad	T	P Dia.
4	.125	.094	.094	.052	.026 ± .005	.293	.036	.031	.050	.062
5	.125	.094	.094	.052	.026 ± .005	.355	.036	.031	.050	.062
6	.125	.094	.094	.082	.041 ± .005	.418	.036	.031	.050	.062
7	.125	.094	.094	.082	.041 ± .005	.463	.049	.031	.063	.062
8	.156	.094	.156	.082	.041 ± .005	.542	.049	.031	.063	.062
9	.188	.094	.156	.114	.057 ± .005	.597	.057	.062	.071	.071
10	.188	.094	.188	.114	.057 ± .005	.675	.057	.062	.071	.071
12	.188	.094	.188	.114	.057 ± .005	.800	.057	.062	.071	.071
14	.188	.094	.250	.142	.071 ± .007	.944	.066	.062	.080	.080
16	.188	.094	.250	.142	.071 ± .007	1.088	.074	.062	.090	.090
18	.219	.109	.313	.174	.087 ± .007	1.213	.074	.062	.090	.090
20	.219	.109	.313	.174	.087 ± .007	1.280	.096	.094	.112	.112
22			.375	.236	.118 ± .007	1.405	.096	.094	.112	.112
24			.375	.236	.118 ± .007	1.530	.096	.094	.112	.112
26			.375	.236	.118 ± .007	1.638	.109	.094	.125	.125
28			.500	.298	.149 ± .007	1.763	.109	.094	.125	.125
30			.500	.298	.149 ± .007	1.888	.109	.094	.125	.125
32			.500	.298	.149 ± .007	2.076	.109	.094	.125	.125
34			.500	.298	.149 ± .007	2.201	.109	.094	.125	.125
36			.500	.298	.149 ± .007	2.326	.109	.094	.125	.125

Code: Dash number designates washer size as noted in the above table.

Example: NAS513-4 Lockwasher for use with a 1/4-28UNF-3A rod end terminal and an NAS509-4 jam nut.

Material: .Spring steel, SAE1095, Spec.AN QQ-S-666, condition cold rolled and annealed.

Finish: Cadmium plate.

Heat-treat: Rockwell C40-45, Spec. MIL-H-6875.

Tolerance: Unless otherwise specified, decimals ±.010, angles ±1°.

Notes: 1. This washer is intended for use with the NAS509 jam nut for positive locking of rod end terminals to hydraulic piston rods.
2. Washer face surfaces must be flat within .010 inch.
3. Unless otherwise specified, dimensions of NAS513-4 to -20 are identical to NAS513-22 to -36.

Figure 8-11 (Sheet 2 of 2) Table of NAS513 Rod End Locking Washers

Cotter-pins

4 Cotter-pins (Item 1) for use on aircraft or engines must be round, mild steel, cadmium plated or galvanized. See Figure 8-2 for approved methods of use. For cotter-pin table, see Figure 8-3. For correct installation, the cotter-pin nominal diameter must be the same as hole size.

Tab Washers

5 Tab washers (Item 2) may conform to Specification NAS460, (see Figure 8-4). When necessary, special designs are used for particular installations and special precautions are necessary in their manufacture and use. Ensure that tab ends are of the proper length and do not override the slot or flat provided.

6 If the tab is not at a direct right angle to the surface over which it is to be bent, take extreme care to make the bend in the direction tending to tighten the assembly. Backing off any threaded member to suit the tab is not permitted.

Lock Washers

7 Lock washers (Items 3 & 4) are used with machine screws or bolts, whenever the self-locking or castellated type of nut is not applicable. Sufficient friction is provided by the spring action of the washer to prevent loosening of the nut from vibration. For lock washer tables, see Figure 8-5 and 8-6. Lock washers may be used to prevent loosening of threaded fasteners in airframe construction under the following conditions:

(a) When a self-locking nut or a castle nut and cotter-pin cannot be used.

(b) When lockwire cannot be used.

(c) When the fastening is not used in primary structure, or when loosening of the locked parts would not endanger the aircraft or personnel.

(d) When corrosion, encouraged by gouging of aluminum or magnesium alloys by teeth of lock washers, would not cause malfunction of parts. Corrosion may be reduced by installing washers with wet primer. (Refer to Part 23, following.)

CAUTION

Lock washers must not be used where the screw is subject to frequent removal, where the washers are on exposed surfaces, or where failure would permit the opening of a joint to airflow.

Miscellaneous Devices

8 For tables of other safetying media, see Figures 8-7 to 8-11 inclusive.

Material Specifications

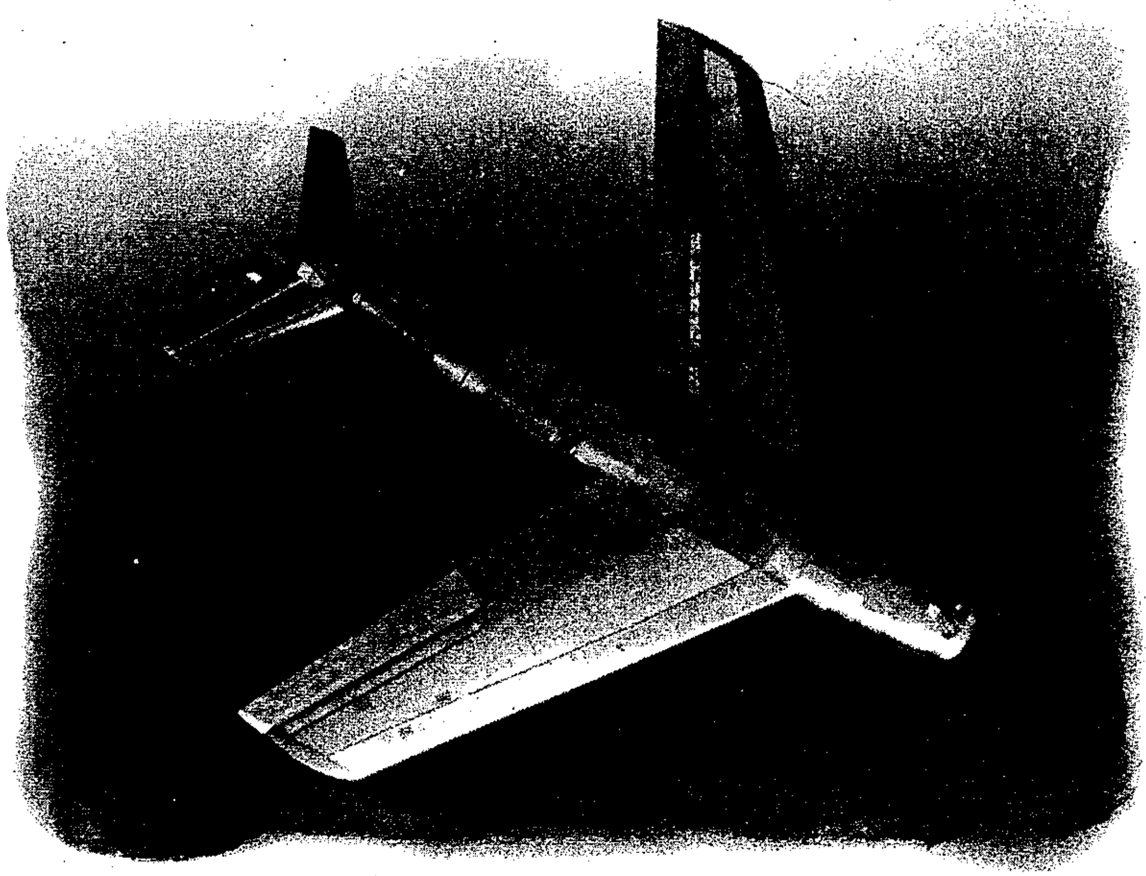
9 For table showing item numbers, materials, specifications and manufacturers, see Figure 8-12.

Item No.	Material	RCAF Ref.	Spec.
1	Cotter-pin AN381	28/	FF-P-386
2	Washer, Tab SAE1010 NAS460	28/	
3	Washer, Lock AN935	28/	FF-M-84
4	Washer, Lock AN936	28/	MIL-W-6986

Figure 8-12 Table of Material Specifications

PART 9

ELECTRICAL WIRING



PART 9

ELECTRICAL WIRING

TABLE OF CONTENTS

(Continued)

LIST OF ILLUSTRATIONS

PART 9

ELECTRICAL WIRING

SOLDERING ELECTRICAL COMPONENTS

General

1 For general instructions regarding soldering of electrical components, refer to Part 20, following.

NOTE

Use only resin core solder (Item 12) for assembly of electrical parts.

Cleaning Prior to Soldering

2 For cleaning of metals prior to soldering, refer to Part 20, following.

Soldering Procedure

3 For soldering, proceed as follows:

(a) Ensure sufficient solder for the job.

(b) Before soldering the first wire to the contact, be certain that the assembly nut and coupling nut are slipped over the wires (or harness).

(c) Strip wires as specified in Paragraph 13, following.

(d) Place the identification sleeves over the wires. Most aircraft wire is tinned when made but re-tin to hold the strands solidly together.

(e) Examine all surfaces to be soldered to ensure that they are clean. Lay the wire end flat in molten solder and touch wire solder to tip of wire just enough to allow flux to escape.

(f) Choose the most convenient contact with which to start. Heat the solder in the terminal pot until it is molten, then push wire into cavity.

(g) Under-heated solder appears granular, dirty and grey. Over-heating gives solder an iridescent appearance with rainbow colours which cool to a dark grey. Neither will be satisfactory. With the right amount of heat, solder appears bright, and on cooling retains a bright colour.

CAUTION

Do not use solder to cover cracks or flaws, to fill in dents or to close holes. Do not solder joints wider than .010 inch. Do not use a torch to solder covered cables where there is danger of burning the insulation.

(h) Ensure that iron is not held close to the insert too long or it will deform and buckle the melamine or phenolic insert, thereby ruining it for further use. Keep wire steady while solder sets, otherwise the solder may crystallize, resulting in a poor joint indicated by a crack or granulization. Resolder such joints and wipe off excess rosin with a non-corrosive solvent, such as clean alcohol.

(j) Follow this procedure carefully with the remainder of the contacts according to the pattern chosen. Check the quality of the work.

(k) When joints have cooled, slip the insulating sleeving over the joints to prevent shorting and corrosion.

Soldering Harness Sleeve to Flexible Conduit

4 Proceed as follows:

(a) Tin sleeve in solder pot.

(b) Solder an adequate area of conduit braid at the desired point of attachment.

(c) Sweat solder the mating parts together, using additional solder as required.

(d) Avoid excessive use of solder.

Soldering Terminals

5 Proceed as follows:

(a) Strip sufficient insulation from wire so that bare wire will completely fill the tubular portion of the terminal. Follow procedures specified in Paragraph 13 following.

(b). Select transparent plastic tubing to give a snug fit. Wall sizes must be as specified in Paragraph 16 following.

(c) Cut tubing to cover tubular portion of the terminal or connector plus 3/8 inch to extend over the wire insulation.

(d) Slip tubing over wire and insert wire into terminal.

(e) Attach terminal by soldering, using rosin core solder. (Refer to Part 20, following.)

(f) Complete the installation by working tubing (Item 8) over the terminal, insulating the tubular portion of the terminal, and to cover joint between cable insulation and copper wire.

Eyelets

6 Parts which have eyelet type terminals (Item 13) for attachment of wiring are to be soldered as follows:

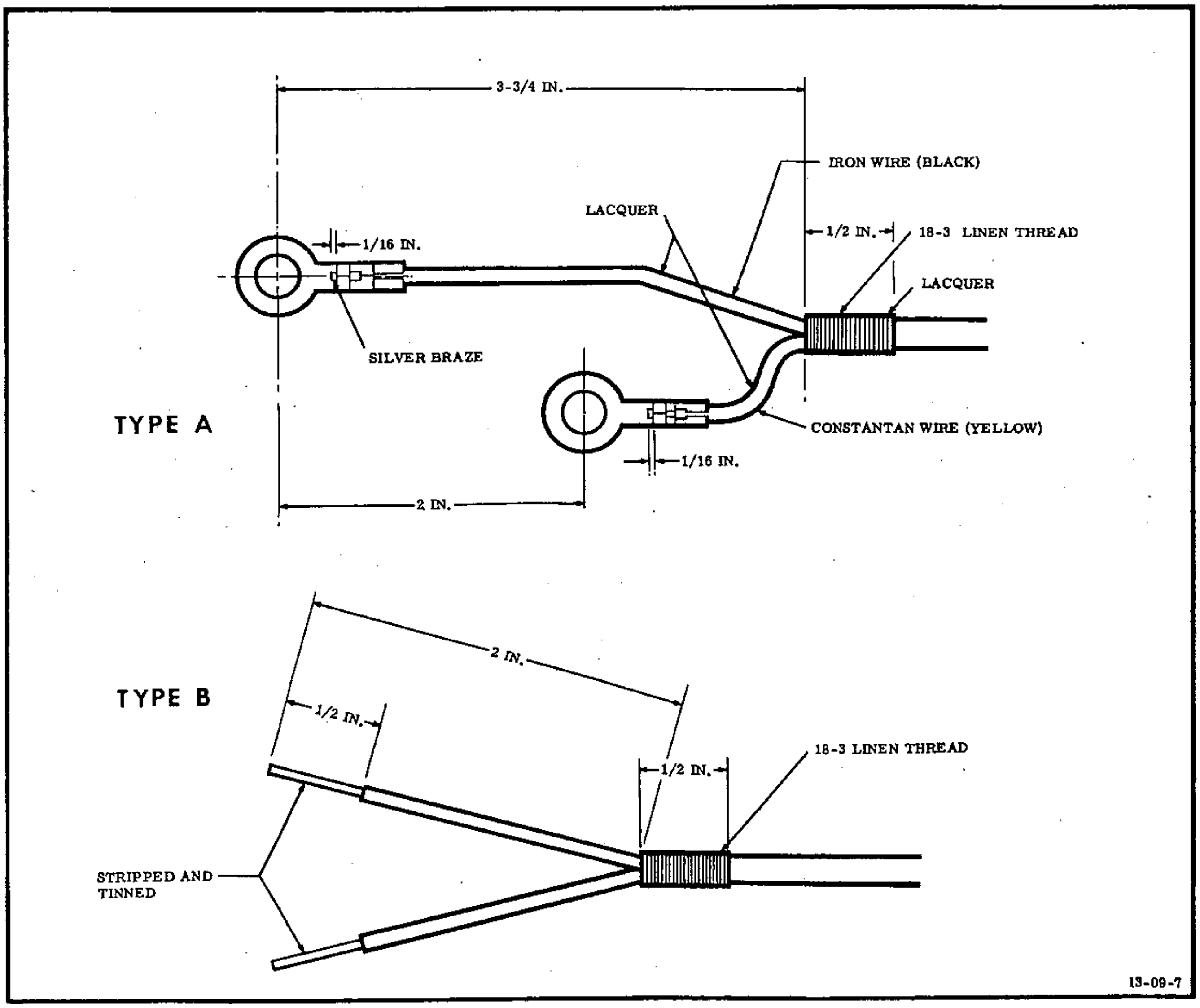


Figure 9-1 Thermocouple Lead Connections

(a) Insert wire through eyelet and wrap wire and one and one-half to two and one-half turns around eyelet.

(b) Solder, (refer to Part 20 following).

(c) Install plastic tubing over soldered joints to give a snug fit as required in Paragraph 5 (e), preceding.

(d) Wrap wires passing through wire clamp with plastic tape (Item 17). The wrap should be thick enough to permit a snug fit to be obtained when screwing down the retaining clamp so that no strain from a wire pull is transmitted to the soldered joint.

Thermocouple Lead Connections

7 Fabricate the type of thermocouple lead connection specified in accordance with Figure 9-1. Observe the following points:

(a) The solder and brazing requirements do not change with change in type of wire.

(b) No mechanically applied terminals are to be used on thermocouple wires.

(c) Use rosin core solder (refer to Part 20, following). Where metal surface conditions require the use of paste (Item 24), it may be used but all flux must be removed due to its corrosive nature.

(d) Terminals which require silver soldering must be cleaned to the bare metal before soldering.

(e) Thermocouple wire insulation is to be coloured as follows:

(1)	Iron	Black
(2)	Constantan	Yellow
(3)	Chromel	White
(4)	Alumel	Green
(5)	Copper	Red

(f) Wrap insulated ends back 1/2 inch with linen thread (Item 14). Apply one coat of varnish (Item 26) or clear lacquer (Item 27) before assembly.

(g) Insulate thermocouple connections individually with plastic tubing (Item 8) where necessary to prevent abrasion of insulation of adjacent wire. Tie tubing, if not snug, with prewaxed cotton cord.

(h) Do not bend or coil thermocouple leads to less than a four inch diameter unless otherwise specified on the Engineering Drawing.

IDENTIFICATION

General

8 All electrical cables must be identified with the code letters and numbers assigned on the drawings. The characters must be of sufficient size to be legible and of a permanent nature to provide positive cable identification.

Electrical Wiring

9 For open wiring, each cable must be identified at not more than 15 inch intervals through its entire length. Electrical cables totally enclosed in rigid and non-transparent conduit, or which have such materials on the surface which do not retain a machine-stamped identification, must be identified at not more than three inches from each terminating point. Indentification of furnished equipment wiring shall not be altered to conform to these instructions.

Methods of Marking

10 Where required to identify wires or cables which have materials on the surface that do not retain a machine-stamped identification, clear plastic tubing, indelibly colour-branded, should be used. Slip the colour-branded piece of tubing over the insulated cable. Skin the insulation from cable end and apply connector. Push clear plastic tubing over the connector, completing the assembly.

11 For electrical cables routed near or through high temperature areas, identify with numbered metallic sleeves (Item 30) or stamped silicone glass sleeving (Item 31).

INSTALLATION

General

12 To make a proper termination on electrical wires use the utmost care in the

preparation of the wire end, selection of terminal, insertion of wire end into the terminal barrel and use of proper tooling. Neglect of proper precautions in any of the foregoing may result in an unsatisfactory joint.

Stripping Insulation

13 In stripping insulation from wire, use only approved strippers, taking care to prevent nicks, cuts or other damage to the wire. When using wire strippers, observe the following:

(a) Use only approved strippers as shown in Figure 9-2.

(b) Select the correct size cutting hole for the gauge wire to be stripped.

(c) Place the wire in the strippers so that the amount of wire from which the insulation is to be removed extends beyond the cutter.

(d) Squeeze the handles of the strippers slowly. Close strippers completely.

(e) Check the stripped insulation for strands of wire and any other indications of damaged wire strands. If such indications are found, the strippers must be adjusted.

Wire Terminals

14 All wires not terminated at soldered terminals, (i.e. Cannon plugs, etc.,) must be staked to approved copper terminals. (See Figure 9-3.) Strip sufficient insulation from the wire so that on sizes No. 22 to No. 10 inclusive, the bare wire will extend through, but not over 1/32 inch beyond, the tubular

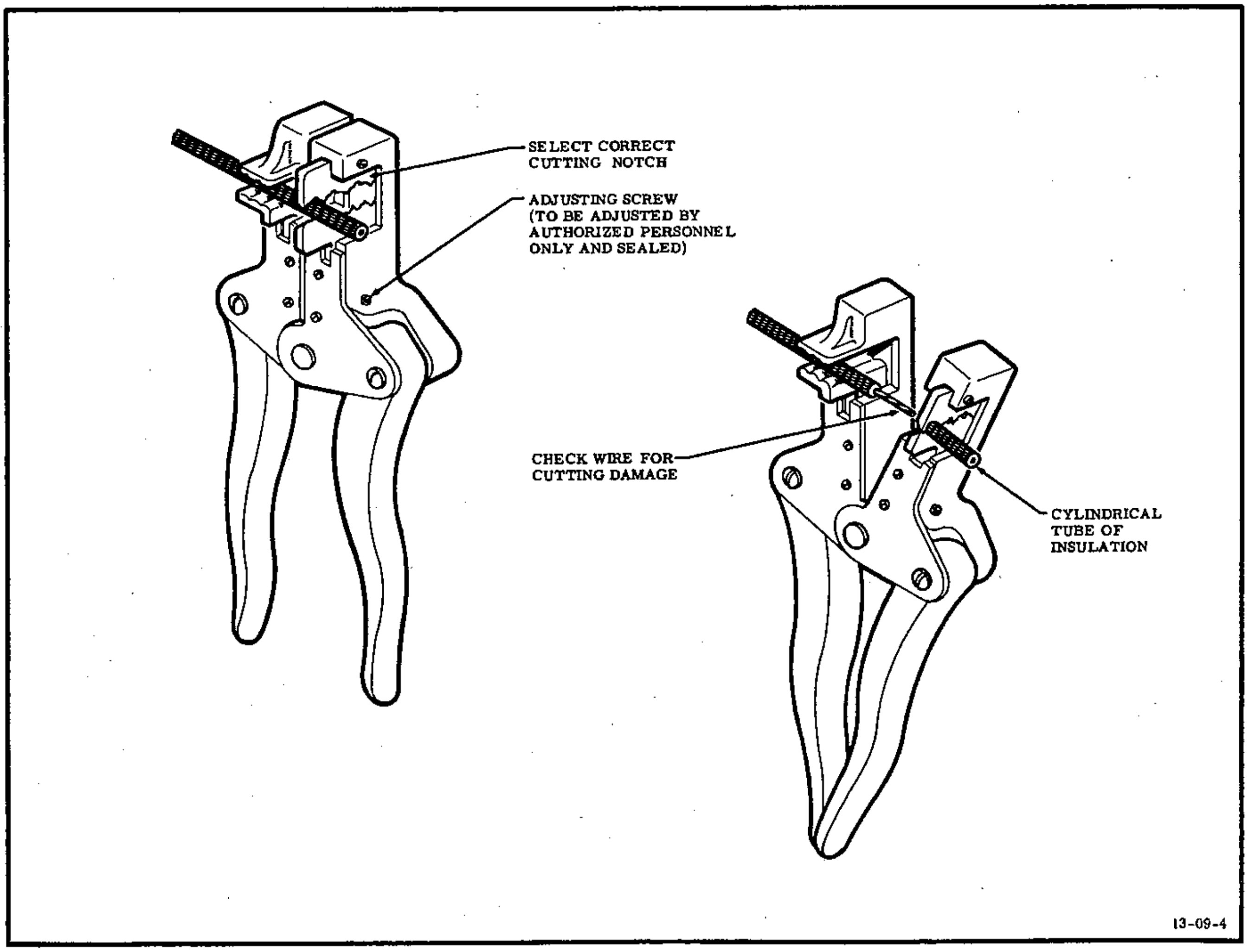


Figure 9-2 Use of Wire Strippers

portion of the terminal, or so that on sizes No. 8 to No. 0000 inclusive, the bare wire will extend through, but not over 1/16 inch beyond, the tubular portion of the terminal. On closed or blocked terminals, the end of the bare wire must be inserted up to the stop and must be visible in the inspection hole. The conductor strands must not protrude past the end of the terminal barrel far enough to interfere with the installation of the proper size washer.

Bending

15 When bent lugs are necessary, preformed terminals (Item 10) should be used. If preformed lugs are not available, copper terminals (Item 7) (see Figure 9-4) for wire size No. 22 to No. 10 inclusive may be bent a maximum of 90° once, if done carefully. Larger sizes may be bent a maximum of 30°. Flag terminals (Item 11) may be bent, when required, so that the barrel tends to close and no stress is applied on the brazed joint. Inspection of terminal installation is to be accomplished without bending the wire at the terminal.

NOTE

Flag terminals are to be used only when specified.

Plastic Tubing

16 To install plastic tubing (Item 8) proceed as follows:

(a) Select transparent plastic tubing to give a snug fit. Wall thickness for wire sizes must be as per Figure 9-5.

(b) Cut tubing to cover tubular portion of the terminal or connector plus 3/8 inch extending over the wire insulation.

(c) Slip tubing over wire and insert wire into terminal.

(d) Stake terminals using approved tooling only. Centre indentation on tubular portion of terminal or connector. Terminals may be staked on either top or bottom as required by the tooling used. All indentations are to be inspected for cracking out. For staking procedures, see Figure 9-6.

(e) Insulation grip must be snug on insulation. Tooling must be checked frequently to insure proper indentation.

(f) Complete the installation by working the plastic tubing over the terminal, insulating the tubular portion of the terminal and covering the joint between cable insulation and copper wire.

Wires not Enclosed in Conduit

17 Observe the following instructions during installation:

(a) Locate attachments at each frame on runs along the length of the fuselage or at each rib on runs through wings. Use a distance of not less than 6 inches and not more than 24 inches between points of attachment. Points of attachment may be less than 6 inches only in distribution and junction boxes and where required by Paragraphs 50 to 57 inclusive, following.

(b) Except for drip loop requirements, leave only enough slack in wiring to permit ease of maintenance such as the removal of plugs or terminals, to prevent mechanical strain on wiring, wiring junctions and wiring supports, and to permit free movement of shock-mounted equipment.

(c) Provide low points or drip loops as shown in Figure 9-7 before wiring reaches connectors, boxes or equipment. Downward attachment of terminals as shown is acceptable where proper drip loops are installed in the wiring and/or conduit just prior to reaching the junction box.

(d) Route wiring above and as far away as possible (at least 6 inches) from inflammable fluid lines such as fuel, oil, oxygen, hydraulic and alcohol. Do not attach to these lines. Wiring installed near a line carrying an inflammable fluid must be securely clipped at specific intervals so that a broken wire cannot touch the fluid line, i.e., the spacing of the clips is to be less than the distance from the wire to the line.

(e) Install and route wiring to allow easy accessibility for replacement and repair. Route wiring in front of interior insulation and soundproofing, not behind, unless some means of replacing the wiring is provided.

(f) Radio wiring must be routed in separate bundles from electrical system wiring except at equipment terminals and at disconnect junctions. Route these radio wire bundles at least three inches away from other wiring.

(g) Install and attach wires to prevent damage to insulation from vibration or other movement of the wire with respect to adjacent structure and parts. This is particularly important in wires of No. 2 gauge or larger. Unfused power leads of No. 2 gauge and larger must not be clipped with other wiring but must be routed in separate, snug-fitting clips.

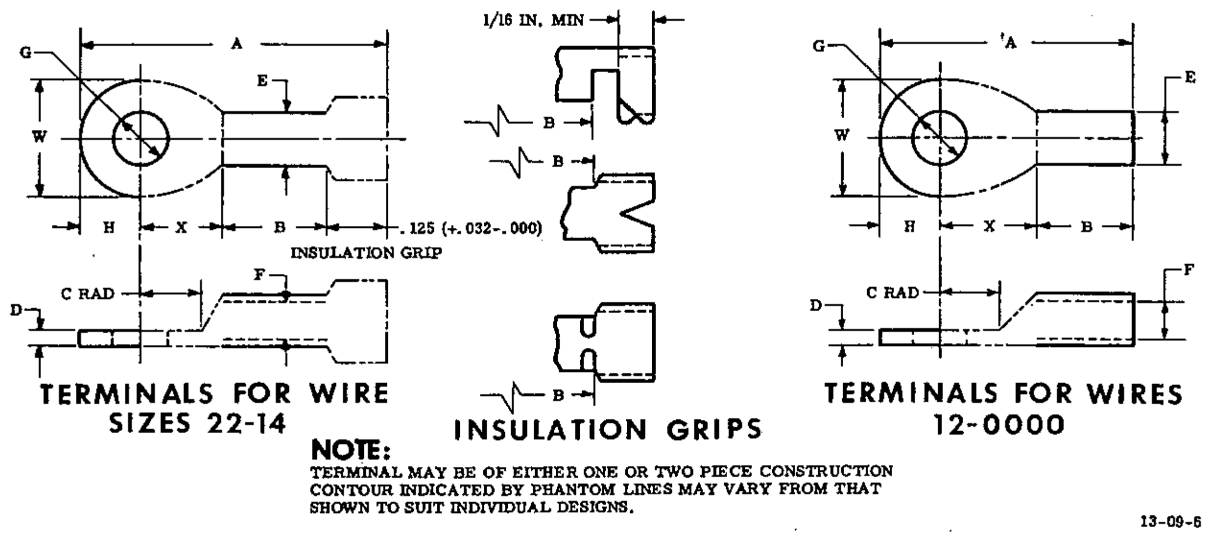
(h) Fasten wiring securely, by means of a clip (Item 1) on each end of wire runs, to reduce strain on connections unless the run terminates in a cable clamp or equivalent. Strain must not be taken by terminals or terminal pots but is to be taken by cable clamps (Item 2), supports or other approved means.

AN Wire Size	For Stud Size	AN659	T & B Part No.	Burndy Hand Tool	Power Tooling T & B 21070	T & B Hand Tool	RCAF Ref. No.
22, 20 & 18	4		A88G				
	6	-1	A85G				
	8		A86G			WW-T-110	
	10	-2	A87G	Y14MV	ABC		1C/2593
	1/4		A71G			WW-T-111	
	5/16		A72G				
	3/8	-25	A73G				
16, 14	6	-3	B85G				
	8	-26	B86G				
	10	-4	B87G			WW-T-110	
	1/4		B71G	Y14MV	ABC		1C/2593
	5/16		B72G			WW-T-111	
	3/8	-27	B73G				
12, 10	6						
	8		C77				
	10	-5	C25-C26				
	1/4		C71	Y14MV	ABC	WW-T-111	1C/2593
	5/16	-6	C72				
	3/8	-28	C73				

Figure 9-3 (Sheet 1 of 2) Copper Terminals and Tooling

AN Wire Size	For Stud Size	AN659	Burndy Part No.		Burndy Hand Tool	T & B Hand Tool	RCAF Ref. No.
			Straight	90°			
8	10	-7	YAV8C-L	-R	MY28	W-T-115	1C/2592
	1/4		YAV8C-L1	-R1			
	5/16	-8	YAV8C-L2	-R2			
	3/8	-29	YAV8C-L3	-R3			
6	10	-30	YAV6C-L1	-R1	MY28	W-T-115	1C/2592
	1/4	-9	YAV6C-L	-R			
	5/16	-31	YAV6C-L4	-R4			
	3/8	-10	YAV6C-L2	-R2			
4	10		YAV4C-L3	-R3	MY28	W-T-115	1C/2592
	1/4	-11	YAV4C-L	-R			
	5/16	-32	YAV4C-L4	-R4			
	3/8	-12	YAV4C-L2	-R2			
2	10		YAV2C-L3		MY28	W-T-115	1C/2592
	1/4	-13	YAV2C-L1	-R1			
	5/16		YAV2C-L2	-R2			
	3/8	-14	YAV2C-L	-R			
0	10		YAV25-L5		MY28	W-T-127	1T/1113
	1/4	-17	YAV25-L1	-R1			
	5/16		YAV25-L2	-R2			
	3/8	-18	YAV25-L	-R			
00	1/4		YAV26-L1	-R1	MY28	W-T-127	1T/1113
	5/16	-19	YAV26-L2	-R2			
	3/8	-20	YAV26-L	-R			

Figure 9-3 (Sheet 2 of 2) Copper Terminals and Tooling



Dash#	Cable Size	Stud Size	A Max.	B Min.	C Min.	D Min.	D Max.	E Max. Dia.	F Min. Dia.	G Dia. Min.	G Dia. Max.	H	W	X Min.
38	22-20-18	4	.893	.250	.187	.029	.043	.155	.055	.116	.122	.115±.020	.225±.031	.218
1		6	.906		.218					.142	.152	.125±.015	.250±.031	.281
2		10	.969		.250					.193	.203	.156±.015	.312±.031	.312
25		3/8	1.312		.343					.385	.410	.320±.015	.656±.031	.437
39	16-14	4	.969	.250	.113	.029	.043	.170	.080	.116	.122	.115±.020	.225±.031	.218
3		6	.969		.218					.142	.152	.156±.015	.312±.031	.281
26		6	.969		.113					.142	.152	.113±.015	.225±.031	.218
4		10	.969		.250					.193	.203	.156±.015	.312±.031	.312
27		3/8	1.312		.343					.385	.410	.320±.015	.656±.031	.437
5	12-10	10	.969	.250	.250	.037	.083	.230	.125	.193	.203	.187±.015	.375±.031	.312
6		5/16	1.125		.312					.320	.343	.265±.015	.531±.031	.406
28		3/8	1.281		.343					.385	.410	.281±.015	.567±.031	.437
7	8	10	1.125	.360	.250	.050	.083	.325	.175	.193	.203	.203±.015	.406±.031	.343
8		5/16	1.437		.312					.320	.343	.281±.015	.562±.031	.406
29		3/8	1.437		.343					.385	.410	.302±.026	.567±.031	.437
30	6	10	1.312	.422	.250	.050	.083	.385	.222	.193	.203	.234±.030	.468±.062	.375
9		1/4	1.375		.281					.260	.285	.250±.030	.500±.062	.375
31		5/16	1.468		.312					.320	.343	.320±.030	.625±.062	.437
10		3/8	1.468		.343					.385	.410	.312±.030	.625±.062	.437

Figure 9-4 (Sheet 1 of 2) AN659 Electrical Terminal

Dash#	Cable Size	Stud Size	A Max.	B Min.	C Min.	D Min.	D Max.	E Max. Dia.	F Min. Dia.	G Dia. Min.	G Dia. Max.	H	W	X Min.
11		1/4	1.406		.281					.260	.285	.250±.030	.500±.062	.375
32	4	5/16	1.500	.437	.312	.070	.106	.450	.280	.320	.343	.312±.030	.625±.062	.437
12		3/8	1.500		.343					.385	.410	.312±.030	.625±.062	.437
13		1/4	1.656		.281					.260	.285	.312±.030	.625±.062	.375
14	2	3/8	1.781	.562	.343	.070	.114	.585	.355	.385	.410	.328±.030	.656±.062	.437
33		1/2	1.906		.468					.510	.535	.395±.035	.812±.062	.625
15		1/4	1.671		.281					.260	.285	.343±.040	.687±.080	.437
16	1	3/8	1.781	.593	.343	.078	.130	.598	.390	.385	.410	.343±.040	.687±.080	.500
34		1/2	1.937		.468					.510	.535	.410±.044	.812±.080	.625
17		1/4	1.969		.281					.260	.285	.375±.040	.750±.125	.437
18	0	3/8	1.969	.656	.343	.088	.130	.665	.440	.385	.410	.395±.020	.790±.040	.500
35		1/2	2.093		.468					.510	.535	.437±.015	.875±.015	.625
19		5/16	2.093		.312					.320	.343	.390±.020	.839±.093	.468
20	00	3/8	2.093	.781	.343	.097	.130	.755	.500	.385	.410	.390±.020	.839±.093	.500
36		1/2	2.156		.468					.510	.535	.411±.035	.900±.031	.625
21	000	3/8	2.344	.781	.343	.097	.145	.820	.557	.385	.410	.468±.040	.937±.125	.500
22		1/2	2.344		.468					.510	.535	.468±.035	.952±.082	.625
23		3/8	2.406		.343					.385	.410	.500±.040	1.000±.125	.500
24	0000	1/2	2.406	.843	.468	.108	.145	.928	.622	.510	.535	.500±.040	1.000±.125	.625
37		7/8	2.906		.781					.890	.937	.625±.015	1.250±.015	1.312

NOTE

Where split barrel construction is used, the split shall be permanently sealed and shall not open as the result of crimping.

Material: Soft Copper, or Copper Tubing, or Gilding Metal, 95% Copper, 5% Zinc.

Optional Barrel Material: Commercial Bronze, 90% Copper, 10% Zinc.

Finish: Tinned Plate

Example of Part No.: AN659-4 - Terminal, Cable size 16-14, Stud size No. 10.

Dimensions in inches.

Figure 9-4 (Sheet 2 of 2) AN659 Electrical Terminal

(j) Coaxial and twin-conductor radio frequency cables are subject to minimum bend radii as specified in relevant Engineering Orders. When not specified, the minimum bend radius must be ten times the outside diameter of the cable.

(k) Separate wiring from all heated equipment. Route wires away from water drainage areas where water may collect.

(m) Install wiring in orderly fashion, with individual cables in the bundle generally parallel, to facilitate maintenance and servicing. Avoid crossovers, snarls, tangles or kinks.

(n) Do not parallel the input and output leads of radio noise filters.

(p) Use positive locking clips (Item 3) in locations where failure of the clip to remain closed would permit wiring to fall into moving equipment, such as control cables, pushrods, etc.

(q) Group wiring and bundles per wiring diagram.

Wires in Rigid Conduit

18 Observe the following instructions during installation:

(a) Drill rigid conduit for drain holes only as required. Do not drill holes in magneto, fire detector or ignition conduit. Holes must have burrs removed. Holes are not to be drilled with wires in conduit. Rigid conduit must be installed with hole at lowest point with respect to aircraft ground attitude to permit drainage.

(b) When pulling wire and wire bundles through conduit, use only a double thickness of regular tying or lacing cord (Item 4) for every ten wires being pulled. Do not use metal wire. Talc (Item 5) may be used on bundles and the lugs may be staggered to facilitate installation. Keep bundles straight when installing.

(c) Pull a felt plug or cloth through all conduit immediately prior to wire pull.

(d) Remove all tape or temporary ties immediately prior to wire pull.

(e) Check wire for damage as it is being pulled.

(f) Do not lay wire on floors at any time.

(g) All partially installed wire which is not to be immediately pulled into conduit must be coiled and covered with a paper bag or wrapping until installation is to be completed.

(h) Wire must not be pulled tight over rolled edge of conduit.

(j) Install rigid conduits with rolled ends, unless otherwise specified.

(k) Install bundles so that a wire may be replaced without removing the entire bundle.

(m) Do not tie or fasten wires together in conduit or insulating tubing.

(n) Radius or smooth out sharp edges on conduit interiors or at flex joints, as applicable, to facilitate installation and removal of wire.

AN Wire Size	Plastic Tubing Wall Thickness
20	.016
18	.016
16	.018
14	.018
12	.020
10	.020
8	.020
6	.020
4	.025
2	.025
1	.025
0	.030
00	.030

Figure 9-5 Plastic Tubing Wall Thickness

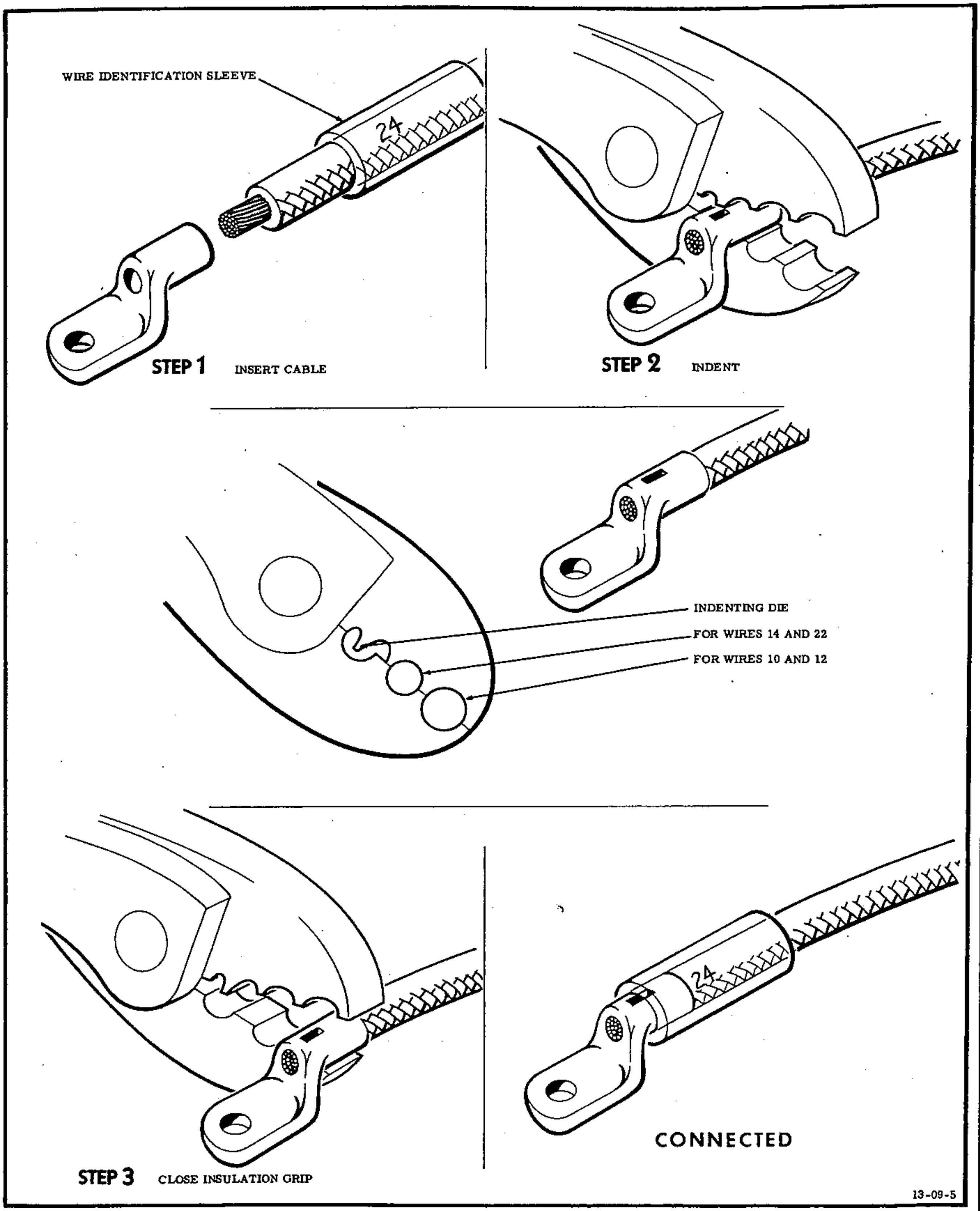


Figure 9-6 Hand Tool Staking

(p) Sharp inside edges of telescoping bell joints are to be broken as follows, to prevent abrasion of wires:

(1) Chamfer at 45° to approximately 20% to 30% of the wall thickness removing all sharp inside edges.

(2) The edges may be radiused with a sharp tool to approximately a 1/64 to 1/32 inch radius.

(q) Wires of No. 2 gauge and larger must not be run with other wires smaller than No. 2 gauge in the same conduit.

(r) Where wire bundles break out at pull points or terminal strips, the wire bundles must not have break-offs less than 1/2 inch from rolled edges of conduit and shall be properly clipped. Where it is impossible to clip the wiring, install tubing by slitting and wrapping around the wire bundle. Locate so

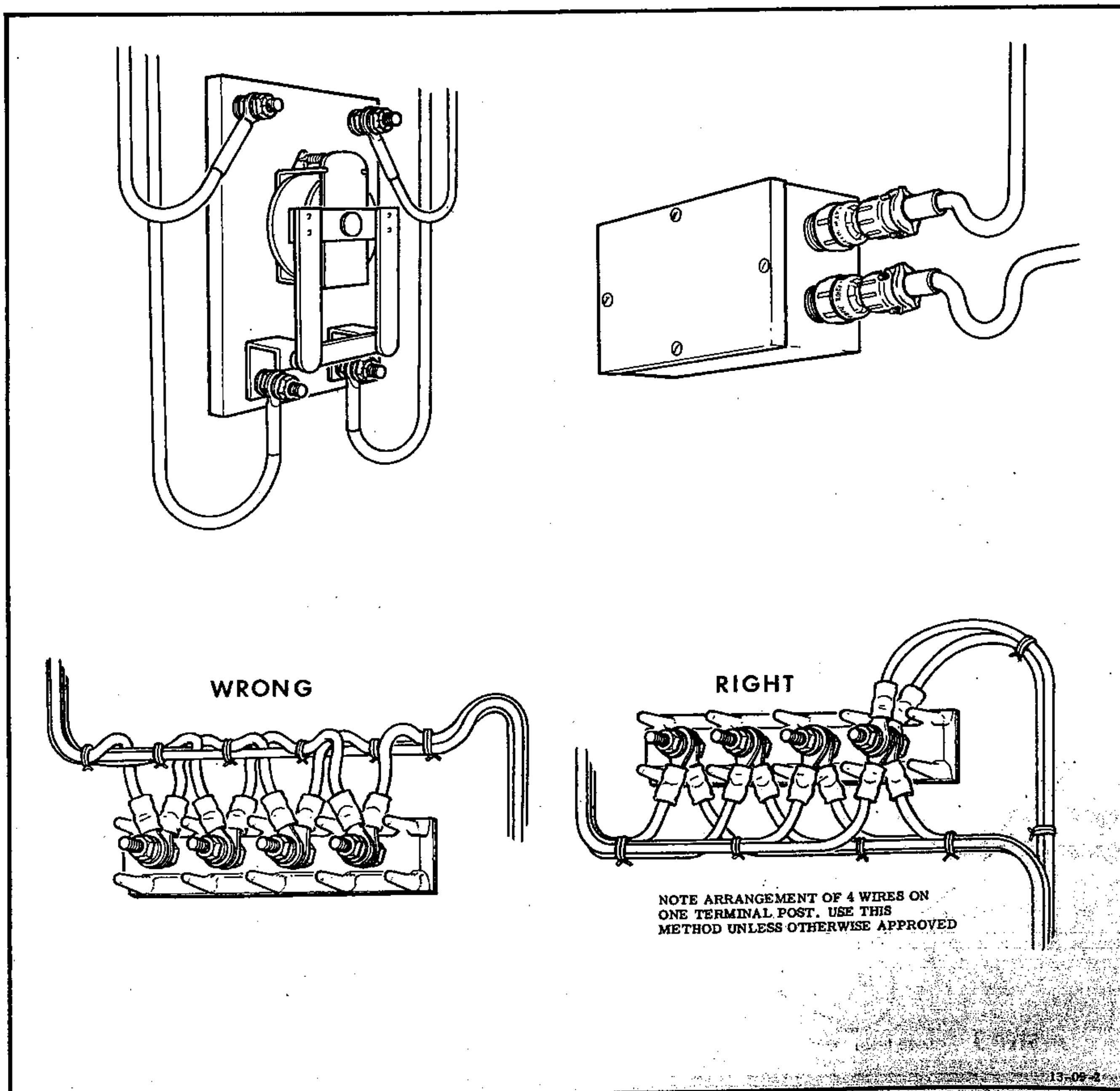


Figure 9-7 Typical Drip Loops

that the tubing extends at least 1/2 inch into the conduit and tie with No. 8 or No. 12 electrical waxed cord.

NOTE

The use of plastic tubing in such cases is not to be considered as a protection against chafing but merely to keep wires together and in a straight run.

(s) Where conduit opens upwards, permitting small hardware and metal chips to enter, wrap with tubing or sheet and tie at each end with No. 8 or No. 12 electrical waxed cord.

(t) Do not fasten rigid conduit to inflammable fluid lines.

(u) Install wire bundles so that the required slack remains. Support firmly to prevent the bundle weight from causing movement and elimination of the slack.

(v) Install clamps over telescoping bell joints. The clamp may be installed up to the edge of the female end, but a 1/16 inch section of the sawcut must be visible at the other edge of the clamp to facilitate inspection. (See Figure 9-8.)

Flexible Conduit

19 Observe the following instructions during installation of flexible conduit:

(a) Do not drill flexible conduit unless done on original installation. Holes must have all burrs removed. Holes are not to be drilled with wires in conduit. Flexible conduit must be installed with the hole at lowest point to permit drainage.

(b) Proper clipping of flex conduit must be maintained to prevent abrasion of adjacent parts.

(c) Install without leaving a residual twist.

(d) Leave only enough slack in flex conduit to permit ease of maintenance, to prevent mechanical strain on couplings and clips, and to permit free movement of vibration-mounted equipment.

(e) Minimum bend radii for flex conduits Nos. 101, 138 and 152 are five times the inside diameter except for 1/4 inch No. 101 flex conduit for which the minimum bend radius is seven times the inside diameter.

(f) Ensure that all flexible conduit nuts are finger tight except on flexible conduit forward of firewall, on ignition flexible conduit where nuts must be finger tight plus 1/16 turn, or where thread interference introduces friction preventing normal tightening of the nut. Use a suitable tool to turn the nut without damage. Avoid excessive tightening.

(g) Do not attach flexible conduit to inflammable fluid lines.

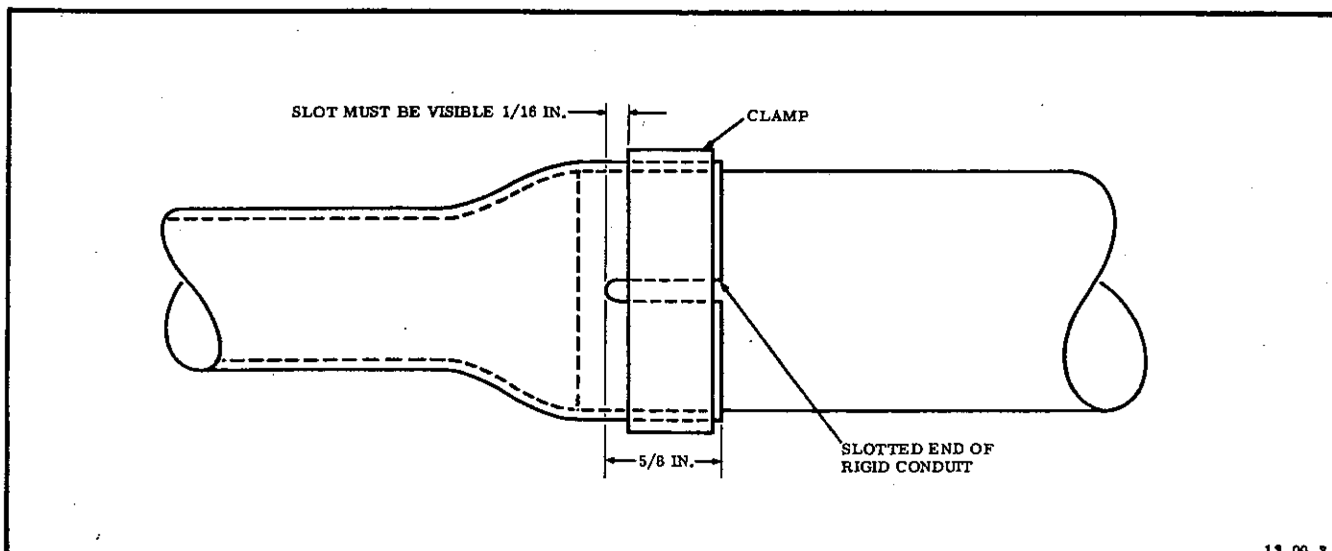


Figure 9-8 Clamp Installation

Ferrules on Flexible Conduit

20 Observe the following instructions when installing ferrules on flexible conduit:

(a) Cut the conduit one inch longer than required.

(b) Tin the ends of the conduit for approximately one inch and cut the tinned ends so as to secure the exact length. Trim the cut with diagonals to remove all ragged edges, loose wires, etc. Tin the collars of the ferrule (Item 16) for approximately one-half of their length.

(c) Roll or swage one ferrule on the conduit.

(d) Slip the nuts on the conduit.

(e) Roll or swage on the remaining ferrule.

(f) Solder and wipe the ferrules and conduit until there are no blow holes between the ferrules and conduit and a smooth exterior is obtained.

(g) Inspect the finished assembly for cracking (small cracks not into the radius of the ferrule are permissible), loose solder inside the conduit, improper mating of the parts and damaged plating. Damaged plating may be corrected by tinning the ferrule completely.

Miscellaneous

21 Install wires in connector plugs, receptacles, pins and sockets as follows:

(a) Where provision is made for mechanical staking of wires, they should be so attached, except for thermocouple leads which must be soldered.

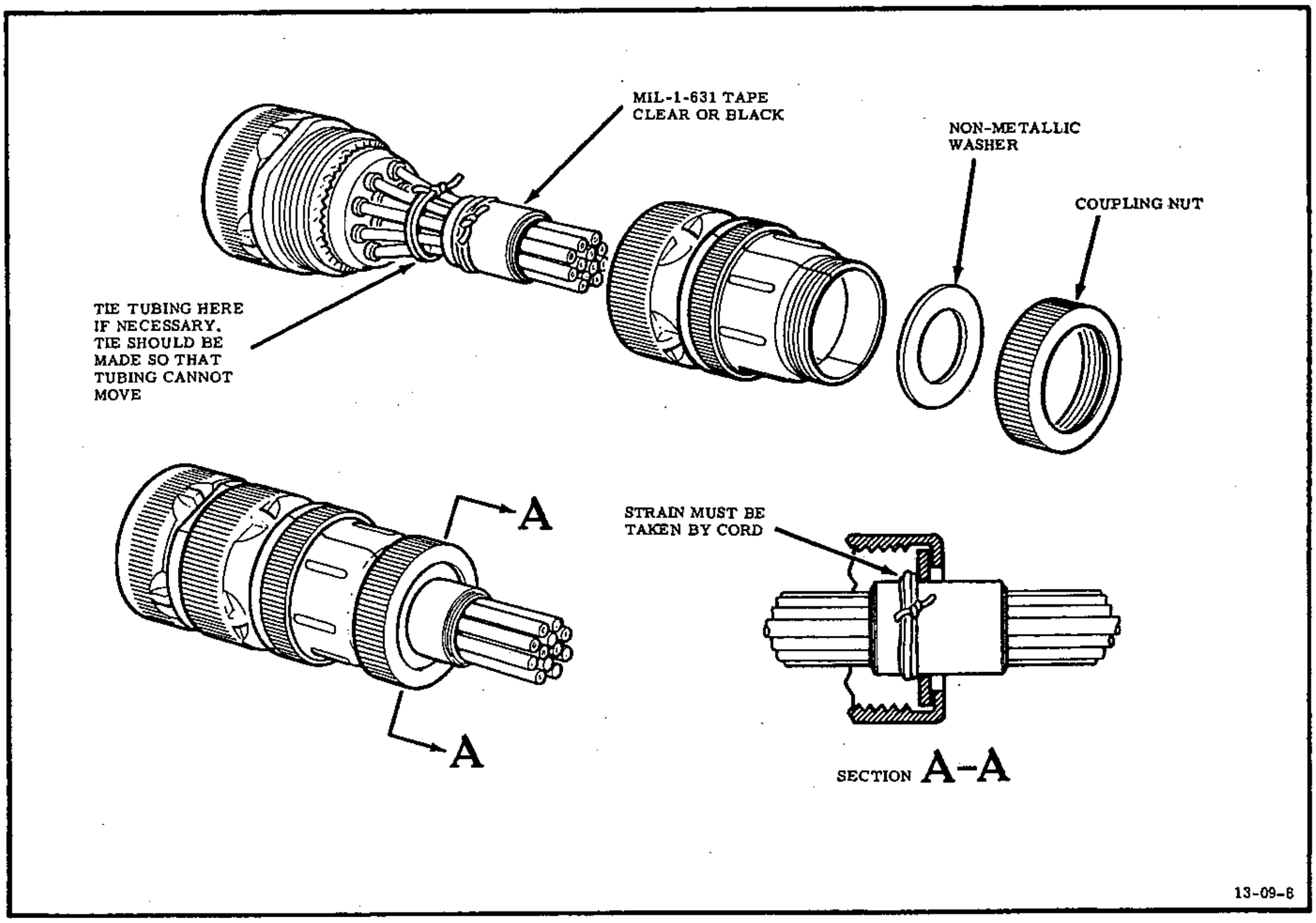


Figure 9-9 Connector Assembly using Washer and Nut

(b) Where solder type connectors are used, solder as instructed in Part 20, following. Connector and wire must be brought to correct temperature to prevent cold solder joints.

(c) Stake Cannon pins and sockets on pressurized panel only with approved tooling.

(d) Insulate and protect each connection and wire end with clean plastic tubing long enough to cover the staked or soldered end. The tubing must not extend more than 3/8 inch beyond the identification number except where necessary for clamping or tying.

(e) Tie plastic tubing securely or serve the wire bundle with cord as shown in Figure 9-9 to avoid slippage of insulation. Use method of tie given in Paragraphs 39 to 41 inclusive, following.

Terminal Strips

22 For the installation of terminal strips observe the following:

(a) Attach terminals to connector panels (terminal strips) as called for on the wiring diagram. The order in which parts are installed must be as shown in Figure 9-10.

(b) Attach not more than four terminals, or four terminals and a bus-bar, to any one terminal post unless otherwise directed on the wiring diagram.

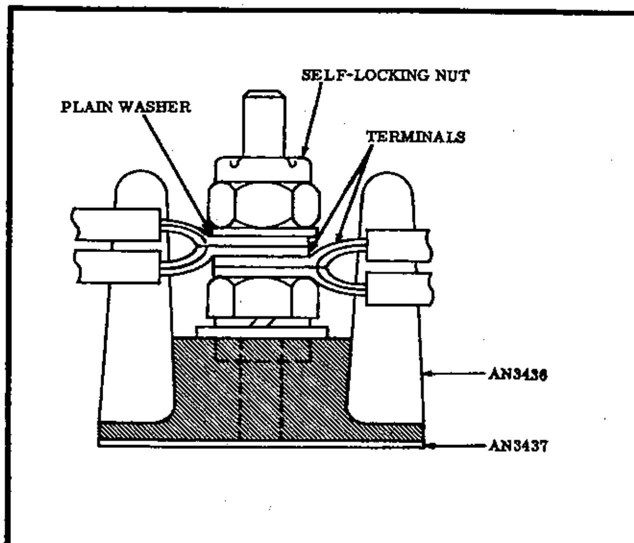


Figure 9-10 Terminal Strip Installation

(c) Elastic stop nuts may be substituted for top nut and lock washer only.

(d) Use only cadmium plated steel nuts, washers and lock washers to attach the terminals. If the engineering drawing calls for unplated or cadmium plated brass nuts and washers, cadmium plated steel may be substituted. This substitution is not reversible. Unless brass parts are called for, only cadmium plated steel may be used.

(e) Do not use lock washers between terminals. Nuts and/or washers, may be used if necessary. Limit the stack height to prevent terminals from slipping over the top of barrier posts.

(f) Base insulating strips (Item 19) are to be cemented to the base of terminal strips (Item 20) unless the suffix C is used, which indicates that the insulating strip is not required.

(g) A bus-bar, when used, may replace the bottom terminal and permits deletion of the bottom washer.

(h) Plain nuts and lock washers may be used as an alternative to self-locking nuts in attaching terminals to the terminal posts,

(j). Terminal strips which have spare connector studs must be provided with self-locking nuts and washers. The self-locking nuts must be tightened down on these spare connector studs.

(k) Tighten self-locking nuts so that the terminal bolt ends extend through the nuts.

(m) Torque No. 8-32 terminal posts (anchor nut only) of terminal strips (Item 20) to 10 to 13 inch-pounds.

Insulation of Connector Panel Attaching Screws and Nuts

23 Attaching screws and nuts must be insulated so that terminals, bus bars and other electrical hardware cannot contact them and cause a short-circuit. Insulate as follows:

(a) Use insulating strips (Item 21). Both post size and number of posts must be specified in ordering.

(b) On connector panel assemblies where insulating strips are not available, wood dough filler or plastic wood (Item 23) may be used. The attaching screw and nut must be sufficiently below the surface to permit at least a 1/16 inch covering of filler. Pack the attaching screw cavity with filler, taking care to eliminate air pockets. Smooth with a spatula and allow to dry. No hump is permitted.

24 When attaching terminals to bus bars or equipment where current passage through terminals and hardware is required, install the larger terminal first.

Rivet Installation

25 Rivets are to be installed in junction boxes and structural members containing wiring with the rivet head inside. If this is not practicable make the upset head comparable to the manufactured rivet head.

26 Wherever Cherry rivets are used in proximity of wire bundles, particularly within junction boxes, the burr remaining after the rivet shank has been cut off must be removed.

Screw Installation

27 For installation of screws observe the following:

(a) Mount equipment with screw head inside box or structure. Use brazier or flush head screws. (Refer to Part 6, preceding.)

(b) Where design requires that either the nut or nutplate be mounted inside the box or structure, the capped type nut or nutplate is to be used. (Refer to Part 6, preceding.) Use lock-washers (Item 32) with cap or cap nutplates.

(c) If screws are used for assembly or mounting of equipment, they must not be a hazard to electrical wiring or be a possible cause for a short-circuit.

ANSTAT DEAD END MAST ASSEMBLY INSTRUCTIONS

General

28 The purpose of this antenna mast assembly, (see Figure 9-11), is to terminate the polyethylene insulated wire in a connector assembly which may also be used as a take-up device for adjusting the wire to the proper amount of tension. It is important that the instructions be followed very closely so that the metallic sections of the assembly will be insulated from the outside electrical effects and will give the equivalent insulating properties of the insulated polyethylene antenna wire.

Assembly of Antenna Mast

29 To assemble antenna mast, proceed as follows: (See Figure 9-11.)

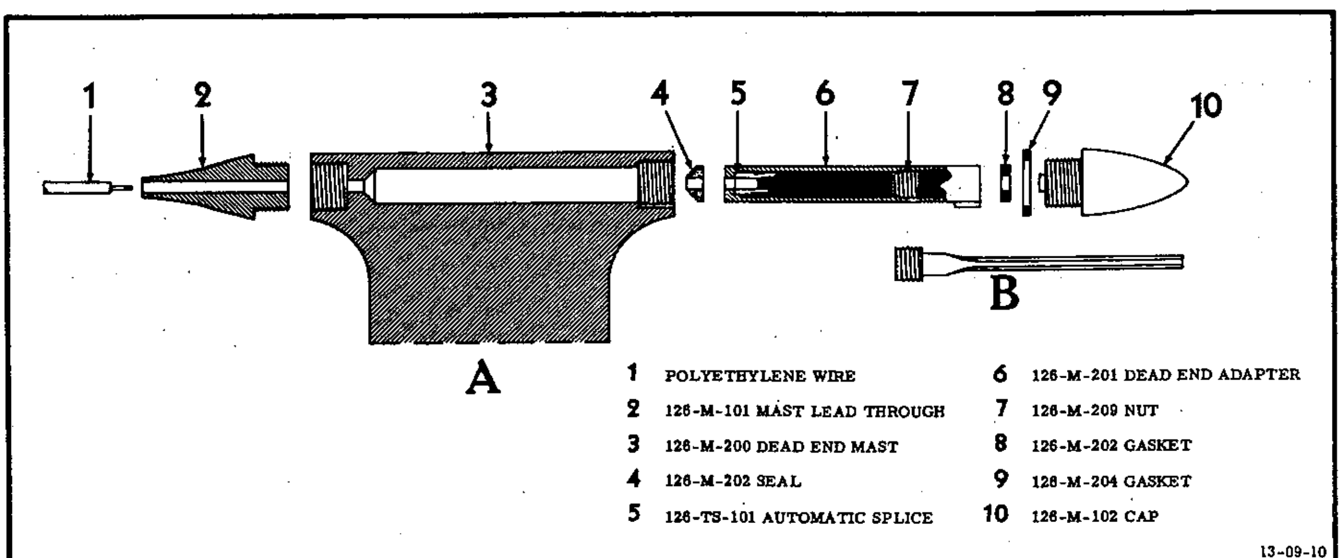


Figure 9-11 Anstat Dead End Mast M-200

(a) Cut antenna wire (1) to the approximate length desired, allowing a few extra inches for later cutting to correct length.

(b) Remove 3/4 inch of polyethylene insulation from end of wire.

(c) Insert wire seal (4) into mast (3).

CAUTION

Do not wipe compound (Item 28) out of mast openings.

(d) Insert dead end adapter (6) into mast (3) so that the keyway is fitted properly and the dead end adapter fits snugly against wire seal (4).

(e) Insert wire (1) through rubber lead-through sleeve (2) and push wire through the opening in the mast (3) until the wire engages the jaws within the connector (5).

(f) Give a slight tug on the wire to make certain that it has been properly gripped.

(g) Screw rubber lead-through sleeve (2) tightly into the mast (3).

(h) When the antenna mast which supports the antenna at its opposite end has been installed, the slack in the antenna wire may be taken up by placing a screwdriver within the dead end adapter (6) and engaging the slot (7) in the screw. By turning the screw counter-clockwise, the antenna wire may be taken up a distance of approximately one inch. When the proper amount of tension is attained, place rubber seal (8) and (9) onto cap (10) and screw into the rear section of the mast as tightly as possible using only the hand. The mast is now assembled and will provide the necessary electrical insulation.

Removal of Antenna Wire

30 To remove the antenna wire proceed as follows: (See Figure 9-11.)

(a) Cut polyethylene wire (1) about 6 inches from mast (3).

(b) Remove cap (10) and rubber seals (8) and (9).

(c) Remove rubber lead-through sleeve (2).

(d) Push wire (1) through the mast (3) so that dead end adapter (6) and rubber seal (4) are ejected.

(e) Insert screwdriver in slot (7) and turn screw clockwise as far as it will go.

(f) Crush the insulation on the remaining polyethylene wire with pliers and remove by twisting and pulling.

(g) Slide wire release tool over the bare wire until it engages jaws (5) within the connector. If necessary, tap on tool to release jaws.

(h) Holding release tool firmly against jaws, pull out antenna wire.

(j) Coat the threads in each end of the mast with compound (Item 28). The mast assembly is ready for re-use.

Antenna Fittings

31 For best results observe the following points:

(a) Pliers or sharp knife must not be used to remove insulation from polyethylene wire. The conductor within the antenna wire is copperweld and, if nicked by sharp tools, becomes mechanically weak and may fail under vibration. Use a vee-shaped soldering iron tip to melt insulation from wire.

(b) Place a small amount of compound (Item 28) in each cap. Do not wipe off, as this helps to prevent air pockets inside the threads of the cap when the unit is assembled.

(c) Do not use pliers or other hand tools to assemble Anstat antenna fittings. Hand tightening, using a clean cloth to grip the parts, is sufficient.

Connecting Wire into Fitting

32 To connect wire into fitting proceed as follows: (See Figure 9-12.)

(a) Remove 3/4 inch of insulation from end of polyethylene wire. (Refer to Paragraph 31, preceding.)

(b) Slide one cap (1) over wire (2).

(c) Slide silicone rubber seal (3) over insulated wire (2).

(d) Hold the fitting firmly in one hand and push bare wire section into connector as far as it will go.

(e) Give a slight pull on wire to be sure it is gripped firmly.

(f) Push silicone rubber seal (3) into entrance of fitting until tapered section of seal is seated.

(g) Screw end cap (1) onto the threads (4) hand tight.

(h) Wipe off excess silicone compound (Item 28) with clean dry cloth.

(j) Connection is now ready for use.

Removal of Wire from Fitting

33 To remove wire from fitting proceed as follows: (See Figures 9-12 and 9-13.)

(a) Cut antenna 6 inches in front of cap (1) with pliers.

(b) Unscrew cap (1) and remove rubber seal (3).

(c) Using a pair of pliers, crush the insulation on the 6 inch section of wire up to entrance of the connector.

(d) Hold the unit in one hand and slide the insulation from the conductor. A slight twisting action will make the insulation slide from the wire easier.

(e) Place the release tool (5) over the wire as shown and slide down inside the connector until it touches the jaws. It may be necessary to use a non-metallic hammer to tap on the end of the release tool to open the jaws from around the wire.

(f) When the jaws are released, hold the release tool firmly against the jaws and pull the bare wire out of the connector.

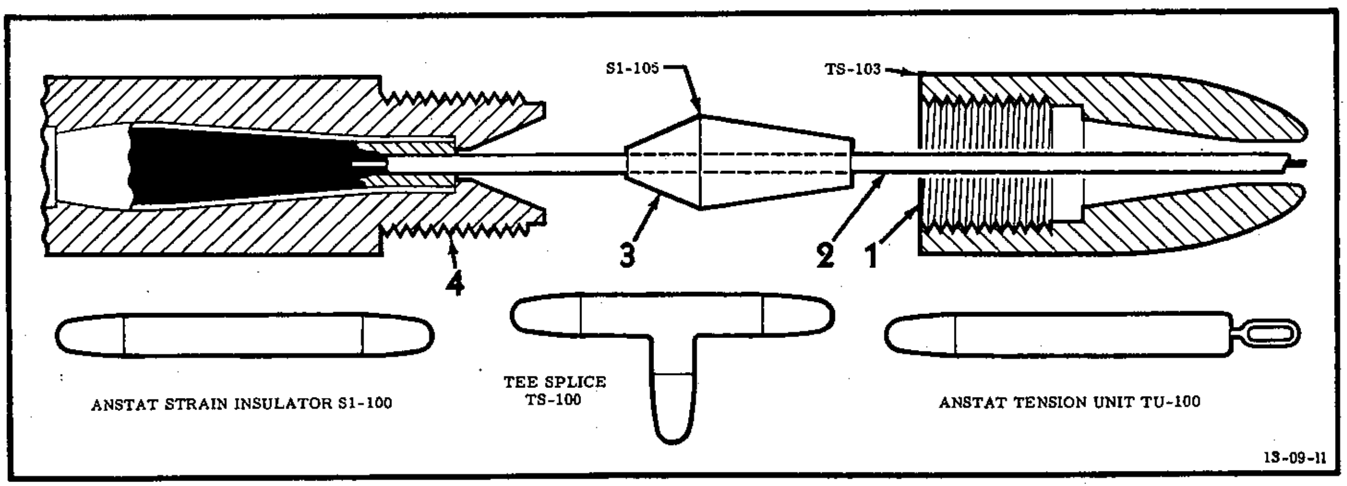


Figure 9-12 Dead End Mast Components

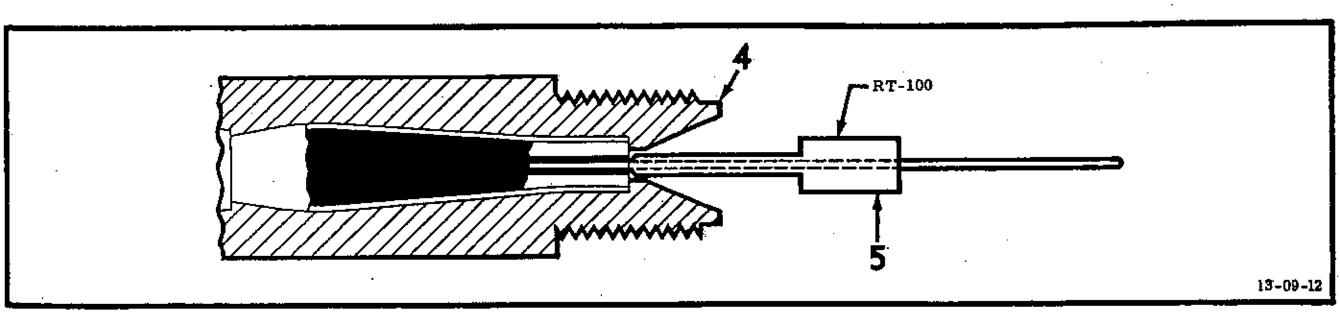


Figure 9-13 Dead End Mast Assembly

(g) The unit is now ready for re-use after replacing the wire seal (3) with a new one and placing a small amount of compound (Item 28) in the cap (1).

SIMMONDS PACITOR TANK UNIT ASSEMBLY

Procedure

34 To assemble Simmonds Pacitor tank unit coupling nut to tank units, proceed as follows: (See Figure 9-14.)

(a) Lubricate male threads only with compound(Item 29), if necessary, to prevent seizing.

(b) Place the coupling nut and O-ring over the end of the coaxial cable.

NOTE

Do not lubricate the O-ring, as friction between the seal and cable holds the cable in place and waterproofs the connection.

(c) Insert the bayonet-type end into the tank unit to the full depth of the central prong.

(d) Complete the assembly by tightening the coupling nut finger tight.

STOWAGE OF ELECTRICAL WIRING AND PLUGS

General

35 Stowage of electrical wiring and plugs is carried out to ensure adequate protection from short-circuits, structural damage and fire.

General Instructions

36 Observe the following instructions:

(a) All wires must be prevented from creeping by tying to a supporting cable run or structural member. Adequate support must be assured, i.e., a plug may not be tied to a cable run of less then 1/2 the diameter of the plug itself, unless specified.

(b) Whenever possible, stowed plugs must be visible for ready inspection.

(c) Wires with stripped ends must have the protruding strands cut flush with the end of the insulation, except when otherwise specified.

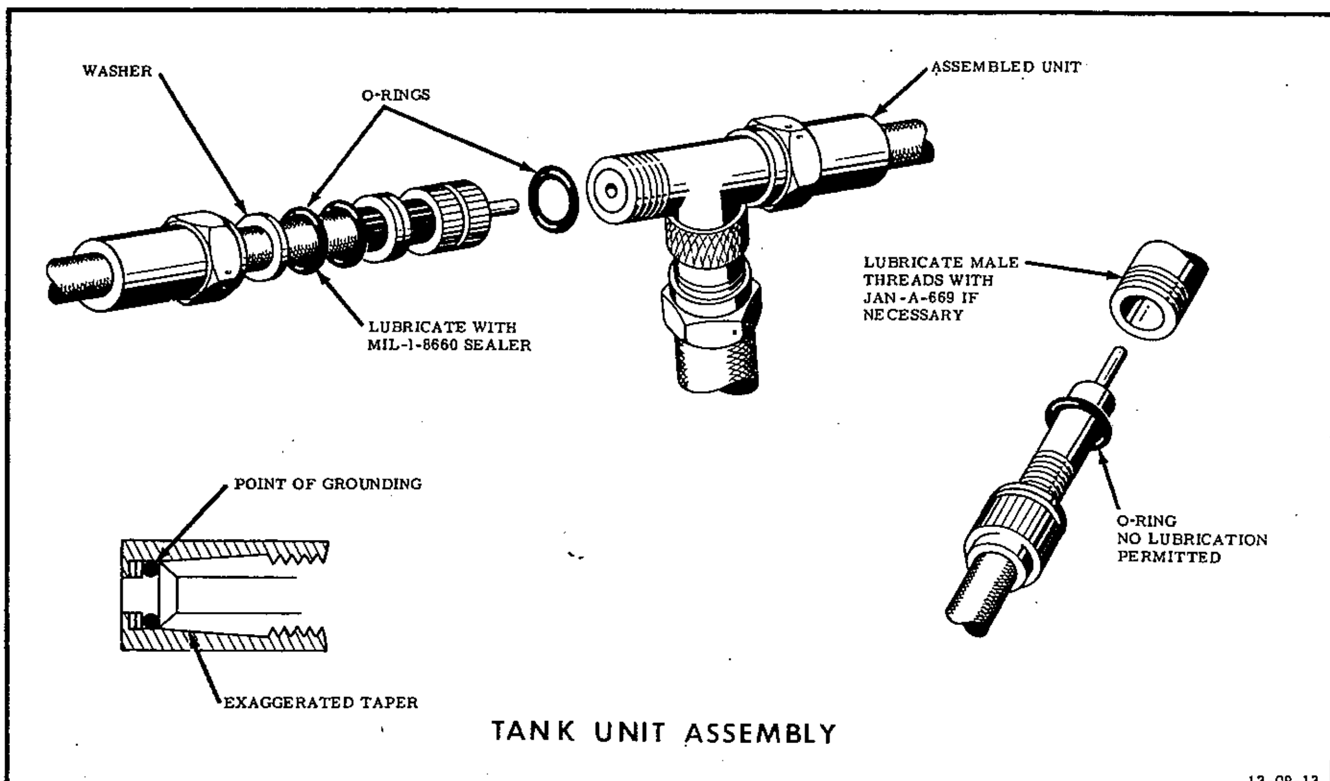


Figure 9-14 Simmons Pacitor Tank Unit Assembly

(d) Wires ending in terminal lugs or other special purpose terminations must be stowed to preserve these ends. Use transparent tubing to show these ends intact whenever possible.

(e) Wire numbers, either stamped or typed on tape, must be clearly visible when stowed.

(f) Each wire of a multiple wire conductor must be treated as a single wire.

(g) Do not bend solid conductors for stowage purposes.

(h) Do not stow wires inside AN connectors, clamps or terminal boxes.

(j) Observe temperature conditions which regulate material being used.

(k) Whenever glass tape (Item 33) is used to box and wrap AN connectors, coat the tape with silicone resin (Item 34).

(m) Do not push stowed wires back into the bundle.

(n) Use a maximum of three and a minimum of two wraps per spot tie.

(p) The radius shown in Figure 9-15 (Sheet 1) must be 3/8 inch minimum for AN20 gauge wire, 1/2 inch minimum for AN18 and 16 gauge wire and 5/8 inch minimum for AN14 and 12 gauge wire. For coaxial cables, the bend radius shall not be less than 6 times the diameter of the coaxial cable.

(q) For insulating conduit in low temperature areas, use a tying cord (Item 4) and tape (Item 35).

(r) For insulating conduit in high temperature areas use tying cord and tape (Item 37).

(s) In cases where more than one wire per bundle is stowed, the individual wires must be staggered.

(t) An alternate method for stowage in the case of wires AN10 and larger sizes for the coaxial cables is shown in Figure 9-15 (Sheet 2).

(u) For shielded wire, strip and push back the shielding from the end of insulating conduit as shown.

Structural Stowage

37 The method used in attaching wires to structural members using clips is shown in Figure 9-15 (Sheet 3). The clip (Item 1) is placed over the first tie. The sizes of the loops are different and are staggered. The wires are individually insulated but bound as a unit.

AN Connectors

38 For the stowage of AN connectors, proceed as follows:

(a) Box and wrap plugs as shown in Figure 9-16. Where dummy receptacles or dust covers are provided for stowage, they must be used and taping will not be necessary.

(b) Tape and cord must comply with temperature limitations, (refer to Paragraph 36, Sub-paragraphs (a) and (r). Expose no part of the plug except as indicated.

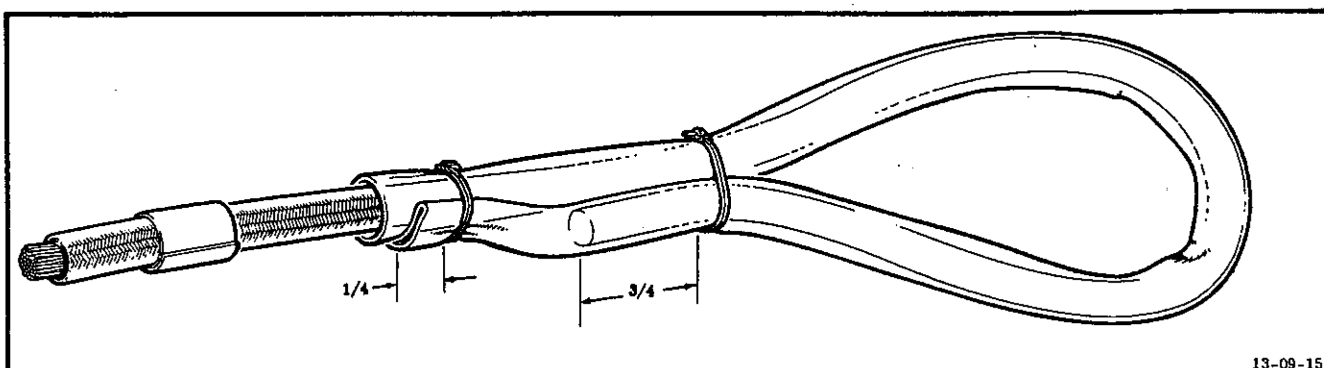


Figure 9-15 (Sheet 1 of 3) Stowage Methods

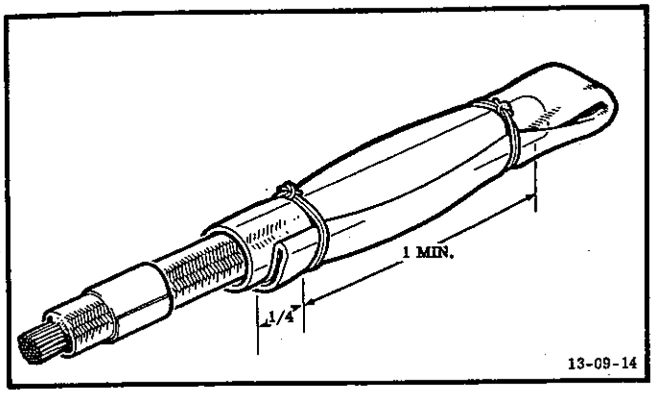


Figure 9-15 (Sheet 2 of 3) Stowage Methods

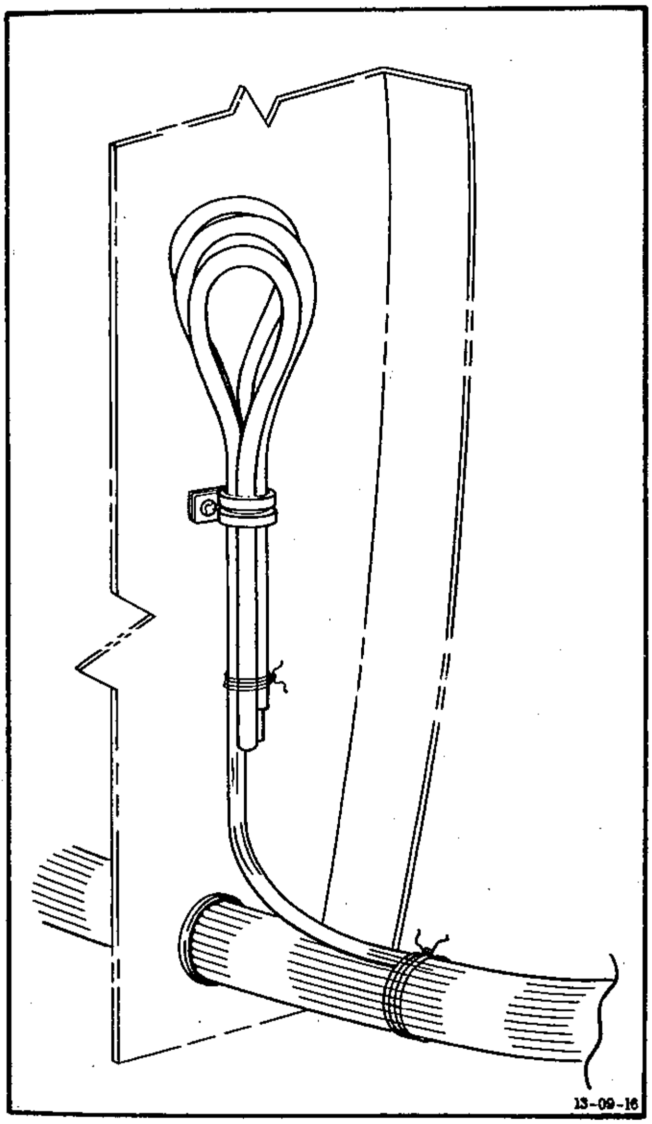


Figure 9-15 (Sheet 3 of 3) Stowage Methods

(c) Plugs must be either tied to cable runs or clamped to structure members as shown in Figure 9-17. Special care should be taken to ensure that fluid can not run down into the wire end of the plug. Use drip loops as required.

Tying Wires

39 Make all wire ties with cord (Item 4) as follows:

(a) Tie a clove hitch around the wire or bundle of wires.

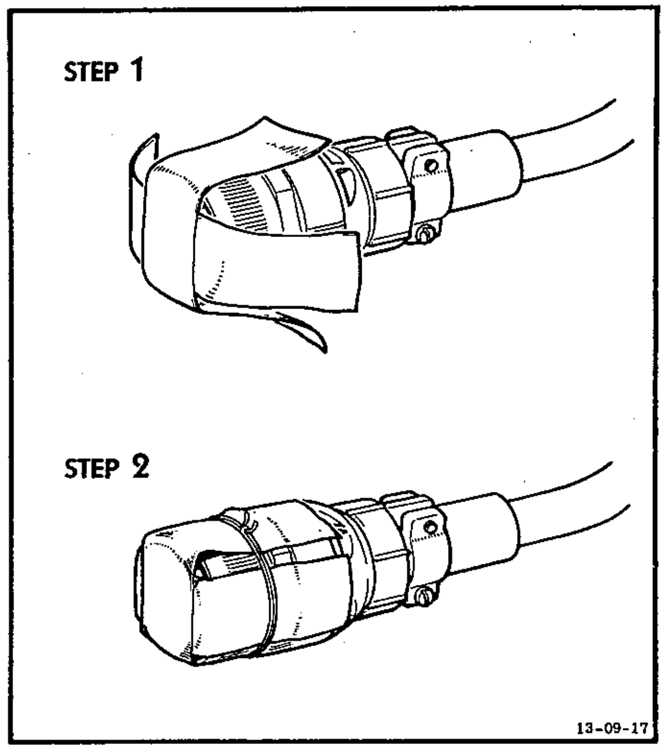


Figure 9-16 Wrapping of Plugs

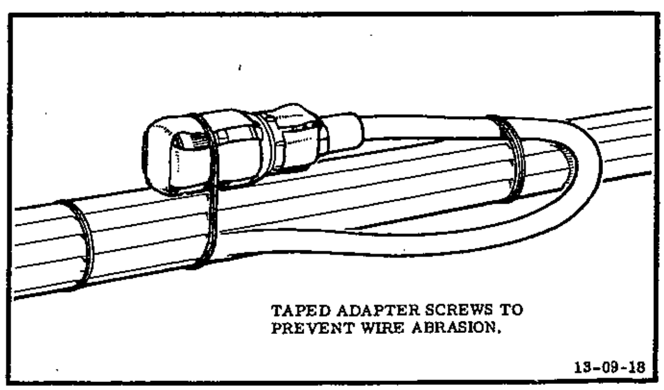


Figure 9-17 Plug Tying

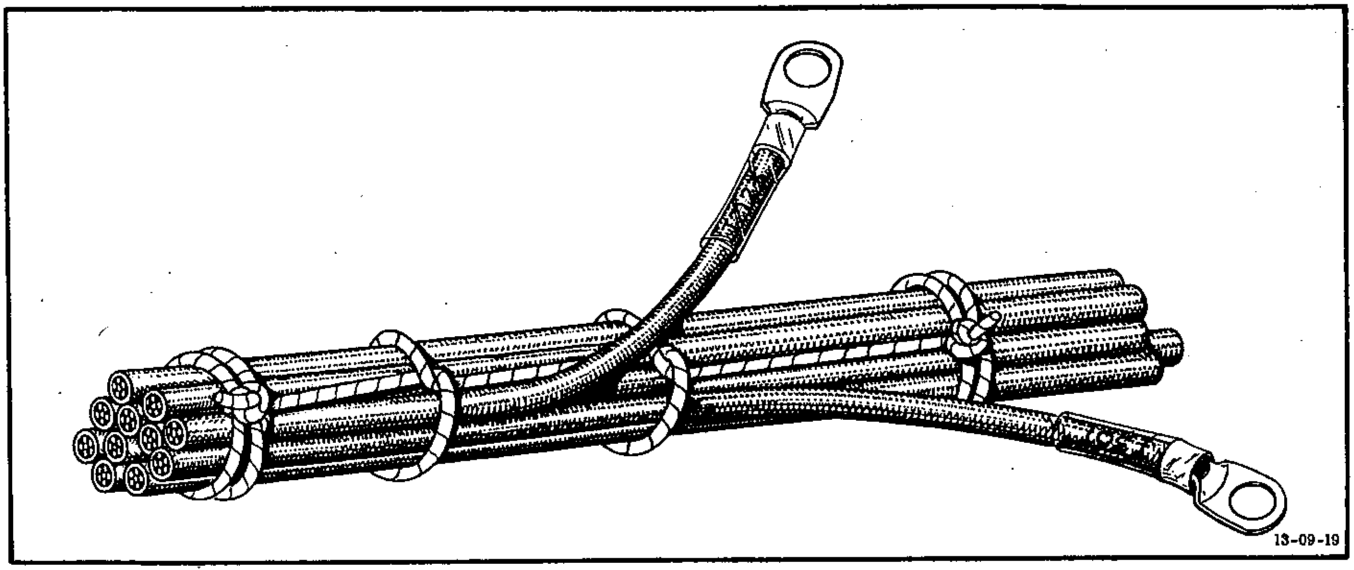


Figure 9-18 Lacing Wire Bundles

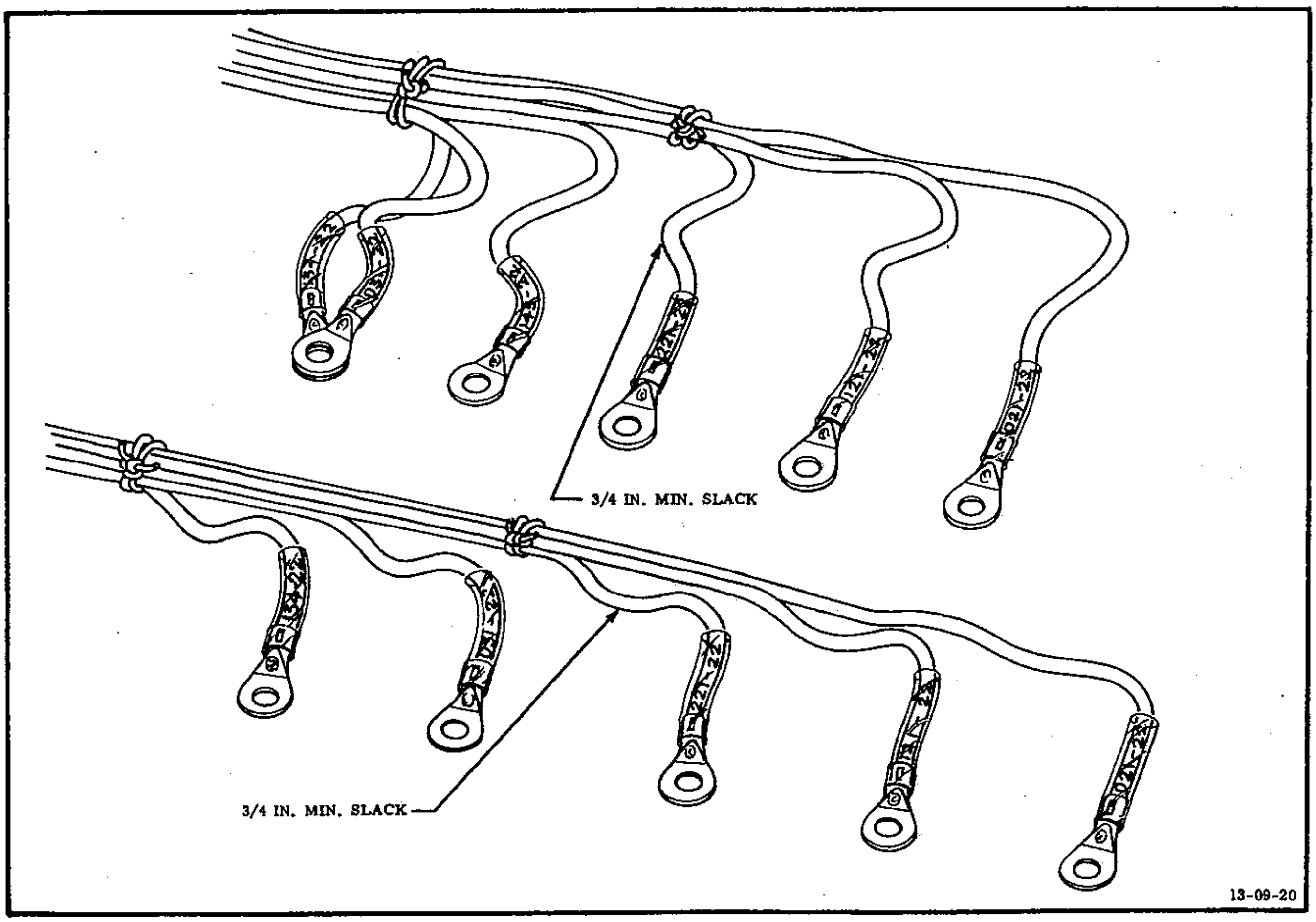


Figure 9-19 Branch Ties

(b) Tie an overhand knot over the clove hitch to produce a square knot.

Lacing

40 Do not use lacing unless specified on the engineering drawing. When specified, proceed as follows: (See Figure 9-18.)

(a) Tie knot as above.

(b) Use an overhand knot for the running knot.

(c) End lacing with knot as above.

Branch Ties

41 Make ties as shown in Figure 9-19. Ties from each branch from the main bundle are not necessary. Tie when wires or groups of wires leave the main bundle and where necessary for support. Allow a minimum of 3/4 inch of slack on each branch from tie to terminal shank. The 3/4 inch slack is essential to prevent strain on terminals.

Excess Wire

42 Excess wire is not permitted except for the installation of alternate equipment, in special instances where specified and where thermocouple leads must be of a specified length and cannot be cut.

Unused Wires

43 To stow unused wires, proceed as follows:

(a) Cover ends of wire not terminating in equipment and which are intended for future or alternate use, with plastic tubing (Item 8). The ends of individual wires must be insulated snugly and tied with waxed cord (Item 4).

(b) Coil and tie to bundle with waxed cord.

(c) Insulate connector plugs which are not used or stowed in mountings as shown in Figure 9-20. Plugs must be stowed with a drip loop adjacent to the plug to prevent entry of fluids, (see Figure 9-7).

Handling Ties

44 Handling ties are used for convenience in handling or storing wire assemblies before

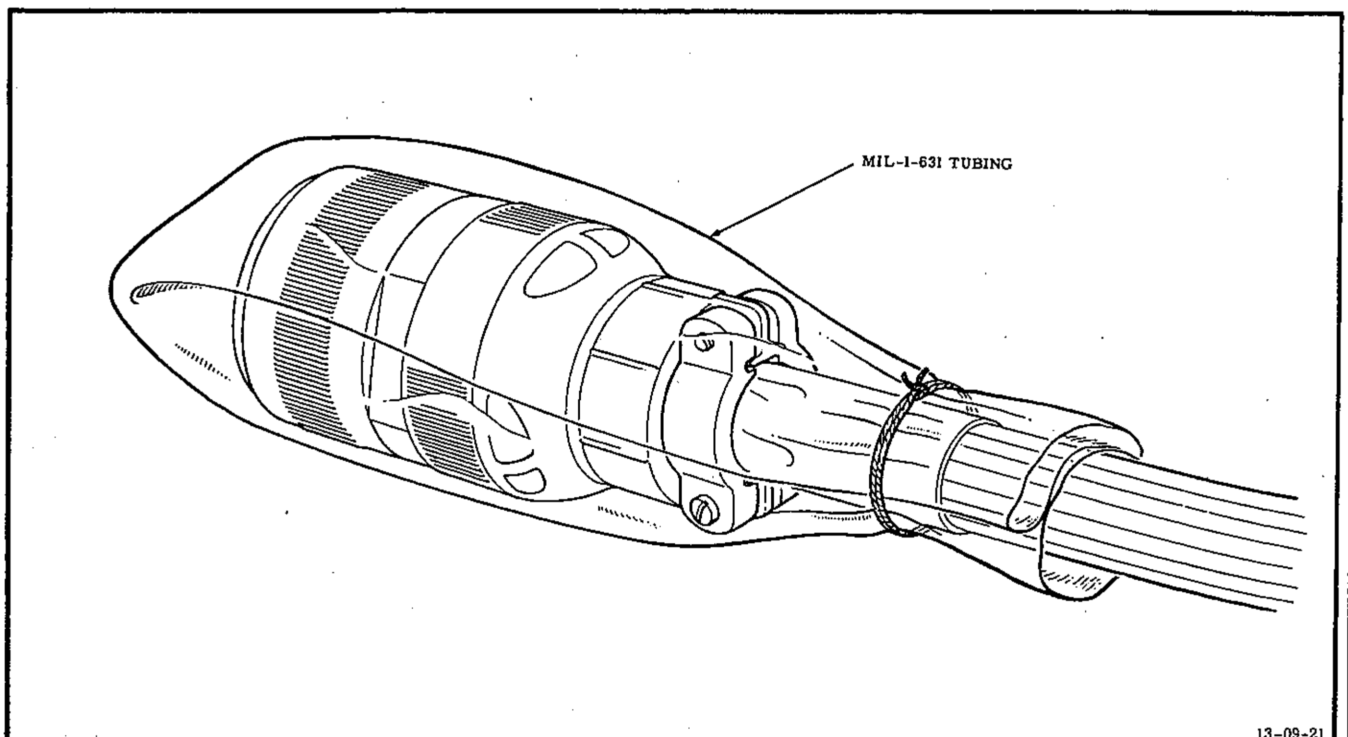


Figure 9-20 Unused Connector Insulation

installation and must be removed from all installed wiring.

Wire Bundles Ties

45 Make ties around wire bundles (outside junction boxes) only where the clipping distance exceeds 24 inches or where necessary to prevent interference between wires and adjacent items. Minimum distance between ties is 6 inches or less, if required by the provisions of Paragraph 17, preceding. This does not apply to branch ties.

46 Inside of junction boxes make ties around wire bundles only where necessary to prevent the interference of loose wires with operating relays or similar equipment. This does not apply to branch ties.

CLAMPING PROCEDURE

General

47 If regular grommets are not available, .020 inch plastic tape (Item 39) clear or black, may be used. Wrap the tape around the bundle to the desired diameter. Tighten the saddle while holding tension on the tape. There must be no gap between saddle and clamp. (See Figure 9-21.)

Washer Method

48 Where the grommet and plastic tape method cannot be used due to space limitations, the washer method may be used. Build up a number of turns with cord (Item 4) over the plastic tape (Item 8) and tie so that the strain on the wiring will be against the cord rather than the connectors, as shown in Figure 9-22.

Disconnect Plug Assemblies

49 On disconnect plug assemblies, make certain that all threads are properly engaged before tightening. Proceed as follows:

(a) Tighten the coupling nuts and the cable adapters finger tight. Cable adapter must be tightened before the saddle is clamped on the wire bundle to prevent twisting the wires.

(b) Safety all connectors in engine nacelles and in areas not readily available for visual ground inspection.

(c) Safety all disconnect plug assemblies which might become disconnected due to wire pull etc., if coupling nut backed off due to vibration.

(d) Do not safety coaxial transmission connectors. Install to correct torque specified in the applicable Description and Maintenance Manual.

(e) Tighten all Cannon Hi-G vibration-proof connectors with a suitable spanner.

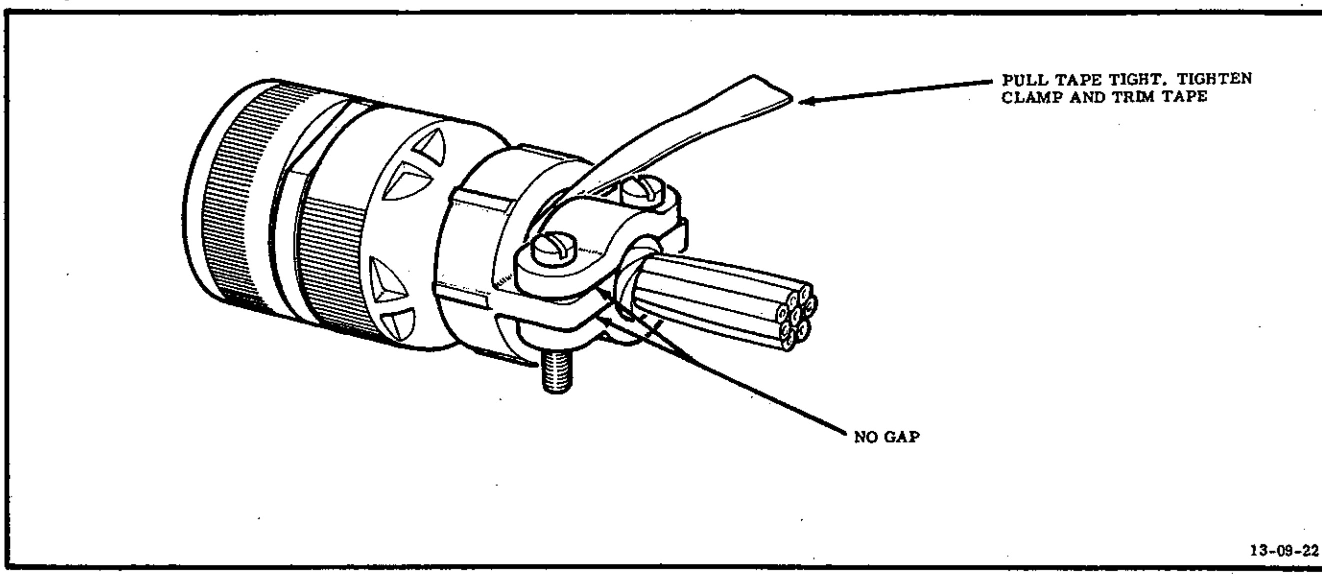


Figure 9-21 Connector Installation

Protection of Plugs

50 Plugs installed so that the wires leave the plug in an upward direction require waterproofing and protection from dirt and metal particles. To obtain the required protection, secure a length of plastic tubing around the plug and extending along the wires to the point where the wires have completed a turn downwards.

51 Where the nut is installed inside the junction box, or on the open wiring side of the bulkhead where conduit terminates in open wiring, safety hexagon lock-nuts used to attach bulkhead type conduit fittings as follows:

(a) Tighten lock-nut on fitting.

(b) Using a medium automatic punch adjusted to full setting, stake the nut against the last visible thread on the fitting with a light blow. Stake at one point only.

52 Ninety degree connectors used without conduit must point downward where possible. (See Figure 9-22.)

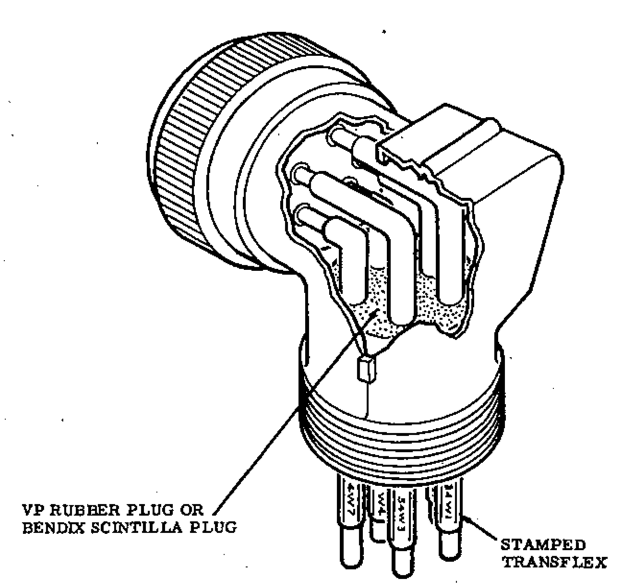


Figure 9-22 VP Rubber Plug Installation

53 Where rubber seals are employed with vibration-proof connectors and flexible conduit, the plastic tubing (Item 8) shall be added as shown in Figure 9-22. Adequate protection is afforded the identification numbers by the flexible conduit. The numbers must be installed close to, yet not be covered or hidden by, the seal.

Clip Applications

54 Locate clips (Item 1) with point of attachment above the wire bundle, wherever practicable. Clip to clear slack from structure. Rigid and flex conduit should be clipped to ensure adequate support according to size, length and shape of conduit. Do not secure conduit to the aircraft structure at intervals greater than three feet. (See Figure 9-23.)

55 Choose clips to insure a snug fit of the wire bundle. Wires in non-loop clips or clips without protective covering must be installed with the wiring suitably protected from chafing.

56 Where secure attachment of the wire bundle is required, fasten in such manner as to prevent slippage of the wire bundle through the clip under flight conditions, but not sufficiently tight to damage the insulation or to prevent closing of the clip. Wrap clear or black plastic tape (Item 39) around the wire bundle if a clip of the proper size cannot be obtained. Where there are exposed terminals in regions subjected to explosive vapour accumulation, clip the leads to prevent side movement of the terminal ends of the cables.

57 Where an angle bracket (Item 40) is required for clipping open wiring, only angle brackets with two or more points of attachment may be used. Two hole attach angles are to be used with rigid conduit where vibration permits movement of conduit and subsequent contact with structures, cutouts, etc. Where conduit is routed so that it crosses over longerons, frames, etc. and is not attached at the point of crossover, a minimum clearance of 1/16 inch is required. Washers may be used under conduit attach clips to obtain necessary clearance but should not exceed a total of 3/16 inch under clip.

Wire Protection

58 The use of plastic tape and tubing to protect wires mechanically from chafing or abrasion is prohibited. Where wiring would chafe on structure, protect the wiring by additional clips or clamps, re-routing or other installation changes. Plastic tape or tubing may only be used to protect wiring insulation from damage by fluids. Do not use friction tape or adhesive tape.

59 For additional protection at all locations noted below, wrap with fish paper and tie with plastic tape (Item 39) and cord (Item 4) or cord alone, as required:

(a) Wires entering plastic grommets which are not fully closed.

(b) Small wires at ground power receptacle clamp.

(c) Wires entering plastic grommets and which run from leading edge centre wing to fuselage seal plug.

60 Wrap with plastic tape (Item 39) all wires in battery enclosure.

Repairing Damaged Wires

61 Repair damage to primary insulation along 3/4 inch of wire or less, except for Nos. 22, 20 and 18 wire, by installing plastic tubing over or wrapping plastic sheet (.020 inch minimum wrap thickness) around the damaged portion and tying at each end, as shown in Figure 9-24.

Splicing Wires

62 Permanent splices are not to be used for initial installation or for repair of damaged wires unless engineering authority is obtained. The following types of wire cannot be spliced without engineering authority.

(a) Thermocouple wires

(b) High tension wires

(c) Shielded wires or cables

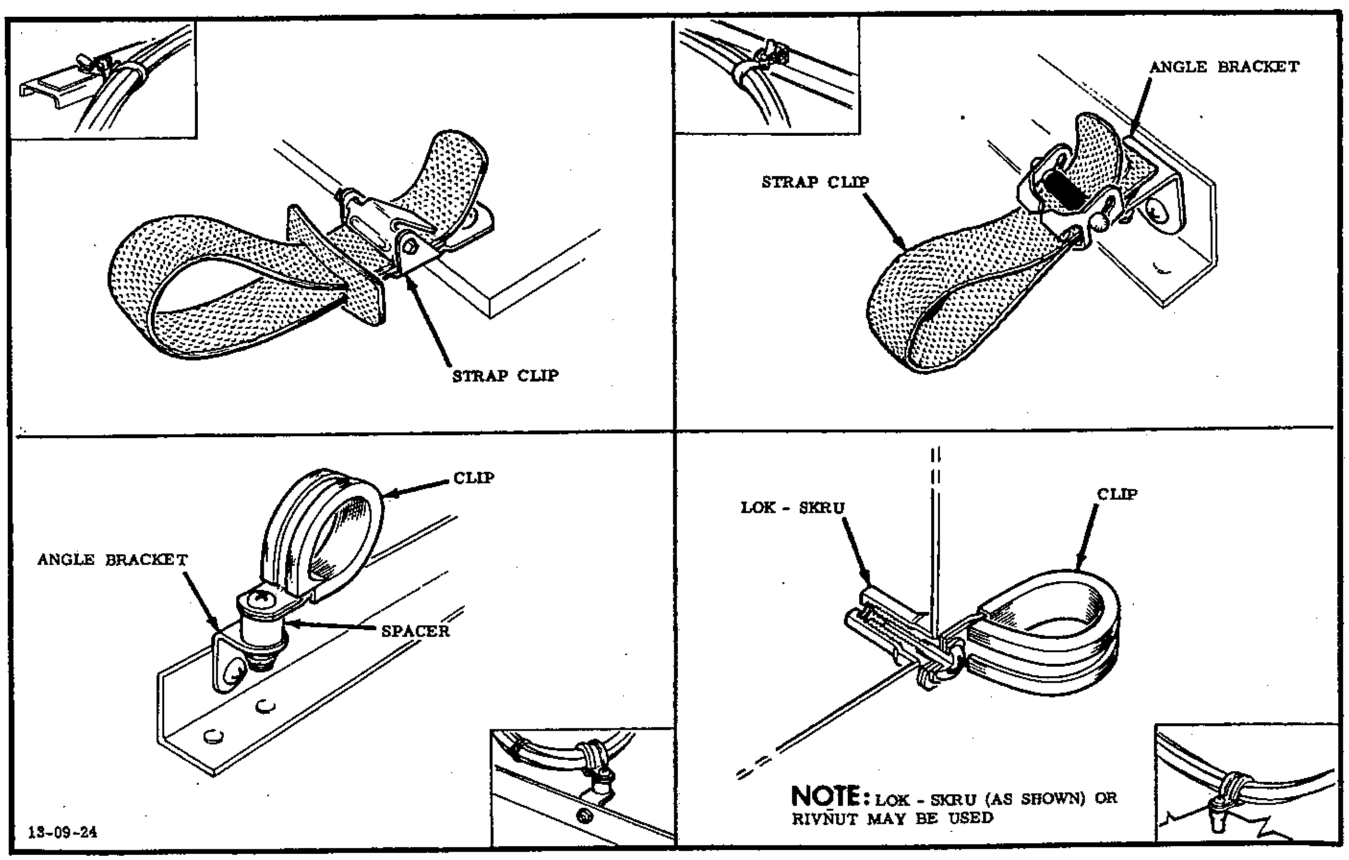


Figure 9-23 Clip Mountings

(d) Twisted wires or multiple cables

(e) Wires with special insulation

(f) Antenna leads or connections

(g) Wires larger than No. 10.

63 To splice wires, proceed as follows: (See Figure 9-25.)

(a) Locate splices so that they will not be in clipping, tying or wrapping areas. Make splices away from clamp or other wire support locations. Do not locate where wire is subject to flexing.

(b) Do not use more than two splices in one wire in any eight foot length. Do not allow splicing to change normal routing.

(c) Stagger splices in wire bundles or tie as shown to prevent relative movement and excessive increase in bundle size.

(d) Splices may be made before wires are installed only if installation will be accomplished without pulling the wire through conduit or a small aperture.

(e) To make splices, select proper connector (Item 36) for the given wire size from Figure 9-3. Plastic tubing sizes are larger for splicing connectors than for terminals. Select tubing for the connector which affords a snug fit. Assemble as shown.

(f) Install plastic tubing (Item 8) over completed splices and tie securely with waxed cord as shown.

SEALING OF ELECTRICAL CONNECTORS (POTTING)

General

64 Sealing is carried out to protect electrical connections against attack by moisture, fuels, oils, fungus and salt air.

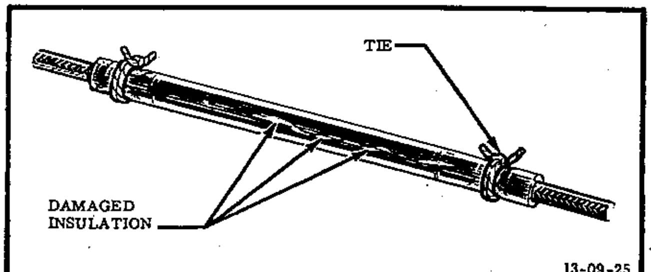


Figure 9-24
Primary Insulation Damage Repair

Preparation of Parts

65 The surfaces of the connectors to be protected with sealer must be free from oil, grease, dirt, etc. Refer to Part 20, following. Clean surfaces by wiping with a clean, lintless, cotton cloth dampened with naphtha (Item 45).

Preparation of Sealant

66 To prepare sealant proceed as follows:

(a) Slowly stir accelerator to a smooth, creamy paste.

(b) Agitate the sealer (Item 43), for at least two minutes by hand stirring.

(c) Weigh out the desired amount of sealer.

(d) Weight out 12 parts of accelerator for each 100 parts of sealer used.

(e) Add the required quantity of accelerator to the base material and thoroughly agitate until no accelerator streaks or traces of unmixed sealer are visible. This usually requires approximately five minutes. The sealer must assume a uniform pink or tan colour.

(f) To ensure that material is adequately mixed, spread a thin film on white paper and examine closely for accelerator or sealer streaks.

(g) The working life of the accelerated sealer is approximately 90 minutes at 75°F to 80°F. Longer working life may be obtained by cooling the sealer to 40°F to 60°F just prior to addition of accelerator.

(h) The accelerated sealer may also be stored, for periods of from 24 to 36 hours, by cooling quickly immediately after acceleration and keeping at a temperature of -20°F.

(j) After storing at low temperature, the accelerated sealer may be thawed out by blowing compressed air on the outside of the container. Do not raise the temperature of the sealer by heating or by blowing air into the container.

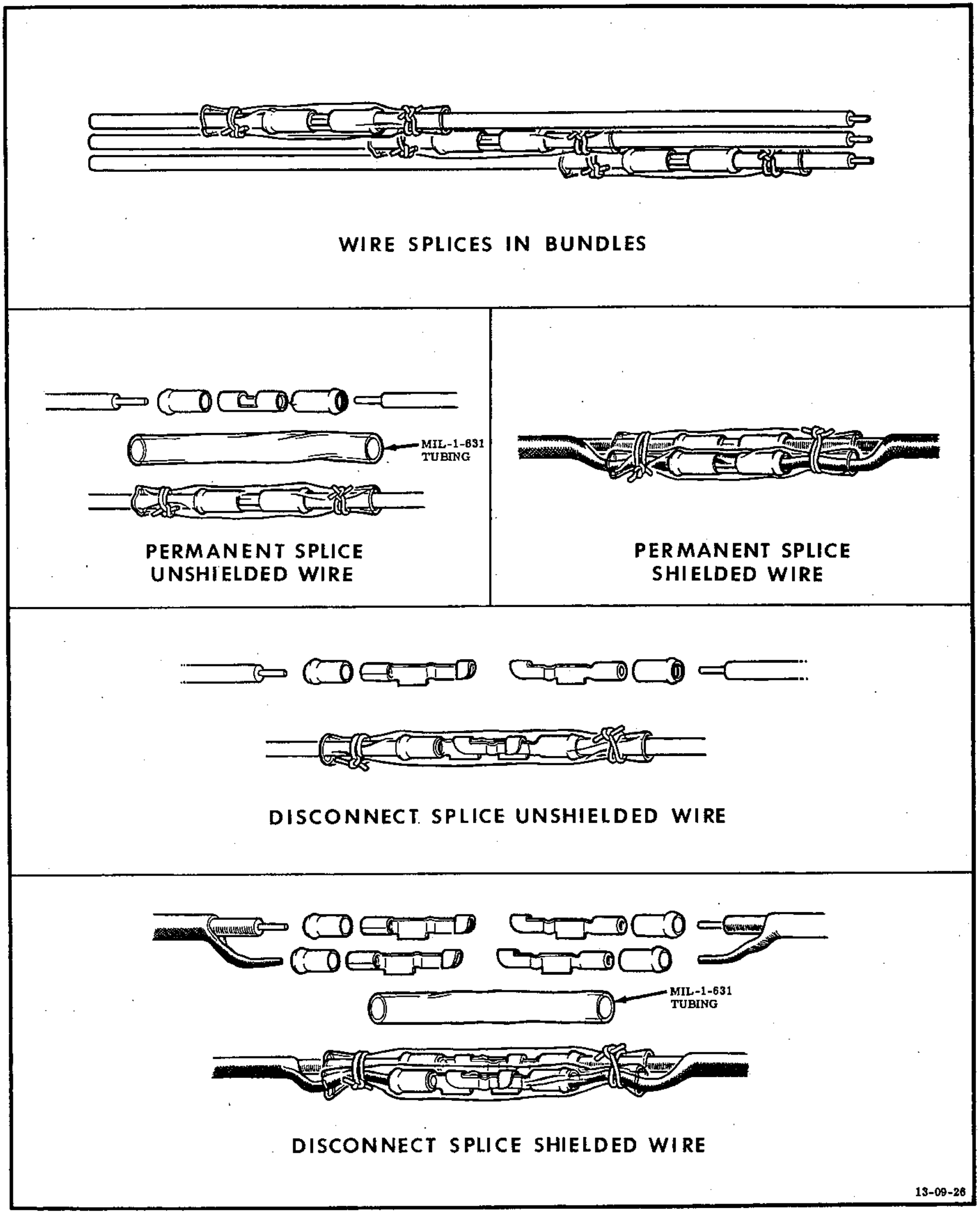


Figure 9-25 Wire Splicing

Application Procedure

67 Apply the properly mixed, accelerated sealer to the connector shell with a spatula, putty knife or flow gun. A flow tip small enough to reach soldered wire connections at base of plug is recommended. Apply the accelerated sealer so that no large entrapped air bubbles remain which result in loss of strength and electrical properties. The sealing of the connectors must protect the electrical wiring connections completely, as shown in Figure 9-26.

Curing of Sealer

68 Cure the accelerated sealer for at least 24 hours at 75° to 80°F before the connectors are installed in the electrical system. The curing time will be shortened if temperatures are higher and will be lengthened if temperatures are lower.

NOTE

Remove excess sealer from equipment before it cures, using toluene (Item 46) or methyl ethyl ketone (Item 47).

69 Where a finish, such as primer or lacquer, has been removed during stripping, refinish the area around the new sealant with the same finish as was used originally.

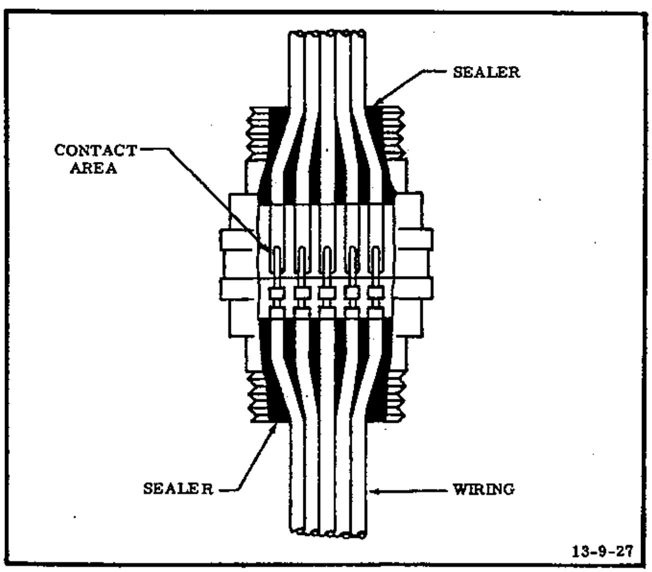


Figure 9-26 Sealing of Connectors

Removal of Sealant

70 For the removal of sealant use the following procedure:

(a) Cut away as much of the sealant as possible around the repair area, using a sharp micarta scraper. Sealant remover tools may be used in a slow-hitting rivet gun or corner hammer to facilitate initial removal of the sealant. Do not use a tool made of metal. Take care not to scratch the surrounding metal surfaces.

(b) Mask off the area surrounding the scraped sealant with fabric-backed masking tape (Item 49), and similarly mask any other areas where the ensuing application of stripper may splash or drip.

(c) Apply stripper (Item 48) to the scraped sealant as heavily as possible without running or dripping. A micarta scraper pushed under the sealant will accelerate the action of the stripper. Wipe off immediately any stripper which falls accidentally on unmasked surrounding areas with a clean dry cloth, and mark its position for cleaning later, (see Paragraph 71, following).

(d) At 10 minute intervals, remove the stripper and any loosened sealant with a micarta scraper, and apply a fresh quantity of stripper. Do not allow the stripper to dry out on the sealer. Repeat this cycle of operations until all the sealant has been removed. If there is any finish, such as primer or lacquer, under the sealant, continue stripping to bare metal.

(e) Remove all masking tape.

(f) Roughen all surfaces of the original sealant adjacent to the stripped area over at least one inch of their length, using a micarta scraper or clean hardwood. Take care not to scratch the surrounding metal surfaces.

(g) If there are structural or other repairs besides the sealant repairs to be made, incorporate at this point.

CAUTION

Rubber gloves must be worn at all times and a heavy pair is mandatory when using stripper. Keep stripper in an air-tight container and store in a cool dry place when not in use.

Cleaning Prior to Resealing

71 Proceed as follows:

(a) Remove all dirt and foreign matter which may have accumulated during stripping operations and other structural repairs.

(b) Scrub the stripped area and surroundings with a clean cloth dampened with methylene chloride (Item 50). Apply the cloth to only a small area at a time and change the cloth frequently. Make sure that all wax residue from the stripper (Item 48) is removed completely, including any surfaces from which splashes or drips have been wiped.

(c) Wipe down the areas in Sub-paragraph (b) thoroughly with a clean cloth dampened with butyl acetate (Item 51). Apply the cloth to only a small area at a time, and wipe off with a clean dry cloth before the butyl acetate dries. Change both cloths frequently.

(d) Wipe the whole area under repair with a clean dry cloth.

CAUTION

Rubber gloves must be worn at all times.

BONDING

General

72 Bonding is used on aircraft to provide current paths, to eliminate danger of arcing or sparking, to eliminate radio static disturbances which originate from vibrating parts and to prevent insulated parts from absorbing energy emitted by the radio transmitter. Attaching parts must be firmly seated and secured to ensure permanent electrical contact. Finishes must frequently be removed, dissimilar metal contacts must be protected against corrosion and other considerations are necessary which directly affect the life and performance of the bond.

Types of Finish

73 Certain finishes are suitable for bonding contacts in that they satisfactorily conduct an electric current. However, non-conductive finishes and surface treatments, such as paint, stain, dye, graphite in lacquer base and anodized oxide and phosphate surface treatments must be removed from the areas in which a bonding contact is to be made.

Bonding Procedure

74 To bond, proceed as follows:

(a) Remove all paint coatings and non-conductive chemical treatments in the area only in which the bonding contact is to be made. Where the use of star-tooth washers is specified do not remove the paint coating or chemical treatment.

(b) Remove all foreign matter, such as oil, grease, tarnish and dirt, from the contacting surfaces just before making the bonding connection.

(c) Install all clamps, screws, rivets, bolts, washers, jumpers, etc. Ensure that they are firmly seated and secured to make good contact. When a star-tooth washer is used, exercise all possible care to prevent it from turning while the nut is tightened.

(d) Touch up the assembled bonding connection or attachment and all areas outside the bonding area from which protective coating has been removed and where bare metal is exposed.

NOTE

Unless otherwise authorized, do not use bonding jumpers under structural fasteners, because the soft bonding strip lug is crushed during application of normal torque to the fastening device. Creep of the lug material, either at rest or under repeated loads, causes the fastener to lose its initial tension and become loose.

Detail Instructions

75 Remove paint coatings, dyes or stains by means of ethyl acetate (Item 9) on a cloth or with a steel wire brush or sandpaper. Remove oil and dirt with a cloth dampened in cleaner (Item 25). Use the following precautions:

(a) In using ethyl acetate or cleaner, exercise extreme care to see that none of the liquid reaches adjacent surfaces, seams or cracks. Use masking tape, if necessary, to protect areas from which finish is not to be removed.

(b) Use only brushes made of corrosion-resistant steel wire of .005 to .006 inch maximum diameter. Remove only a minimum of the metal surface, especially in the case of clad aluminum alloys. Avoid grinding a concave surface which will fail to make intimate contact when assembled.

(c) Use sandpaper (Item 38) and hand rub the surface. Do not use any mechanical method.

76 When using washers in electrical connections, select the washers with the finish specified for the particular materials involved. When a star-tooth washer is used in contact with magnesium alloy surfaces, dip the washer in wet zinc chromate primer before assembly. Install and tighten the attaching parts before the primer is dry.

77 The following finishes and surface conditions are satisfactory for bonding connections and need not be further stripped or removed:

(a) Bare metal surfaces.

(b) Cadmium, chromium, copper, solder, tin or zinc plating.

(c) Dow No. 1 (Chrome Pickle) Treatment on magnesium alloy.

(d) Dow No. 7 (Dichromate) Treatment on magnesium alloy.

(e) Graphite (powder, flake or stock).

78 After installation, touch up the entire bonding connection or attachment and all areas outside the bonding area from which protective coating has been removed, by the following methods:

(a) Aluminum alloys: Touch up exposed areas with weak chromic acid solution, and finish the entire bonding connection and exposed areas with a brush or heavy spray coat of zinc chromate primer. (Refer to Part 23, following.)

(b) Magnesium alloys and unplated steel: Touch up entire bonding connection and exposed areas with a brush or heavy spray coat of zinc chromate primer. (Refer to Part 23, following.)

(c) Apply a final coat of lacquer or enamel where necessary to match adjoining areas.

79 Check each bonding connection or attachment to ensure that:

(a) The correct cleaning procedure has been followed.

(b) The correct sequence of attachable parts has been followed.

(c) The connection is mechanically secure and firmly seated.

(d) The protective organic finish has been applied correctly.

Grounding Coaxial Cable

80 For grounding the outer conductor for RG59U coaxial cable when terminating in a plug or receptacle, use the following procedure:

(a) Strip the outer insulation from the cable, avoiding such damage as nicks, scratches and broken strands in the outer conductor.

(b) Comb the outer conductor, divide it into three equal and parallel groups, and braid the groups into a single pigtail.

(c) Tin the end of the braid (at least one inch distant from the cable) and splice to a length of single conductor copper wire (Item 44) at least one inch of which must be pliable after all soldering operations. Overwrap with 24 gauge copper or brass wire for a distance of 3/8 (±1/8 inch) and sweat and braid the wire and overwrap together. The overwrapping operation may be omitted when the braided pigtail is inserted into another braid.

(d) Install the proper diameter transparent plastic (Item 8) tubing for the full length of the grounding pigtail.

(e) Solder into the pot of plug or receptacle, (refer to Part 20, following).

(f) Serve the wire bundle with linen thread (Item 14) and apply a medium coat of varnish (Item 26) or lacquer (Item 27). Start serving as close to the number bands as possible without covering the numbers.

(g) Attach terminal of ground wires or shielding grounds to a suitable grounding screw.

Cannon Bonding Rings

81 Use bonding rings only when specified on the engineering drawing.

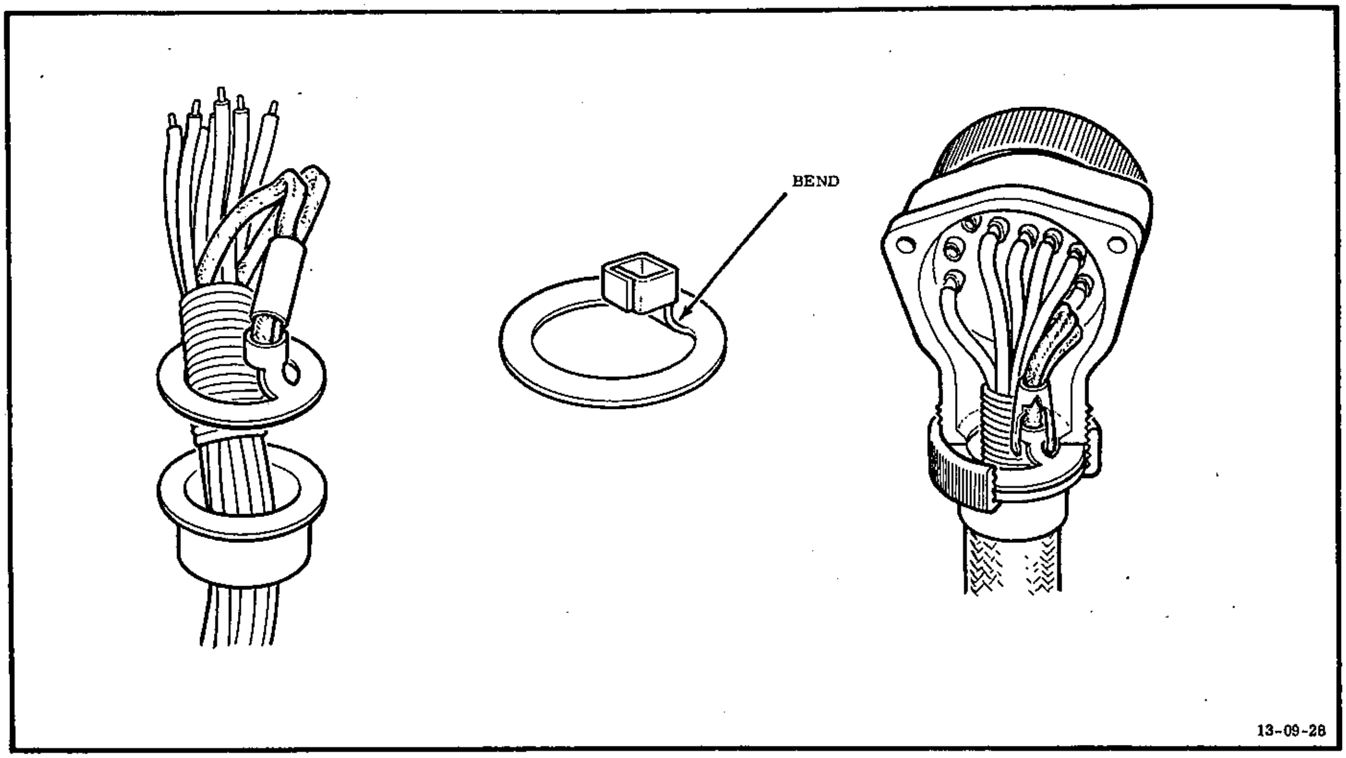


Figure 9-27 Cannon Bonding Ring Installation

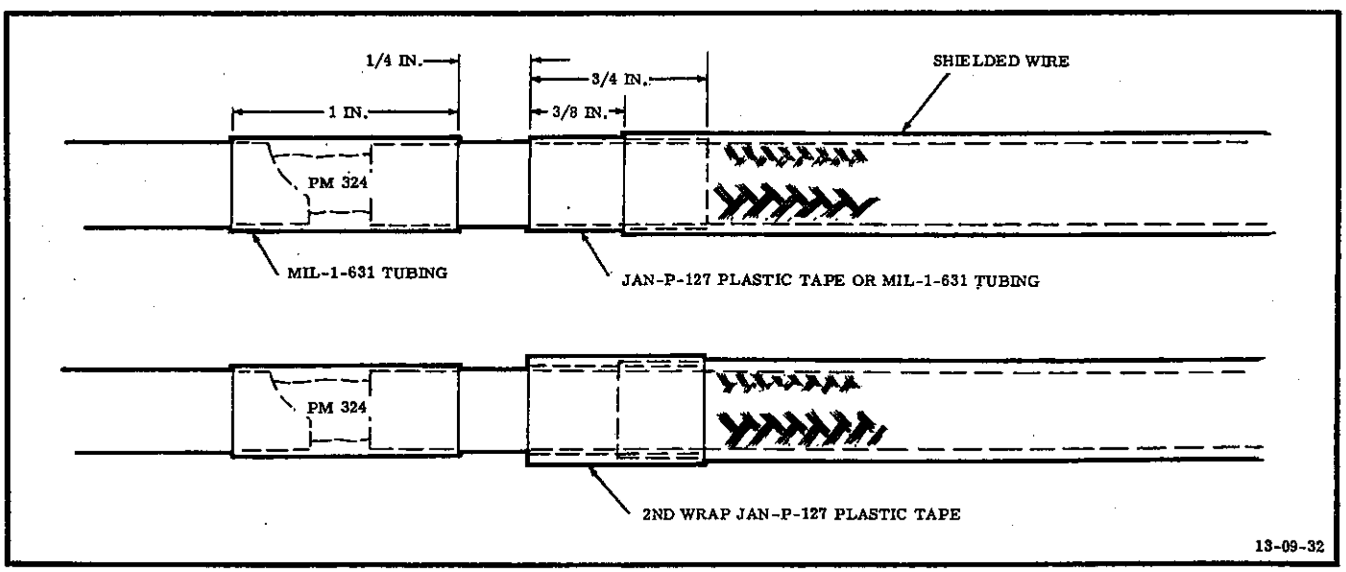


Figure 9-28 Taping Shielded Wires

(a) Separate wire shielding from wire to form a pigtail as described in Paragraph 80, preceding.

(b) Install a short length of plastic tubing (Item 8) over the pigtail or pigtails to prevent any stray wires of the shielding braid from rupturing the insulation of other wires and causing a short-circuit.

(c) Bend tongue of bonding ring into position for attaching pigtails as shown in Figure 9-27. Dotted portion indicates how legs of tongue are bent around pigtails before soldering. All excess lengths of tongue may be cut away.

(d) Serve wires and shielding with linen thread (Item 14) and apply one coat of varnish (Item 26) or lacquer (Item 27).

(e) Assemble as shown in Figure 9-27. Soft solder the tongue and pigtails.

(f) Slip plastic tube (Item 8) over soldered joint and tighten flexible conduit nut to complete assembly. During assembly, do not allow the ring to turn in relationship to the plug. Cutaway of 90° Type K Connector is shown as finished assembly in Figure 9-27.

GROUNDING WIRES AND SHIELDING

General

82 Ground the shielding on shielded wires at each end unless otherwise specified on the engineering drawing. Where drawings specify grounding on one end of the shielding only, finish the other end by wrap or tape method.

Wrap Method

83 For wrap method (for two conductors and over) proceed as follows:

(a) Undo the shielding and fold back to give an overlap of 1/4 to 3/4 inch.

(b) Secure the end by serving with linen thread (Item 14) and apply one coat of varnish (Item 26) or lacquer (Item 27).

Tape Method

84 For tape method proceed as follows:

(a) Install a one inch length of plastic tubing over soldered joint to give a snug fit. This procedure provides additional support for the soldered joint. (See Figure 9-28.)

(b) Pull shielding back from soldered joint and apply 1-1/2 to 2 turns of 3/4 inch plastic tape (Item 39) or tubing (Item 8) beginning 1/4 inch from the end of the identification sleeve.

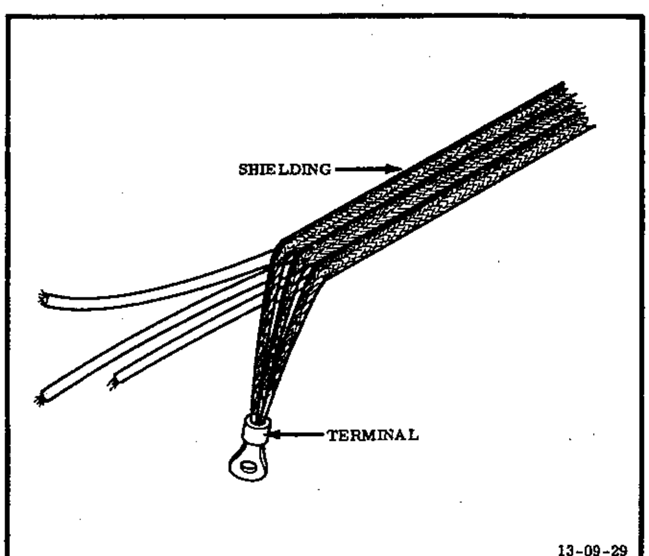


Figure 9-29 Shielded Wire Soldering

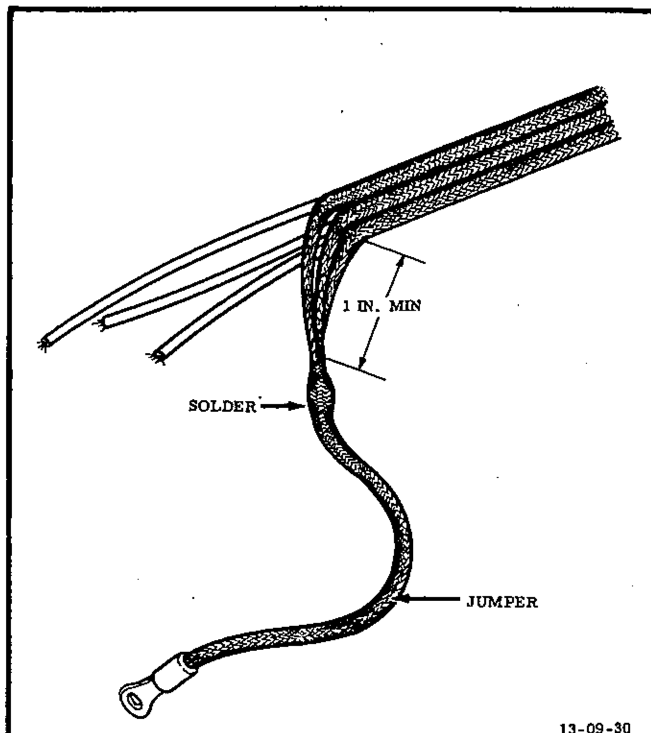


Figure 9-30 Shielded Wire Soldering

(c) Pull shielding forward so that the shielding end lies at the centre of the tape without any residual tendency to move forward or aft.

(d) Overwrap the shielding positioned on the tape or tubing with a second wrap of plastic tape consisting of 1-1/2 to 2 turns. In the case of multiple shielded wires, overwrap together all shielded wires with a second wrap of plastic tape (1-1/2 to 2 turns).

(e) Ground wires or pigtails are to be as short as possible and are not to be over four inches in length.

(f) Install plastic tubing over the pigtail or jumper to prevent short-circuits with other equipment when inside junction boxes or at terminal strips.

Grounding Shielded Wires

85 Form pigtail as follows:

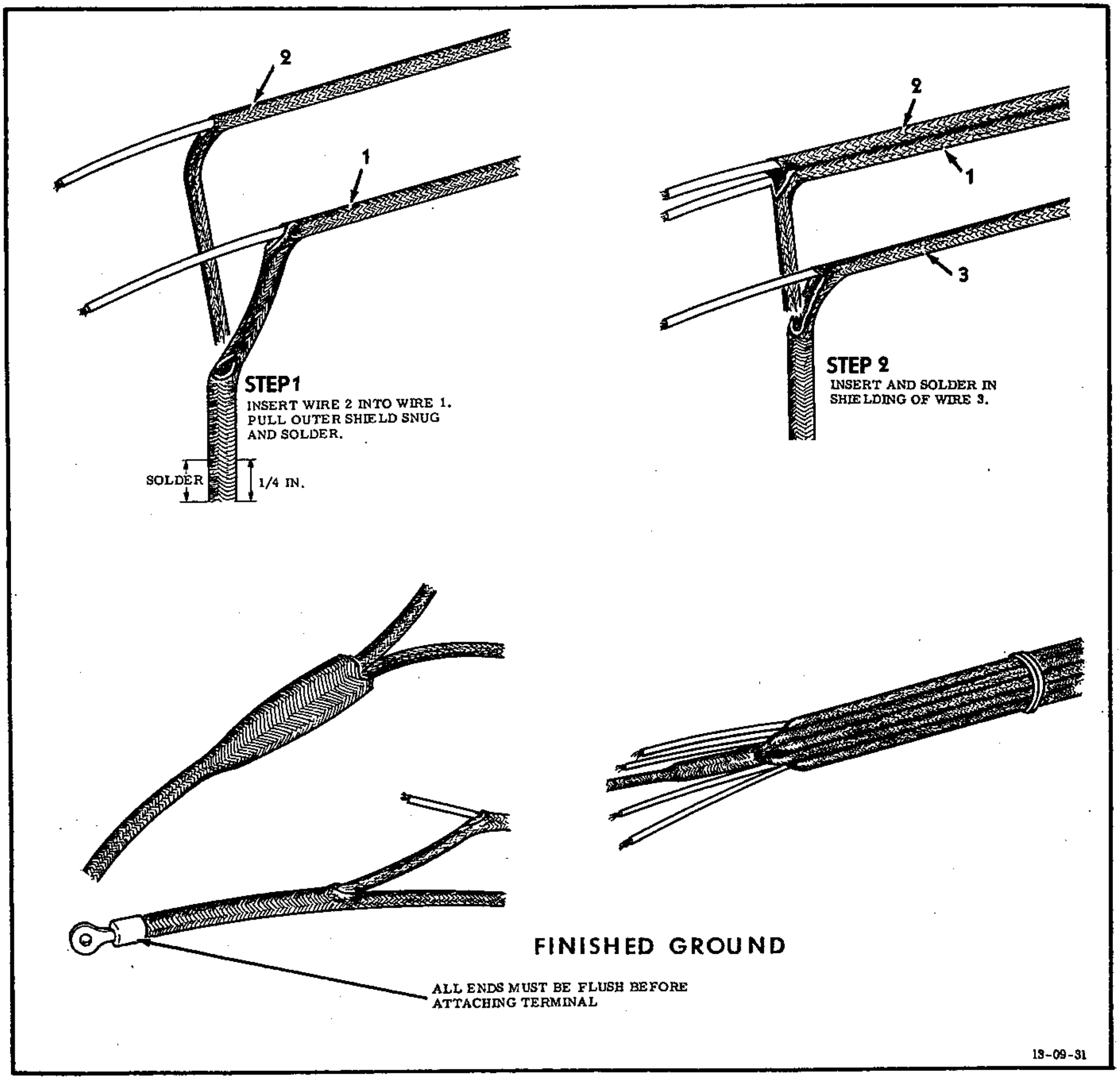


Figure 9-31 Multiple Shielding Grounds

(a) Approximately three inches from the end of the wire, insert a scriber into the shielding without damaging the strands.

(b) Work an open circular area into the shielding without damaging the strands.

(c) Insert scriber between shielding and wire and pull wire through circular area previously formed. The shielding can be loosened or puffed by working the shielding and thus facilitating withdrawal of the wire.

86 Use one of the following methods when two or more shields are grounded to the same point.

(a) Bring pigtails individually into a terminal and attach by approved staking or soldering methods, (see Figure 9-29).

(b) Solder short pigtails into a longer one, (see Figure 9-30).

(c) Loosen or puff up one pigtail and draw others through it as shown in Figure 9-31. Attach terminal by approved staking or soldering methods.

(d) Loosen or puff up shielding inserting the second into the first and soldering as shown in Figure 9-31. If necessary, repeat the process, soldering as illustrated. If shielding is to be staked, omit the soldering operation.

(e) Ground shielding at a soldering cup by forming a pigtail by one of the approved methods and solder into cup.

Grounding and Assembly of Plessy Plugs

87 Use the following method of grounding shielded wires when used in a British Plessey plug: (See Figure 9-32.)

(a) Separate wire shielding from wire to form a pigtail, (refer to Paragraph 80, preceding).

(b) Install unstamped plastic tubing over each soldered connection. Plastic tubing to extend approximately 1/8 inch over wire insulation.

(c) With bonding ring (3) positioned against plug body (2), wrap pigtails to bonding ring and soft solder in place.

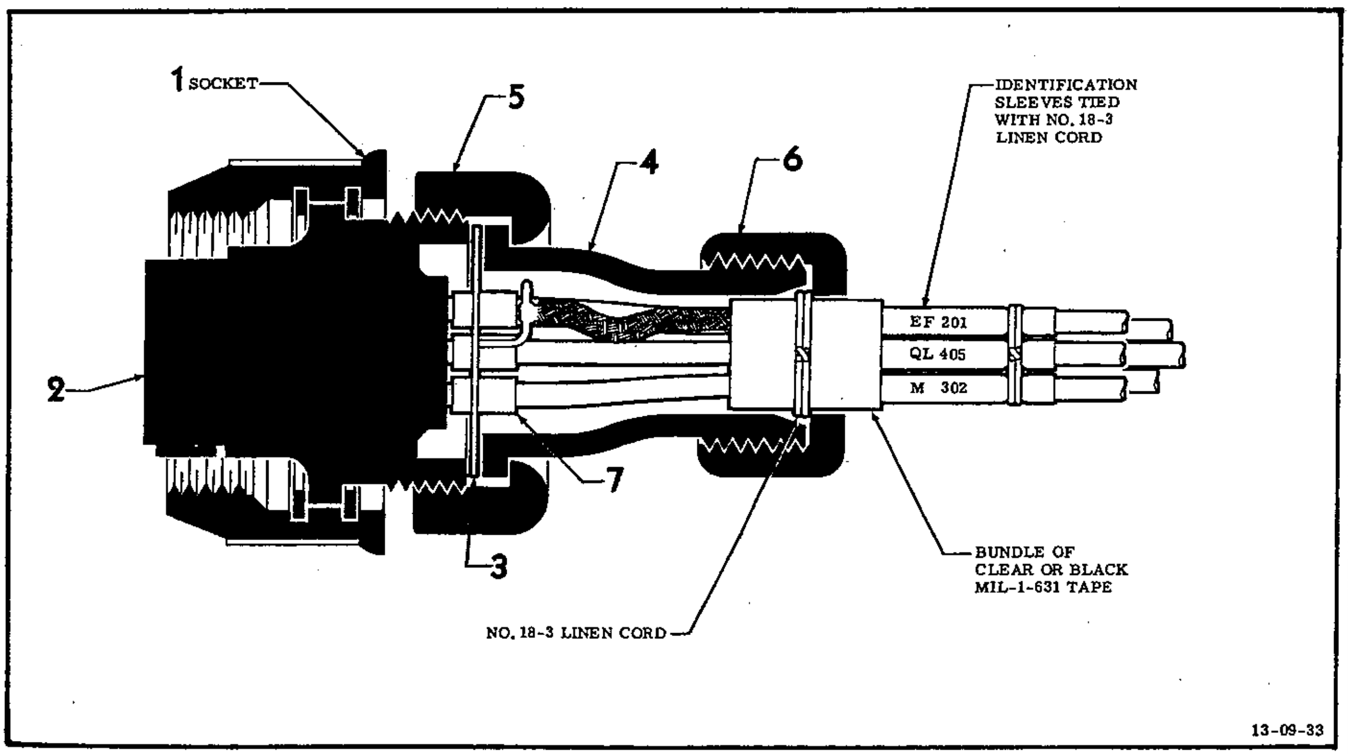


Figure 9-32 Plessy Plug Assembly

(d) Wrap clear or black tape .020 inch thick around wire bundle, building up the bundle to the necessary thickness. Tie with prewaxed cotton cord over the tape so that the strain on the wiring will be against the cord rather than the connectors. Tape must extend beyond outlet nut (6) as shown.

(e) Slip outlet (4) in position, then tighten union nut (5) and outlet nut (6).

(f) Add identification tubing outside the plug assembly as shown. Tie identification tubing together at one end with linen thread, (Item 14).

Material Specifications

88 For the table showing the item numbers, specifications and manufacturers, see Figure 9-33.

Item No.	Material	RCAF Ref	Specification	Manufacturer
1	Clip	5K/	MIL-C-8603	
2	Clamp, Cable	5K/	MIL-C-8603	
3	Clip, Positive locking, Cushioned Type MS2191C	28/	MIL-C-8603	
4	Cord, Lacing or Tying		MIL-C-2520	
5	Talc	33C/11	MAT-2-1	
6	Clamp	28/	MIL-C-8603	
7	Terminal, Copper, AN659	5K/	MIL-T-5042	
8	Tubing, Plastic	5K/	MIL-I-631	
9	Ethyl Acetate	33C/299	C-31-302	
10	Terminal, Preformed	5K/		
11	Terminal, Flag	5K/184, 223		
12	Solder, Resin Core		QQ-S-571 Comp Sn50	
13	Terminal, Eyelet	5K/		
14	Thread, Linen	32B/408	3-F-34	
15	Lacquer		MIL-L-7178	Canadian Ind. Ltd. P.O. Box 10, Montreal
16	Ferrule, AN3083	5K/		
17	Tape, Plastic		JAN-P-127	

Figure 9-33 (Sheet 1 of 3) Table of Material Specifications

Item No.	Material	RCAF Ref	Specification	Manufacturer
18	Nut, Cadmium Plate Steel	28/		
19	Strip, Insulating Base, AN3437	5F/		
20	Strip, Terminal, AN3436	5CC/		
21	Strip, Insulating, AN3434	5F/		
22	Solder, Silver			
23	Wood, Plastic	33A/458		Canadian Industries Ltd., P.O.Box 10 Montreal
24	Flux, Soldering, Paste			Canada Metal Co. 721 Eastern Ave., Toronto
25	Cleaner	33C/182	3-GP-8	
26	Varnish, Glyptal	33G/144	1-GP-20	Canadian General Electric, 212 King St. W. Toronto
27	Lacquer, Clear Cellulose Nitrate	33A/420	1-GP-31	
28	Compound, Insulating	33G/49	MIL-I-8660	Fibreglas Can. Ltd. 50 St. Clair Ave., Toronto
29	Compound, Anti-seize	34Z/164	3-GP-801	
30	Sleeve, Numbered, Metallic		AAF650	
31	Sleeving, Stamped, Silicone GLA33			
32	Lock-Washer, Split, AN935	28/		
33	Tape, Glass	33G/158	MIL-T-4053A	
34	Coating, Clear Silicone Resin	33A/487		
35	Tape	33G/137	JCNAAF-T-14	
36	Connector, Splice, AN753	5K/275 etc.	MIL-S-6852	
37	Cord, Tying, Varglass No.46			
38	Paper, Abrasive, Waterproof	29/1869, 1870		

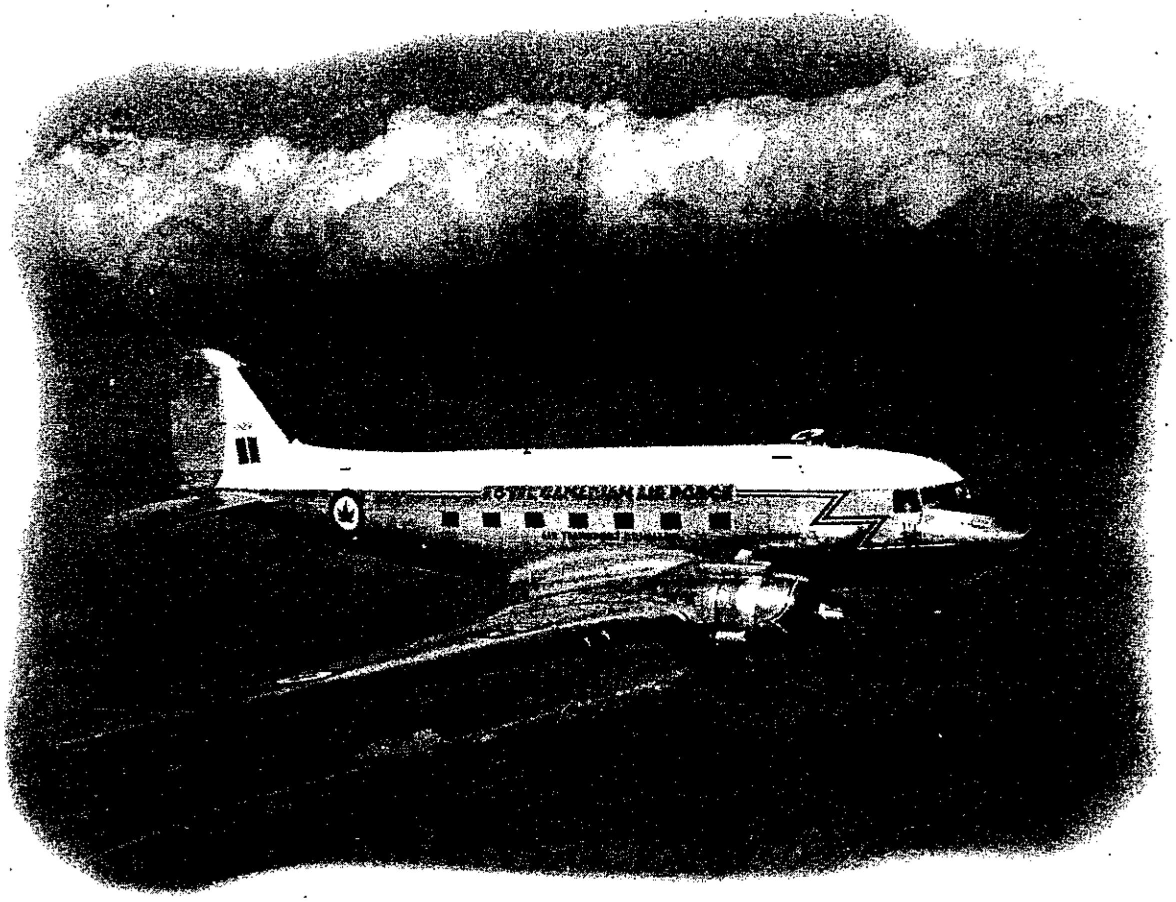
Figure 9-33 (Sheet 2 of 3) Table of Material Specifications

Item No.	Material	RCAF Ref	Specification	Manufacturer
39	Tape, Plastic	32/E	JCNAAF-I-7	
40	Bracket, Angle, AN743			
41	Plastic, Sheet		MIL-I-631	
42	Alcohol, Non-corrosive Solvent	34A/214	3-GP-525	
43	Compound, Sealing, EC-1120-PC	33G/163	MIL-S-8516A	Minnesota Mining and Mfg. Co., London, Ontario
44	Wire, Copper, 24 Gauge	5E/		
45	Naphtha, Aliphatic	33C/653	TT-N-95	
46	Toluene	22A/467	TT-T-548	
47	Methyl Ethyl Ketone	33C/520	TT-M-261	
48	Stripper	33C/584	LAR 388	B. W. Deane & Co. Ltd. 3620 Namur St., Montreal
49	Tape, Masking, Fabric Backed	32B/282	AN-T-12	Bauer & Black, Curity Ave., Toronto
50	Methylene Chloride	33C/583	MIL-M-6998	
51	Butyl Acetate			Commercial Product

Figure 9-33 (Sheet 3 of 3) Table of Material Specifications

PART 10

CABLE SWAGING AND SPLICING



PART 10

CABLE SWAGING AND SPLICING

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LIST OF ILLUSTRATIONS

PART 10

CABLE SWAGING AND SPLICING

CABLE SWAGING AND SPLICING

General

1 Control cables are mainly of extra-flexible, preformed, corrosion-resistant steel. Tinned steel cable is also used interchangeably. Preformed cable (Item 7) has almost entirely replaced the earlier non-preformed type. Control cables vary from 1/16 to 3/8 inch in diameter. Cables of 1/8 inch and larger are composed of seven strands of nineteen wires each. Cables 1/16 and 3/32 inch in diameter are composed of seven strands of seven wires each.

Inspection of Cables

2 Tests have shown that control cables may have broken wires and still be capable of carrying the design load of the cable. Watch for frayed cables at each regular inspection period. Inspect cables for broken wires by passing a cloth along the length of the cable. Broken wires will be indicated where the cloth is snagged. Replace any 7 x 19 cable that shows more than six wires broken in any one inch length, (see Figure 10-1) or any 7 x 7 cable that shows more than three wires broken in any one inch length. Watch particularly for breakages occurring in that length of a cable normally passing over a pulley or through a fairlead. Pay particular attention to inspection for corroded or badly worn cable. If corroded, badly worn or kinked, replace the cable even though the number of broken wires is less than that specified for replacement. Because of the number of wires in 7 x 19 cables (133) and in 7 x 7 cables (49), their failure is never abrupt but is progressive over periods of extended use. Some broken wires show up soon after placing the cable in service, probably due to being under greater tension or being much harder than the rest. After these overstressed or overhard wires have broken, few additional broken wires will be encountered in normal service for considerable time. Tests show that the loss in cable strength due to broken wires depends upon their concentration at any point rather than on the total number in the cable.

Cable Replacement

3 Wherever possible, use duplicate spare cables for replacements. If spare replacement cables are not available, fabricate replacements from preformed cables (Item 7) and swaged terminals (Item 8). If this is not possible and immediate replacement is imperative, prepare replacements using thimbles (Item 9), bushings (Item 10) and turnbuckles (Item 11) in place of original terminals. (See Figure 10-2.) When this is done, cables having a diameter of 3/32 inch or over may be woven spliced by means of the five-tuck

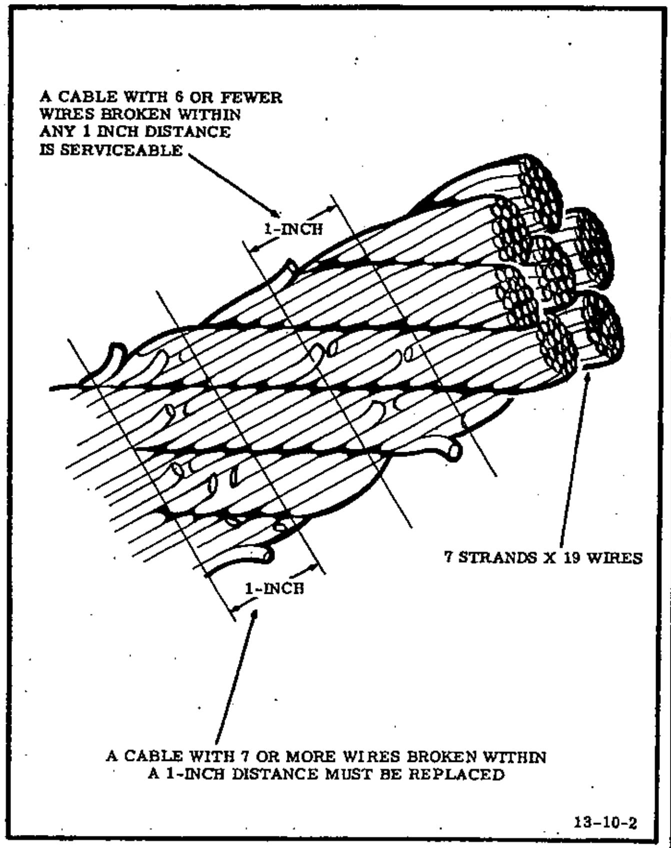


Figure 10-1 Cable with Broken Wires

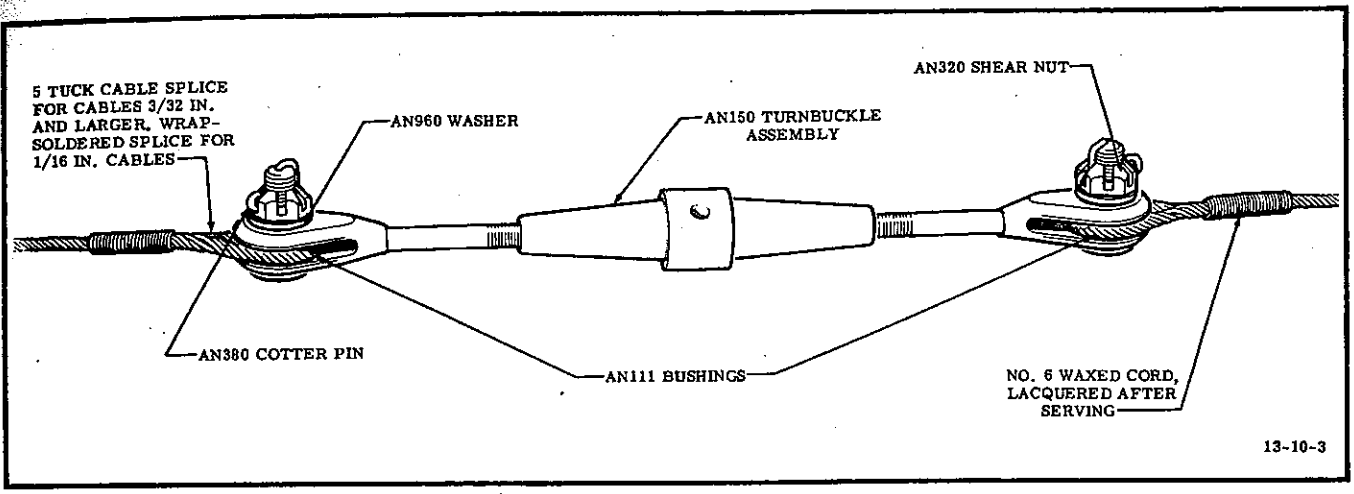


Figure 10-2 Turnbuckle and Splice

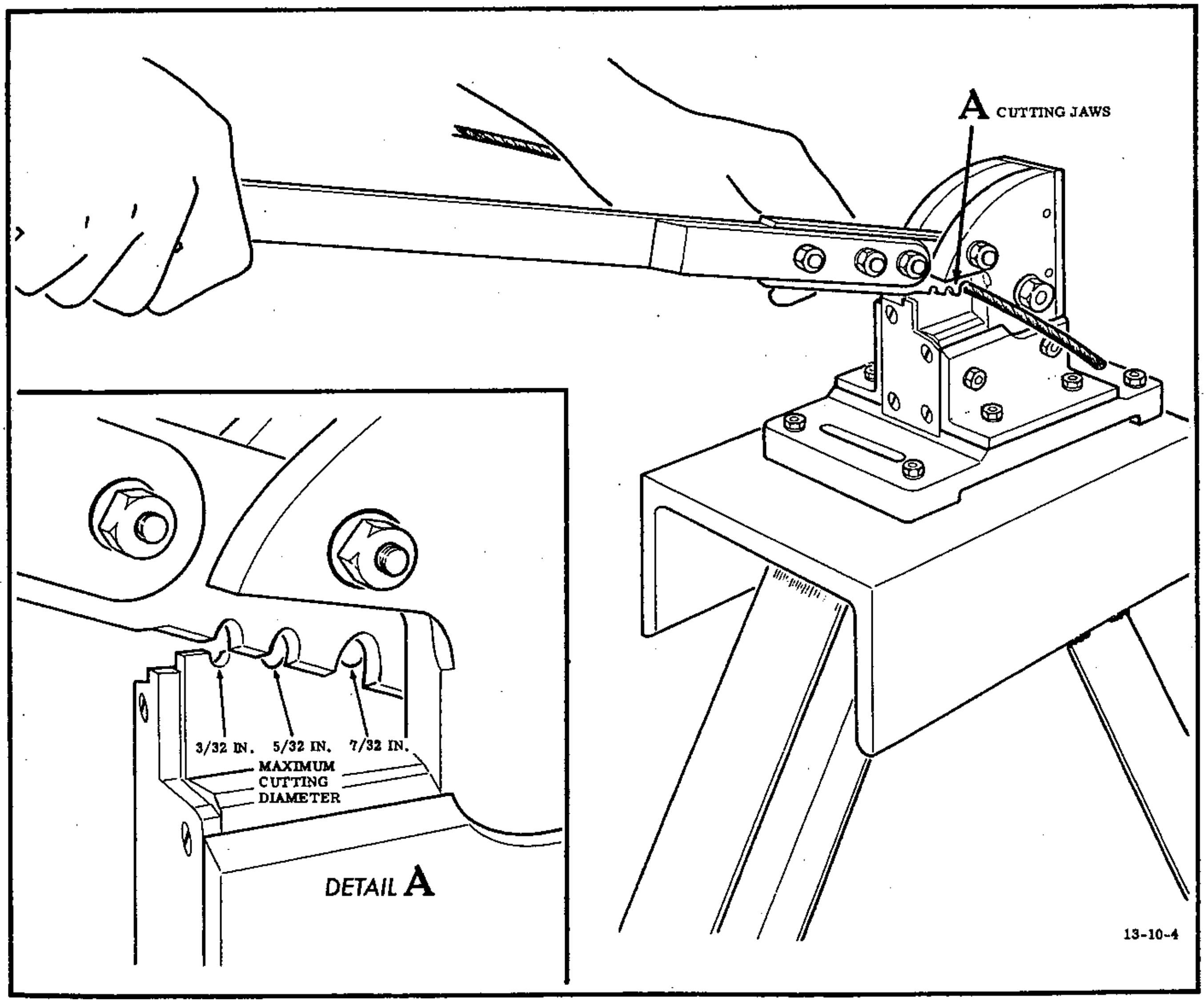


Figure 10-3 Cable Cutting Machine

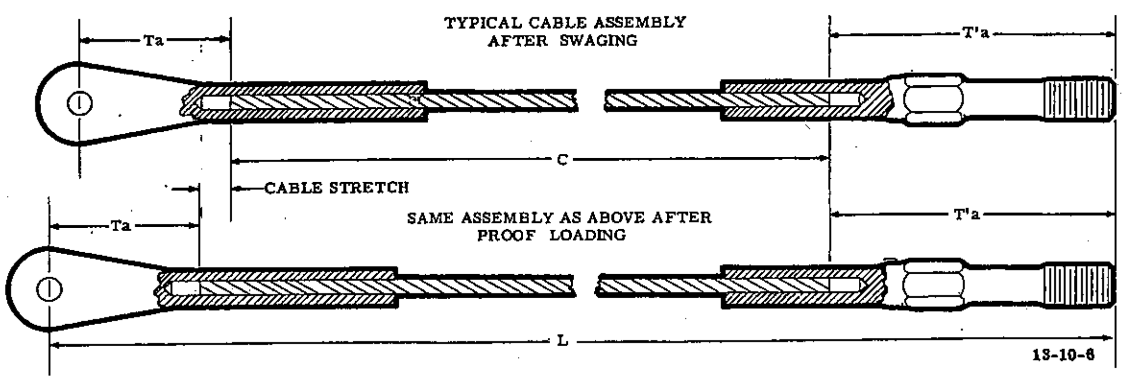
method, and cables less than 3/32 inch in diameter may be wrap soldered or sweat soldered.

Cutting Cables

4 Cut cables by any method, except a torch, depending upon the tools and machines available. If a cable tends to unravel or fray when cut, sweat solder (Item 1) or wrap a strip of masking tape (Item 2), cellulose (Item 3), or friction tape (Item 4) over the cut so that half the soldered or taped width will remain on each end after cutting. Cut small diameter cables with a pair of heavy-duty diagonal cutters, side cutters, or with a pair of wire nippers. Best results are obtained if the cutting jaws are held perpendicular to the cable during the cutting operation. Cables up to 3/32 inch diameter may be cut in one operation by this method while larger cables will require two or more cuts. When cutting large diameter cables in this manner, use the end of the cutting blade and cut a few strands at a time. A cold chisel, used in conjunction with a soft metal block, may be used for cutting cables. Hold the chisel straight up and place the cutting blade at right angles to the cable. Use a heavy hammer and strike the chisel with a hard sharp blow to effect a clean, square cut. The most satisfactory method of cutting cables is with a cable-cutting machine having special jaws to accommodate cables of various diameters. (See Figure 10-3.) Position the cable in the proper diameter groove and hold the cable firmly within two inches of the cutting blades. Hold the cable at right angles to the cutting blades and pull the operating handle down sharply. Large cables (3/16 and 7/32 inch) should be cut with an abrasive cut-off wheel, if available.

Preparation of Cable and Terminal

5 Cut the cable (Item 7) to length according to formula (see Figure 10-4). Cable stretch must be found by trial, when proof loaded in accordance with Paragraphs 27, 28 and 29, following. Terminal allowance (Ta) is the difference between the length of the terminal after swaging and the amount of cable inserted into the terminal. For recommended terminal allowances, see Figure 10-5. Insert the cable



C - Length cable is cut (swaging does not change this length).

L - Length of cable assembly after swaging and proof loading. (Finished length required.)

Ta, T'a - Terminal allowances.

C - L - (Ta + T'a) - Cable Stretch.

C - L - (Terminal allowances) - Cable stretch.

Figure 10-4 Determination of Terminal Allowance into the terminal until it bottoms. (See Figure 10-6.)

NOTE

If the cable does not enter the hole to the point marked, examine the fitting to ensure that no foreign matter is present. If cleaning of the fitting fails to admit the cable to the full extent, reject the fitting. In terminals which are bored through, insert the cable so that the end is even with the end of the hole before swaging.

6 Mark the cut cable at a distance from the end equal to the proper depth of insertion, using red paint (Item 17) or red grease pencil (Item 18), to ensure that the terminal bore is filled and that no slippage takes place during swaging and proof loading. (See Figure 10-7.) Open-end type terminals (Item 8) do not require this marking.

7 Insert the cable approximately one inch into the terminal and then bend toward the terminal so that a bend or kink results at the point of insertion. This bend provides sufficient friction to hold the terminal in place until the swaging operation can be performed, and also tends to separate the strands of the cable inside the barrel, thereby reducing the strain on them. After kinking, push the cable the remaining distance into the barrel.

FABRICATION OF SWAGED ASSEMBLIES

General

8 For replacement use swaged terminals (Item 8) wherever practicable. After preparing the necessary cable length with allowance

Cable Size	1/16	3/32	1/8	5/32	3/16	7/32	1/4
AN669 (short)	1.7	1.8	1.9	2.0	2.1		
AN668	.65	.9	1.0	1.2	1.3	1.4	1.5
AN667	.5	.7	.9	.9	1.0	1.1	1.1
AN669 (long)	2.6	2.6	2.8	2.9	2.9	3.0	3.1
AN666	1.5	1.7	1.9	2.0	2.2	2.5	2.6

Figure 10-5 Table of Terminal Allowances

Dash No. of Terminal	Cable Diameter	Depth of Hole in Terminal
2	1/16	1-3/64
3	3/64	1-17/64
4	1/8	1-33/64
5	5/32	1-49/64
6	3/16	2-1/64
7	7/32	2-17/64
8	1/4	2-33/64
9	9/32	2-49/64
10	5/16	3-1/64
12	3/8	3-33/64

Figure 10-6 Table of Terminal Hole Depth

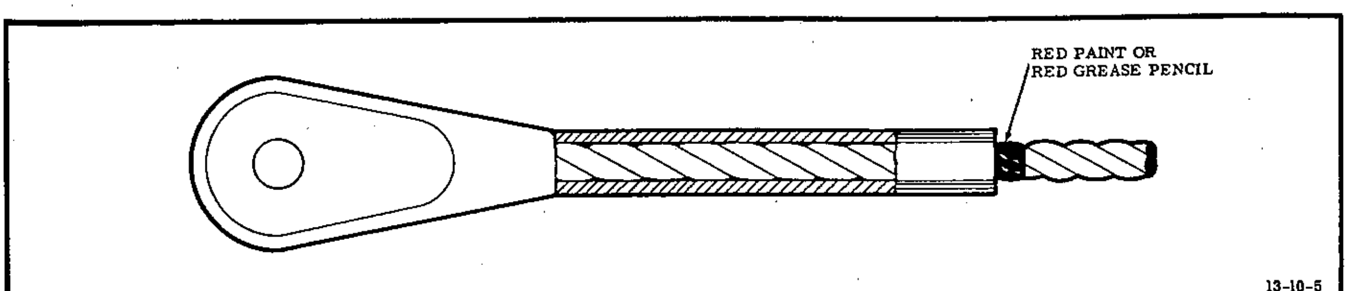


Figure 10-7 Preparation of Cable Before Swaging

made for the fitting elongation under swaging and proof loading, coat the end of the cable with lubricating oil, (Item 5).

NOTE

Swaging may be performed on preformed cable only.

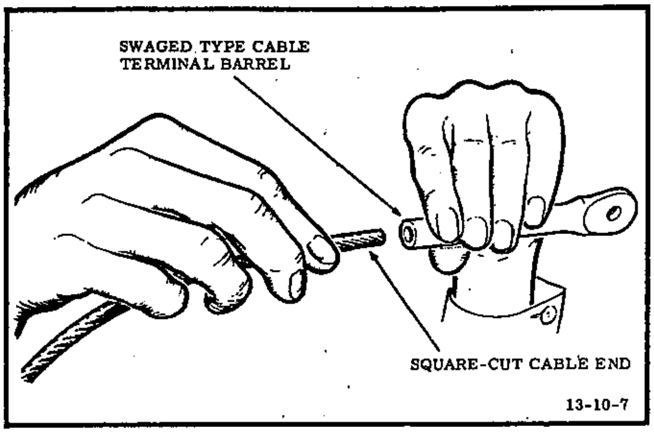


Figure 10-8 Inserting Cable in Terminal

Swaging Terminals

9 To swage the terminal onto the cable end, proceed as follows:

(a) Ascertain that all strands are clipped so the entire cable end will go inside the terminal barrel. (See Figure 10-8.)

(b) Insert cable into the terminal as instructed in Paragraph 7, preceding.

(c) Ascertain that the proper size swaging dies are in the swaging machine. (See Figure 10-9.)

(d) With a micrometer, check the terminal barrel diameter after swaging. (See Figure 10-10.) If, after swaging, the terminal has more than the allowable 1/2° bend, secure in a vise and straighten with as few applications of pressure as possible.

10 If swaged terminals are to be used on

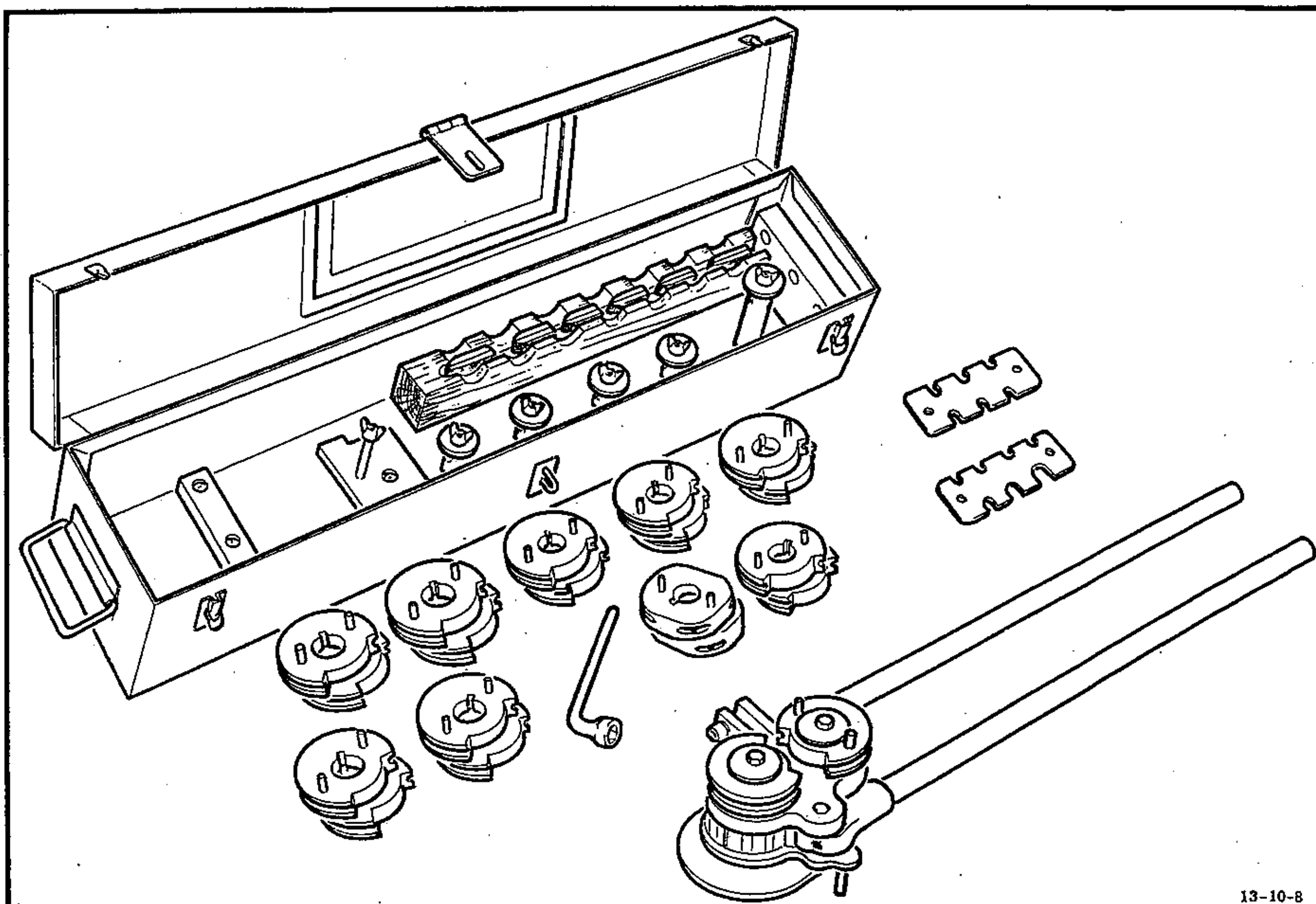


Figure 10-9 Hand Swaging Machine with Dies

Dash No. of Terminal	Diameter Cable	Barrel Diameter after Swaging
2	1/16	.138 +.000 -.005
3	3/32	.190 +.000 -.005
4	1/8	.219 +.000 -.005
5	5/32	.250 +.000 -.005
6	3/16	.313 +.000 -.005
7	7/32	.375 +.000 -.007
8	1/4	.438 +.000 -.007
9	9/32	.500 +.000 -.008
10	5/16	.563 +.000 -.008

Figure 10-10
Table of Swaged Terminal Diameters

both ends of the cable, perform the following operations prior to the second swaging:

(a) Measure the over-all cable length and trim the cable as required.

(b) Ensure that all additional fittings are slipped onto the cable in proper sequence.

(c) Slip the end of the cable through the swaging dies and swage the terminal.

TRU-LOC CABLE TERMINAL SWAGING MACHINE

General

11 This hand-operated machine applies pressure by a combined lever and cam acting through a pair of suitably shaped dies, the action being repeated at close intervals along the length of the cable terminal.

Layout of Machine

12 A sectional view of the swaging machine is shown in Figure 10-11. The steel frame has a recess, guarded by side plates, in its upper surface in which a cam is rocked by its operating lever. The forward end of the cam is cylindrically shaped to engage a concave recess in the rear die against which it exerts a horizontal, forward thrust when the operating lever is pressed. The reaction to this thrust is taken by a roller which is held against

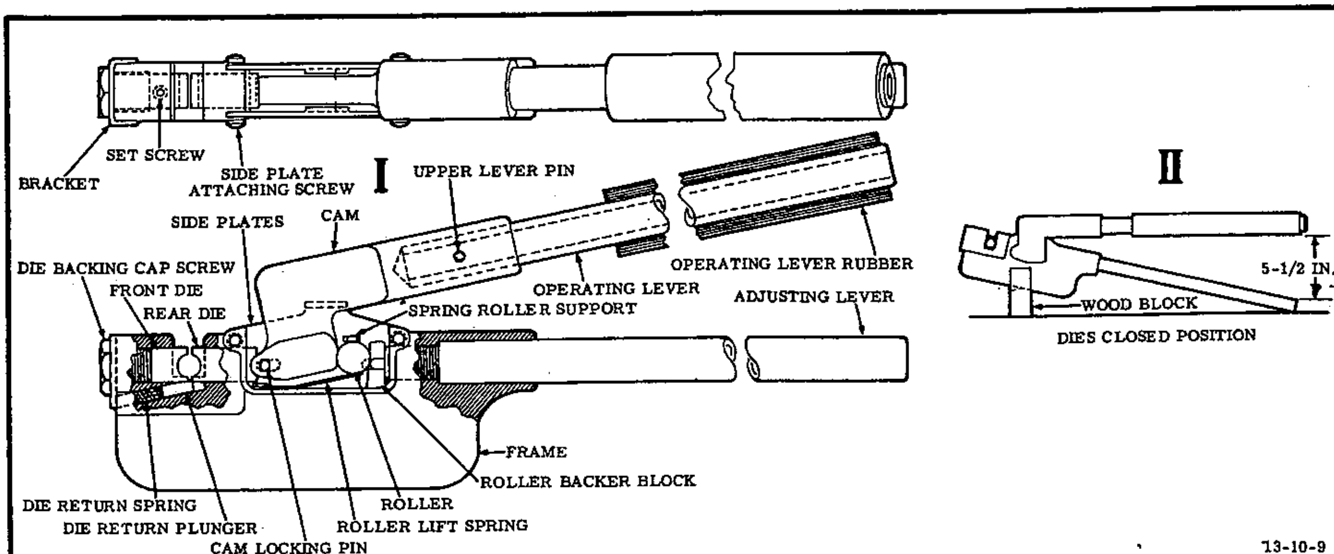


Figure 10-11 Tru-Loc Cable Terminal Swaging Machine

the rear face of the cam by a flat spring, a roller backing-block, and a rotatable adjusting lever. The front die, held in position by a die backing cap-screw and prevented from rotating by a set-screw, meets the swaging face of the rear die in a recess in the frame through which the work can be introduced. A spring-loaded die return plunger, in an inclined cylindrical bore at the forward end of the frame, presses against the rear die and ensures that it returns with the cam after the working stroke is completed.

Interchangeable Dies

13 A set of front and rear dies to suit cables of various diameters is provided with each swaging machine, (see Figure 10-12).

Gauges

14 To guard against excessive squeezing of the cable and terminal, a pair of plate gauges is supplied for each size of die. These gauges are marked GO and NOT GO and must be used during the operation of the machine.

Setting Up

15 Place the swaging machine so as to enable the operator to apply the weight of his body on the lever to full advantage. The operating lever should be parallel with the edge of the bench, the frame with the dies being at the operator's left hand. This will bring the dies into the correct position for introducing and feeding the terminal to be swaged. The speed of operation can be increased if two operators are engaged, one to feed and rotate the terminal between the dies, the other to operate the handle.

Dia. of cable	Die number
1/16	24-M/25-M
3/32	26-M/27-M
1/8	28-M/29-M
5/32	30-M/31-M
3/16	32-M/33-M

Figure 10-12 Table of Tru-Loc Dies

16 The amount of squeeze transmitted to the dies is important. Clockwise rotation of the adjusting lever forces the roller against the cam, lifting the operating lever and causing the dies to be brought together earlier in the downward or operating stroke. Counterclockwise rotation of the adjusting lever allows the cam to settle lower and the dies to meet later in the operating stroke. The correct adjustment is obtained when, with the dies together, a gap of 5-1/2 inches exists between the ends of the operating lever and the adjusting lever. (See Figure 10-11.)

Cable Length

17 During the swaging operation an elongation of the cable terminal occurs. This should be taken into account when cutting the cable for existing conditions. Refer to Paragraph 5, preceding, for determination of terminal allowance.

Inserting Dies

18 Use the following sequence of operations when inserting dies in the machine:

(a) Remove die-backing cap-screw and bracket from front end of machine frame. (See Figure 10-11.)

(b) Apply heavy coating of extreme pressure grease (Item 6) to the outer surface and cam-end of rear die.

(c) Insert the rear (long) die into the hole vacated by the die backing cap-screw, making sure that the flat is on the underside.

(d) Insert the front (short) die with the set-screw, the flat face being uppermost and the plunger groove downwards.

(e) Align the set-screw and the flat on the front die. Tighten set-screw.

(f) Ensure that the die-return plunger and spring are in the inclined hole under the front die, then replace the bracket on the front end of the swaging machine.

(g) Screw in and tighten the die-backing cap-screw in front of the machine.

(h) Rotate the adjusting lever until the operating and the adjusting levers are 5-1/2 inches apart at their extreme ends. (See Figure 10-11.)

Examination of Parts before Swaging

19 Examine the cable and end-fitting before swaging as follows:

(a) Check if any preliminary stretching of flexible cable has been effected.

(b) Measure the external diameter of the terminal shank, its length, the depth of hole and ensure that each connection is correctly mated to its particular cable.

(c) Check that the ends of the cable have been squarely cut and that the correct allowance has been made for stretching of the terminal during swaging, (refer to Paragraph 5, preceding).

Swaging

20 With the swaging machine set up and the dies in position, proceed as follows:

(a) Insert the cable into the terminal.

(b) Apply a few drops of oil (Item 5) to the cable and to the terminal to be swaged.

(c) Open the dies by raising the operating lever.

(d) Place the terminal and cable in the front die recess so that the end of the terminal is centered in the die. (See Figure 10-13.)

NOTE

Always insert the terminal into the bell-mouthed side of the dies.

(e) Squeeze the terminal by pushing down the operating lever until the dies are completely closed.

(f) Open the dies by raising the operating lever sufficiently to rotate the terminal one-quarter of a revolution and feed it 1/16 inch into the dies. (See Figure 10-13.)

NOTE

Where possible, rotate the terminal the opposite way to the lay of the cable. Otherwise, rotate the terminal one-quarter of a revolution, in alternate directions, to each 1/16 inch feed. Do not overfeed the terminal into the dies; to do so would call for a pressure in excess of the power range of the cam and lever.

(g) Repeat Sub-paragraphs (e) and (f) until the correct length of shank has been swaged. Terminals marked Class A and D, (see Figure 10-13), are swaged as far as the shoulder. The swaging lengths for Class B and C terminals are tabulated in Figure 10-14.

(h) To finish the swaged tapered portion of the terminal, rotate and swage several times without feeding movement.

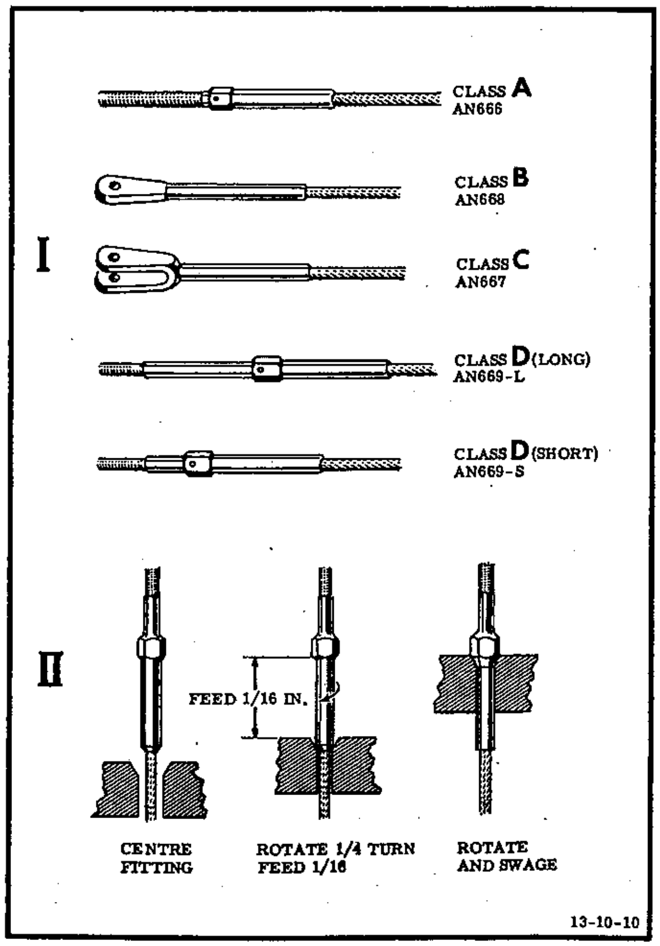


Figure 10-13 Terminals for Swaging

(j) When the swaging operation is completed, gauge the diameter of the cable terminal with the GO and NOT GO gauges supplied.

Examination of Parts after Swaging

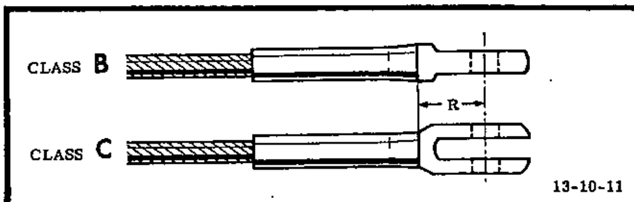
21 Examine the cable and terminal after swaging, as follows:

(a) If the shank of the fitting fails to enter the GO gauge, the amount of swaging is insufficient and further application of the swaging machine should be made.

(b) If the NOT GO gauge slips easily over the shank, it indicates excessive swaging and consequent crushing or fracturing of the cable. In severe cases of excessive swaging, reject both the cable and terminal.

(c) Measure the increase in length of the terminal. This dimension will give an additional indication of the amount of swaging that has been applied. An insufficient increase in length suggests incomplete swaging; undue increase in length suggests excessive swaging.

(d) Ensure that the length of the cable in engagement with the shank is as originally intended. For blind-hole terminals, use the locating mark on the cable for this purpose.



Cable dia.	Dimension R	
	Class B	Class C
1/16	21/32	5/8
3/32	7/8	3/4
1/8	29/32	29/32
5/32	1	31/32
3/16	1 3/32	1 1/8

Figure 10-14 Swaging Lengths

(e) Notice that the lay of the cable is correct, and that the angle of the lay has not slipped during the swaging operation.

(f) Measure the overall length of the cable assembly when tensioned by a load of 20 pounds. This must be to the length required in the installation.

(g) Where possible, subject the complete cable and terminal to a proof loading test of the strength of the cable. Refer to Paragraphs 27, 28 and 29, following.

Removal of Dies

22 In order to remove the dies, turn the adjusting lever in a counterclockwise direction until the operating lever and the adjusting lever come together, then remove the die-backing nut and bracket from the front of the machine. Loosen the set-screw above the front die and push both dies out of the machine with the die push-out rod provided.

Servicing

23 The dies are the parts principally subjected to wear. Make periodic examination for scoring, pitting or corrosion of the working surface. Use the plate gauges to show up any appreciable change that may take place in the profile of the dies.

Lubrication

24 It is important to keep the working surfaces of the rear die heavily coated with grease (Item 6). Grease the rear surface of the cam which contacts the roller periodically and ensure that all working parts are kept clean and free in operation.

POWER SWAGING MACHINE, ROTARY DIE REDUCING METHOD

General

25 Procure dies from authorized manufacturers. When this is not possible, machine and heat treat to manufacturer's design drawings.

Type of Cable	Nominal Diameter of Cable	Strands by Wires per Strand	Minimum Breaking Load (Lbs)	Proof Load (Lbs) (Approx. 60% of Min. Breaking Load)
Carbon Steel Cable to Specification MIL-C-1511	1/16	7 x 7	480	288
	3/32	7 x 7	920	552
	1/8	7 x 19	2000	1200
	5/32	7 x 19	2800	1680
	3/16	7 x 19	4200	2520
	7/32	7 x 19	5600	3360
	1/4	7 x 19	7000	4200
	9/32	7 x 19	8000	4800
	5/16	7 x 19	9800	5880
	11/32	7 x 19	12500	7500
	3/8	7 x 19	14400	8640
Corrosion Resistant Steel Cable to Specification MIL-C-5424	1/16	7 x 7	480	288
	3/32	7 x 7	920	552
	1/8	7 x 19	1900	1140
	5/32	7 x 19	2600	1560
	3/16	7 x 19	3900	2340
	7/32	7 x 19	5200	3120
	1/4	7 x 19	6600	3960
	9/32	7 x 19	8000	4800
	5/16	7 x 19	9600	5760
	3/8	7 x 19	13000	7800

Figure 10-15 Table of Proof Loads for Swaged Cable Assemblies

Operating Instructions

26 When operating the power swaging machine, observe the following points:

(a) Shim, when required, sufficiently to force the dies of the swaging machine firmly together and to produce swaged fittings of the required diameter. Avoid heavy shimming.

(b) Check the swaging machine spindle to make certain that it rotates in the same direction as the lay or twist of the cable to be attached to the fitting so that it will not tend to unlay the cable.

(c) Do the swaging operation as quickly as practical to avoid cracking of the terminal.

(d) Lubricate the outside of the terminals with machine oil (Item 19) or light grease (Item 20) before and during swaging, to lessen friction with the dies.

(e) With cable in place hold terminals manually to resist rapid rotation. Terminals may be allowed to rotate slowly.

(f) After feeding the correct length of terminal into the swaging dies, ensure that terminal is concentric before withdrawing, a few extra blows being all that is necessary. Feed terminals into the swaging dies positively and uniformly.

(g) Dimensions after swaging must conform to the standard drawings or special drawings for non-standard terminals.

(h) When installing ball type terminals at the end of a cable, one inch of cable must protrude for trimming after swaging.

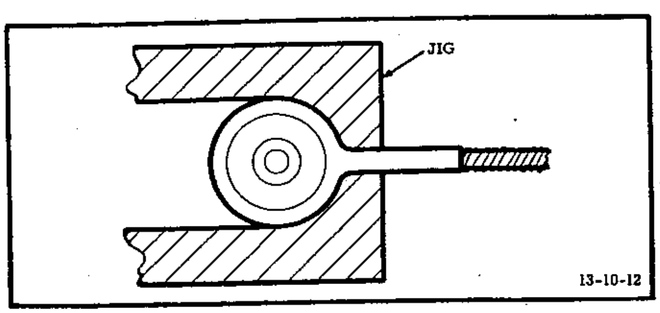


Figure 10-16 Proof Loading Jig

PROOF LOADING

General

27 Proof load all swaged assemblies, as specified in the applicable drawing or in Figure 10-15, for a period of not less than one minute. Apply load gradually and continually until the full value is attained. Release load evenly and gradually. Reject any assemblies showing any evidence of slipping or failure.

Ball or Ball with Shank Assemblies

28 Proof load assemblies, having a ball or ball with shank terminal swaged between the end terminals, between the ball and one end in addition to the end-to-end test.

Ball-bearing Swaged Fittings

29 Proof load by means of a jig which allows a straight pull on the outer face of the casing. A typical jig is shown in Figure 10-16.

Identification of Cable

30 Colour code each control cable in accordance with the applicable practice for the aircraft. Mark the cable assemblies by applying the specified code marking to each cable terminal and turnbuckle. Where it is impractical to apply the marking tape (Item 21) to the cable terminal, apply the tape to the cable approximately 1/4 inch from the terminal.

Tensioning of Aircraft Control Cable

31 For information regarding tensioning of cables, refer to EO 05-1-2AK.

Rust Prevention

32 Remove dirt, oil or grease from the terminal by wiping with a clean cloth moistened with carbon tetrachloride (Item 22). If the cables are made from tinned steel, use a rust-preventive compound to coat the cable. Use exterior surface corrosion preventive (Item 23). Dip the cable into a tank of the compound at 77° (± 5°)C (170° (± 10°)F) for 30 seconds. Wipe off all excess oil. Corrosion-resistant steel cables do not require this treatment.

Cleaning

33 To remove Parkeltone from coated cables, use a clean cloth lightly moistened with cleaner (Item 24).

Tolerances

34 Cable to pulley alignment, (see Figure 10-17), is subject to the following tolerances:

(a) The maximum fixed misalignment tolerance between a cable and the pulley or pulleys through which it runs is 2° each side of the centre.

(b) Where a control cable has an angular motion with respect to the plane of the pulley, the maximum variable misalignment resulting from this motion must not exceed 2° each side of centre for neutral position of controls and 3° each side of centre for any position of the control between one-half and full movement.

(c) All main control cables and all other cables rigged in excess of 125 pounds must not rub against the pulley flange. If the cable has paper clearance (approximately .002 inch) at the point of tangency of the outer radius of the flange and the inner surface of the groove, it may be considered as not rubbing on the flange.

SPLICING

Woven Splice

35 In place of swaged terminals use the five-tuck woven spliced terminals on cables of 3/32 inch diameter or greater where facilities are limited and immediate replacement is imperative. In some cases it will be necessary to splice one end of the cable on assembly. For this reason, investigate the original installation for pulleys and fair-leads that might restrict the passage of the splice. The procedure for the fabrication of a woven splice is shown in Figures 10-18 and 10-19.

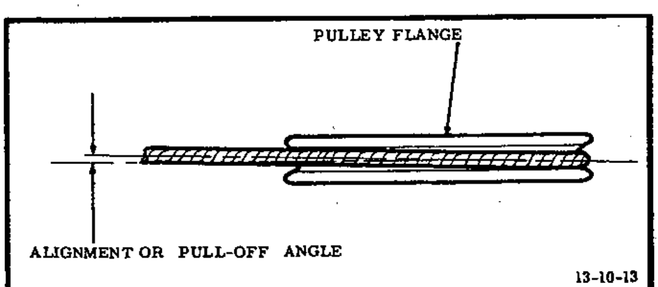


Figure 10-17 Alignment Angle Measurement

Alternate Method - U.S. Navy Splice

36 Perform the U.S. Navy splice as follows: (See Figure 10-20.)

(a) Secure the cable around a bushing or thimble by means of a cable clamp, (see Figure 10-18), leaving eight inches or more of free end. Secure the cable clamp in a vise with the free end to the left of the standing wire and away from the operator. If a thimble is used as the end fitting, turn the points outward approximately 45 degrees.

(b) Select the free strand (1) nearest the standing length at the end of the fitting and free this strand from the rest of the free ends. Insert a marlinspike under the first three strands (A, B and C) of the standing length nearest the separated strand of the free end and separate them temporarily by twisting the marlinspike. Insert the free strand (1) under the three separated strands through the opening created by the marlinspike. Pull the free end taut by means of pliers.

(c) Unlay a second strand (2) located to the left of the first strand tucked, and insert this

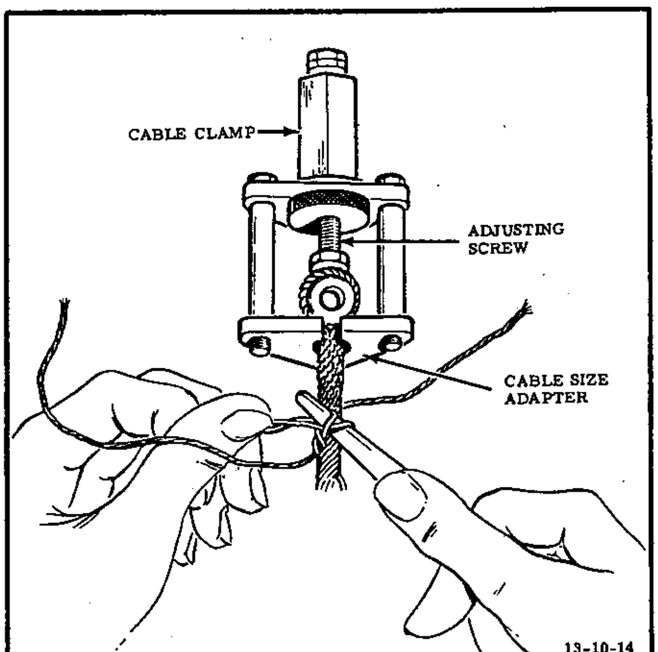
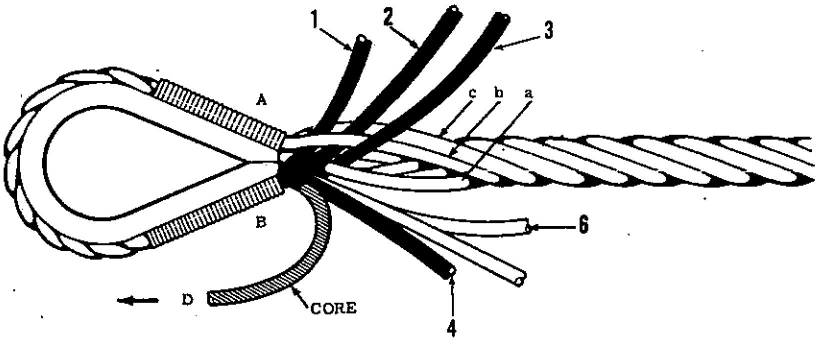


Figure 10-18 Cable Clamp for Woven Splice

NOTE: STRANDS NUMBERED COUNTERCLOCKWISE VIEWED FROM END OF CABLE.



1st HALF OF NO.1 TUCK

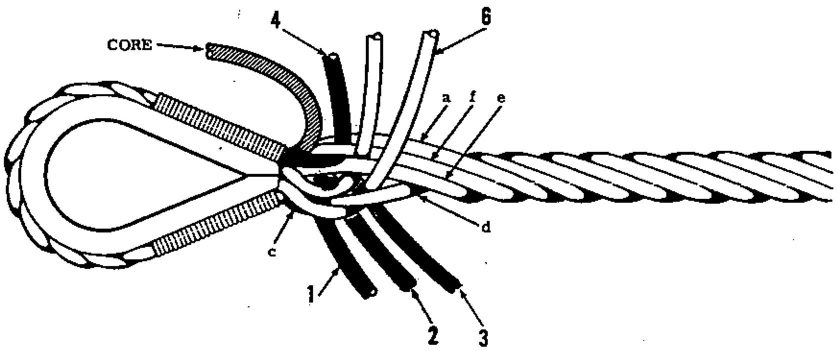
SERVE CABLE AT A AND B WITH WAXED THREAD

BEND CABLE AROUND THIMBLE WITH CORE TURNED BACK IN DIRECTION OF ARROW D.

THREAD NO. 3 STRAND UNDER a.

THREAD NO. 1 STRAND UNDER b and c.

THREAD NO. 2 STRAND UNDER b.



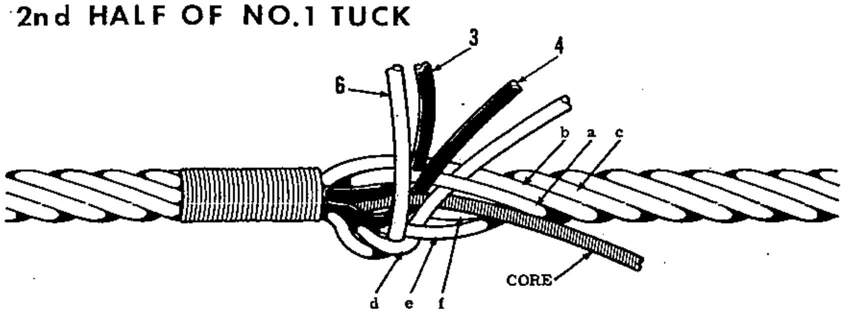
2nd HALF OF NO.1 TUCK

THREAD NO. 4 STRAND UNDER f.

THREAD NO. 5 STRAND UNDER e.

THREAD NO. 6 STRAND UNDER d.

ONE TUCK IS COMPLETED WHEN EACH STRAND HAS BEEN THREADED ONCE.



COMMENCEMENT OF 2nd TUCK SHOWING CORE TUCKED IN

IN THE 2ND, 3RD, 4TH AND THE HALF TUCKS, LAY THE CORE ALONG THE CABLE AND TAKE IT UNDER A SUITABLE STRAND (IN ILLUSTRATION, NO. 6 STRAND), THUS FORCING THE CORE INTO THE CENTRE OF SPLICE.

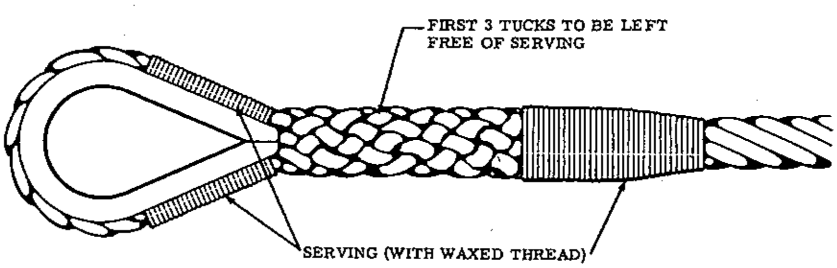
IN THE 2ND, 3RD AND 4TH TUCKS, TAKE STRANDS 1, 2, 3, 4, 5 AND 6 OVER AND UNDER ONE STRAND (a, b, c, d, e, f)

e.g. IN 2ND TUCK, TAKE NO. 3 STRAND OVER b AND UNDER c.

IN 3RD TUCK, TAKE NO. 3 STRAND OVER d AND UNDER c.

IN 4TH TUCK, TAKE NO. 3 STRAND OVER 1 AND UNDER a.

MAKE HALF A TUCK BY THREADING ALTERNATE STRANDS ONCE.



COMPLETED SPLICE

A COMPLETE SPLICE CONSISTS OF 4-1/2 TUCKS.

AT COMPLETION OF SPLICE, CUT OFF AND SERVE LOOSE ENDS.

13-10-15

Figure 10-19 Woven Splice - Preferred Method

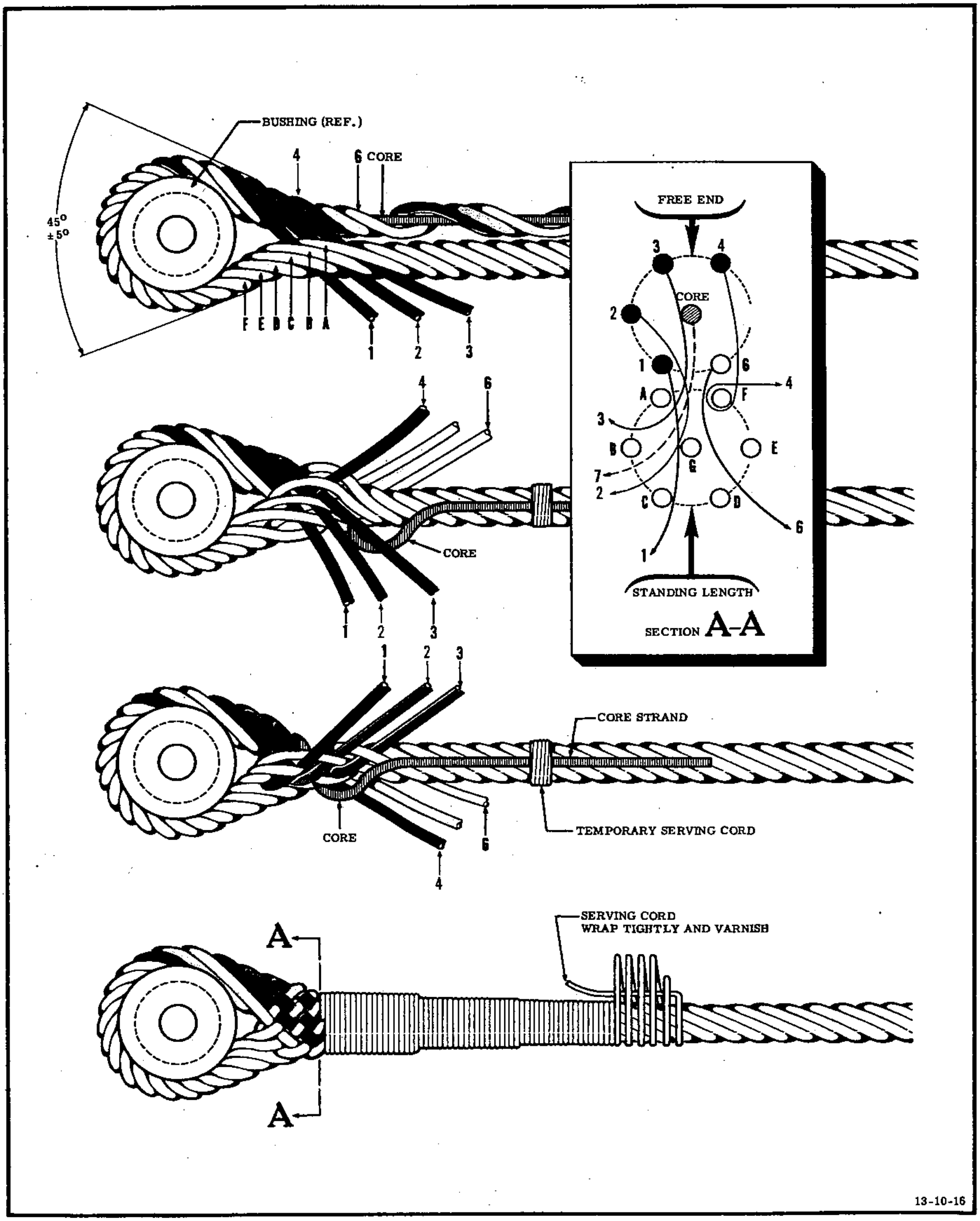


Figure 10-20 Woven Splice - Alternate Method

second strand under the first two standing strands (A and B). Loosen the third free length strand (3), located to the left of the first two, and insert it under the first standing strand (A) of the original three, (see Detail A).

(d) Remove the centre or core strand (7) from the free end and insert it under the same standing strands (A and B). Temporarily secure the core strand to the body of the standing cable, (see Detail B). Loosen the last free strand (6) located just to the right of the first (1) and tuck it under the last two strands (E and F) of the standing cable. Tuck the fifth free end (5) around the fifth standing strand (E). Tuck the fourth free end (4) around the sixth standing strand (F). (See Details B and E.) Pull all strands snug toward the end fitting with the pliers. This completes the first tuck.

(e) Begin with the first free strand (1) and work in a counterclockwise direction, tucking free strands under every other standing strand. After the completion of every tuck, pull the strands tight with pliers. Pull toward the end fitting. (See Detail C.) After the completion of the third complete tuck, cut off half the number of wires in each free strand. Make another complete tuck with the wires remaining. At the completion of the fourth tuck, again halve the number of wires in the free strands and make one final tuck with the wires remaining. Cut off all protruding strands and pound the splice with a wooden or rawhide mallet to relieve the strains in the wires. Serve the splice with waxed linen cord, (see Detail D). Start 1/4 inch from the end of the splice and carry the wrapping over the loose end of the cord and along the tapered splice to a point between the second and third tucks. Insert the end of the cord back through the last five wrappings and pull snug. Cut off the end, and if a thimble is used as an end fitting, bend down the points. Apply two coats of shellac (Item 26) to the cord, allowing two hours between coats. Carefully inspect cable strands and splices for local failure. Weakness in a woven splice is made evident by separation of the strands of serving cord.

Splicing Instructions

37 The following instructions must be followed during splicing:

(a) When cables are cut, precautions must be taken to prevent unlaying by firmly soldering the cable for a length of 2 or 3 inches. Cold cut in the centre of the soldered portion, or use an approved electric cutter or arc. Blow torches or oxy-acetylene torches must not be used.

(b) The cable should be snugly fitted and secured to the thimble by either a serving of waxed cord or an approved type of splicing clamp, (see Figure 10-18). When a reel type of thimble is used, extend the serving beyond the reel into the apex of the splice.

(c) The splice should be hammered taut after each tuck. A hardwood or rawhide mallet and a hardwood anvil are to be used and the splice rotated while being hammered so that all strands are equally tautened. Do not hammer to such an extent that strands and/or individual wires are damaged or broken.

(d) The correct number of tucks must be used and the splice finished off by serving with waxed cord (Item 13). The serving must finally receive two coats of orange shellac. (Item 26).

Inspection of Splicing

38 When inspecting the final splice, check the following:

(a) That the splice is symmetrical, of good appearance and that the strands and wires lie close together. No light should show between the strands when the splice is held before a light.

(b) That the splice is stiff and, when bent, the strands and wires remain close together. A poor splice is quite flexible and, when bent, the strands and wires become slack, although before bending it may appear acceptable.

(c) That the thimble is tight in the loop and of proper size.

(d) That the lay of the cable is maintained as far as possible.

(e) That the serving is applied satisfactorily. It should be even and tight with ends properly secured. Check that two coats of shellac or approved substitute have been applied as protection against moisture.

(f) That each cable has been given a proof load of 60% of its specified strength. (See Figure 10-15.)

Wrap-soldering Terminals

39 On cables of 1/16 inch diameter only, employ the wrap-soldered splice to fabricate end fittings. To replace an eye-type fitting, use a cable bushing (Item 16). To replace a clevis-type fitting, use a cable thimble (Item 9) and a cable shackle (Item 29). Proceed as follows:

(a) Arrange the cable and the fittings, allowing approximately 2-1/4 inches of free end. Before wrapping the cable around a thimble, place the cable shackle in position, as this cannot be done after the splice is completed.

(b) Clamp the assembly in a cable clamp or similar holding device, and secure in a vise.

(c) Starting as close as practicable to the end fitting, press the free end and standing length of the cable together tightly and wrap with a single layer of soft steel wire, (Item 27), leaving a space of approximately 1/8 inch between every 1/2 inch of wrapping. Allow the wrapping to extend approximately 1/4 inch beyond the free end. (See Figure 10-21.)

NOTE

Be careful to prevent the standing length from twisting during this operation.

(d) Thoroughly apply flux (Item 28) to the entire splice. (Refer to Part 20, following.)

(e) Remove the splice from the cable clamp and dip the wrapping in solder (Item 1). Carefully sweat the solder into the cable about the wrapping and apply the solder until the wrapping wire is barely discernible, making certain that the open spaces between the wrapped sections are thoroughly impregnated with molten solder. If a solder pot is not available, a soldering torch may be used. Be careful to thoroughly impregnate the entire splice with solder.

(f) Allow the splice to cool. Do not quench.

(g) After the splice has cooled, thoroughly wipe clean and wash away all soldering flux from the splice and adjacent cable with hot water.

(h) Dry the splice and impregnate the spliced section with a corrosion preventative (Item 23).

(j) Carefully inspect the splice. A wrap-soldered splice which can be easily bent with the fingers is unsatisfactory because of poor solder penetration. Cracks in the solder, between the wrapping wire and the short space provided between wraps, are a positive indication of slippage in the wrap-soldered splice.

Sweat-soldering Terminals

40 Sweat-soldered terminals are employed only on lightly loaded cables. Use this type of terminal for replacement of similar types only. Sweat-soldered terminals can be easily distinguished from swaged terminals by the air holes in the barrel of the terminal, which allow the molten solder to permeate the strands

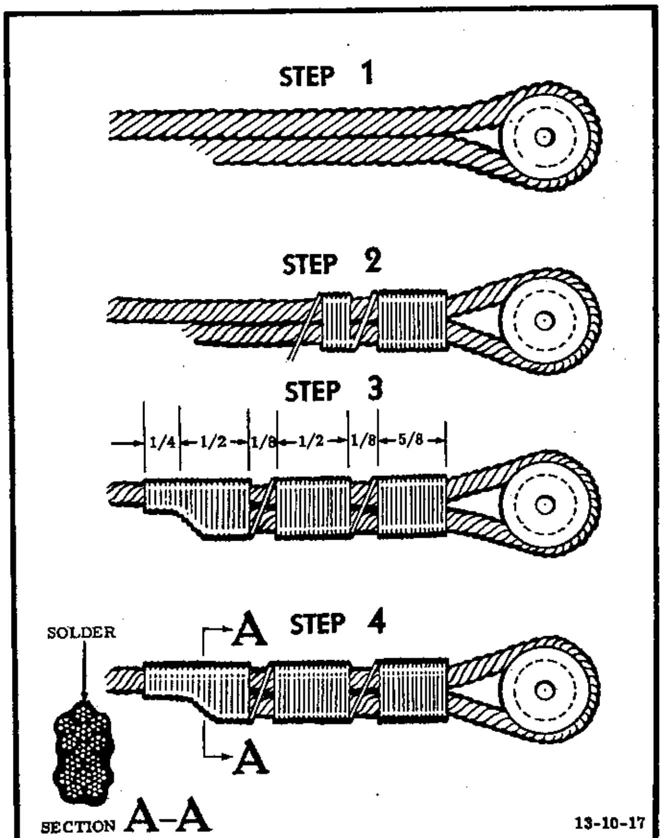


Figure 10-21 Wrapped Soldered Splice

of the cable with no entrapped air bubbles. To attach sweat-soldered terminals to cables, proceed as follows: (See Figure 10-22.)

(a) Select the proper size and type terminal and place, barrel up, in a suitable clamping device. Use a clamping device with jaws of fibre or some other non-conductive material that will not dissipate heat readily.

(b) Apply heat to the terminal barrel with a soldering torch or a high-wattage soldering iron.

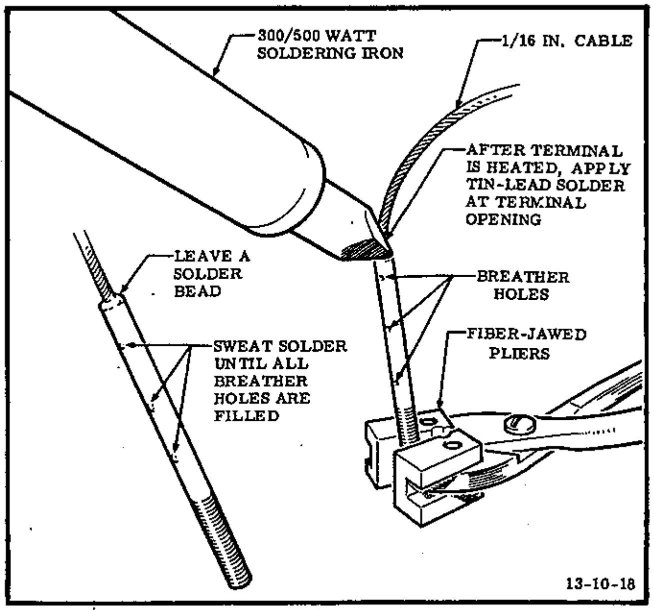


Figure 10-22 Sweat Soldering

(c) After the terminal is thoroughly heated, insert a small amount of soldering flux (Item 28) into the barrel. (Refer to Part 20, following.)

(d) Apply soldering flux to the end of the cable and insert into the barrel of the terminal. On clevis-type terminals, allow the cable to extend through the barrel a short distance, free the end strands of the cable and allow them to fray. Pull the cable back into the barrel until the end is flush with the clevis.

(e) Apply solder (Item 1) around the cable at the terminal opening and thoroughly sweat solder into the cable barrel until solder appears at the opposite end of the barrel and fills each breather hole. Avoid overheating the solder.

(f) Leave a solder bead around the cable at the terminal opening and allow the terminal to cool in air. Do not quench.

CAUTION

Do not use sweat-soldered terminals on control cables of corrosion resistant steel.

Material Specifications

41 For table showing item numbers, materials, specifications and manufacturers, see Figure 10-23.

Item No.	Material	RCAF Reference	Specification	Manufacturer
1	Solder		QQ-S-571comp Sn50	
2	Tape, Masking	33G/ 99, 100, 101	UU-T-106A (US)	
3	Tape, Cellulose	33G/ 63, 64, 65, 66, 67	L-T-101	
4	Tape, PVC, 3/4 inch wide	33G/ 136, 137		Commercial grade.
5	Oil, Lubricating No. 10SAE	34A/35	3-GP-45	
6	Grease, Extreme pressure	34A/207	MIL-G-7118	
7	Cables, Preformed		AN-RR-C-43	

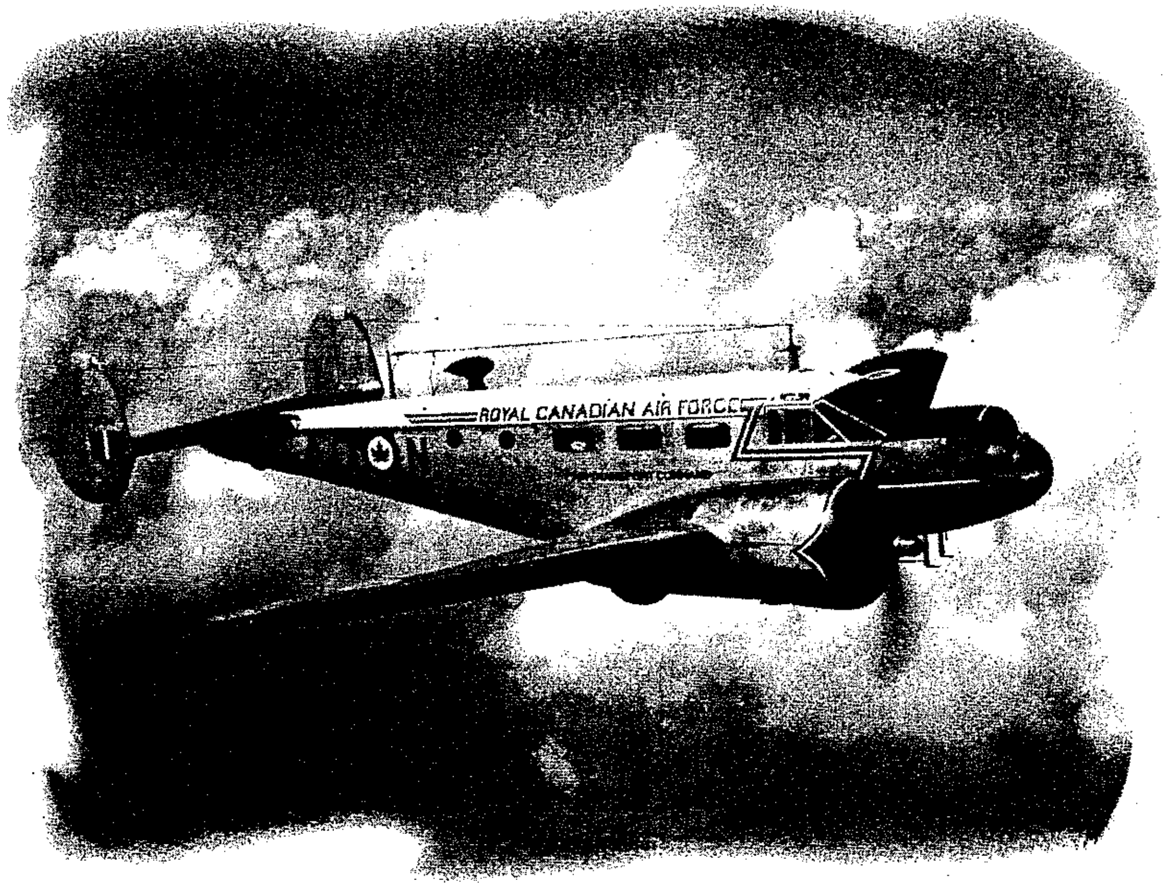
Figure 10-23 (Sheet 1 of 2) Table of Material Specifications

Item No.	Material	RCAF Reference	Specification	Manufacturer
8	Terminals, Swaged	28/	C-28-71	
9	Thimbles	28/	MIL-T-5677	
10	Bushing AN3420	28/		
11	Turnbuckle AN150	28/	MIL-T-5685	
12	Shear Nut AN320	28/	MIL-N-6034	
13	Cord, Waxed, Linen, No. 6 Barbour	32B/	MIL-C-2520	
14	Washer AN960	28/		
15	Cotter Pin AN380	28/	FF-F-386	
16	Bushing AN111	28/		
17	Paint, Red	33A	1-GP-28	Commercial grade
18	Grease Pencil, Red			Commercial grade
19	Oil, Machine	34A/124	3-GP-335a	
20	Grease, Light	34A/192	3-GP-683a	
21	Tape, Identification, Cellulose	33G/ 63, 64, 65, 66, 67		
22	Carbon Tetrachloride	33C/102	O-C-141	
23	Corrosion Preventative	40D/585	31-GP-1	
24	Cleaner	33C/182	3-GP-8	
25	Deleted			
26	Shellac	33A/93	1-GP-16a	
27	Wire, Zinc coated soft steel No.20 AN995			
28	Flux, Paste or Liquid	33C/		Canada Metal Co., 721 Eastern Ave., Toronto.
29	Shackle	28/	ANS 23	

Figure 10-23 (Sheet 2 of 2) Table of Material Specifications

PART 11

FLEXIBLE HOSE LINE REPAIR AND REPLACEMENT



PART 11

TABLE OF CONTENTS

FLEXIBLE HOSE LINE REPAIR AND REPLACEMENT

LIST OF ILLUSTRATIONS

PART 11

FLEXIBLE HOSE LINE REPAIR AND REPLACEMENT

AIRCRAFT HOSE

General

1 For information regarding permitted types of aircraft hose and the restrictions governing installation, repair and storage, refer to EO 110-10-10.

Assembly Precautions

2 The following list of precautions refers to all types of aircraft hose:

(a) Hose will change in length from +2% to -4% when pressurized. Provide slack or bend in the hose to compensate for any changes in length which might occur. (See Figure 11-1.)

(b) Where hose lines pass close to a hot exhaust manifold, protect the hose with fire-proof boot or metal baffle. (See Figure 11-2.)

(c) Where a hose assembly is to be subjected to considerable flexing or vibration, allow sufficient hose length to eliminate any strain on metal hose fittings. (See Figure 11-3.)

(d) Ensure that hose is not twisted when installed. Under high pressures a twisted hose may fail or may cause attaching nuts to loosen. (See Figure 11-4.)

(e) Keep the bend radii of the hose as large as necessary to avoid kinking of line and restriction of flow. (See Figure 11-5.)

(f) Use elbows and adapters to ensure cleaner installations for easy inspection and maintenance. (See Figure 11-6.)

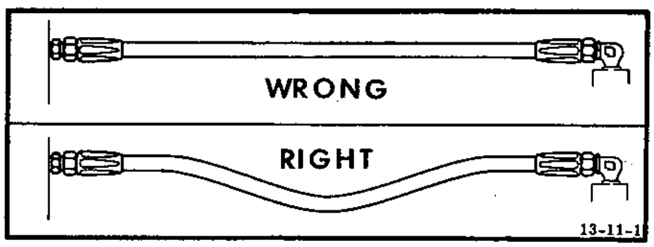


Figure 11-1 Hose Assembly

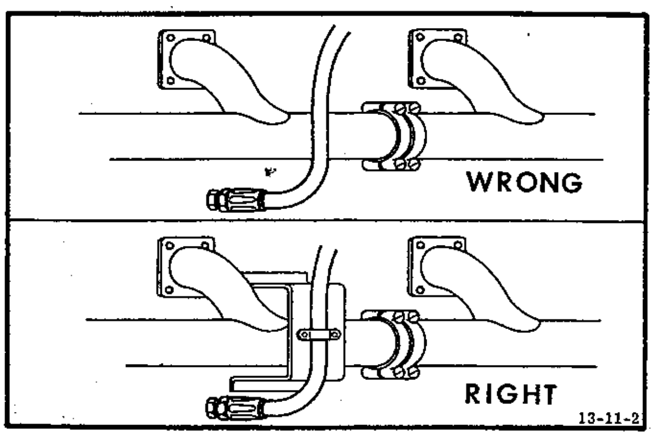


Figure 11-2 Hose Assembly

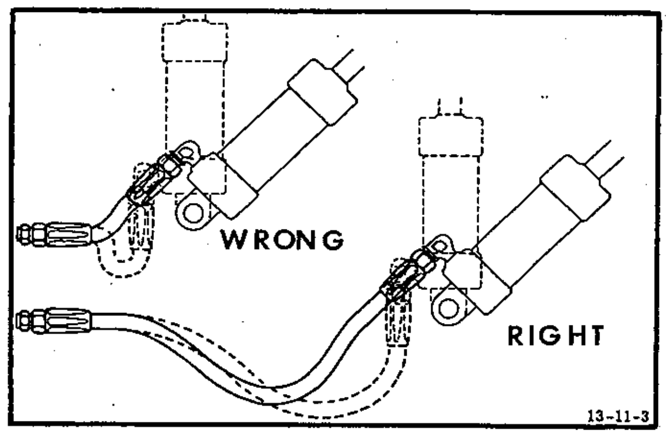


Figure 11-3 Hose Assembly

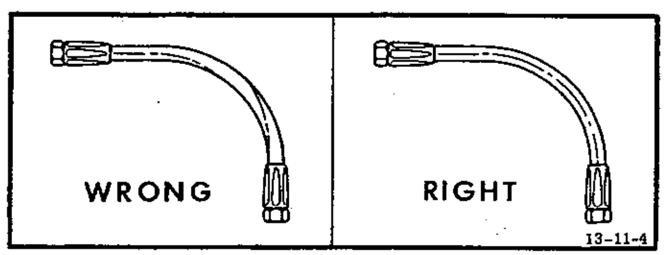


Figure 11-4 Hose Assembly

Installing Flexible Hose

3 Use the following procedure when flexible fuel line hose (Item 12) is installed:

(a) Immediately prior to installation, lubricate male threads with anti-seize compound (Item 1).

CAUTION

Use a light coating of anti-seize compound on male threads only, as compound must not be forced into line when connection is made.

(b) Using fingers only, start B nuts on fittings, and turn until the nuts are finger-tight. Do not use a wrench until nut is finger-tight.

(c) After nuts on both ends of hose are finger-tight, use a torque wrench to tighten one nut to the correct torque. At the same time, use a wrench on the hex or flat of the fitting to prevent the fitting from turning. (See Figure 11-7.)

(d) Tighten other end nut in the same manner.

(e) After installation, make sure that flexible hose is not twisted. This is important, as pressure tends to untwist and straighten hose. If hose is twisted, it tends to shear off hose ends or loosen fittings.

NOTE

If it becomes necessary to retorque a B nut, back off the nut and then torque to its indicated value.

(f) Ensure that flexible hose clears all adjacent parts wherever possible to prevent rubbing.

NOTE

Use care in positioning clamps and supports so that hose is not pulled or twisted in service or forced to bend sharper than the minimum allowable radius.

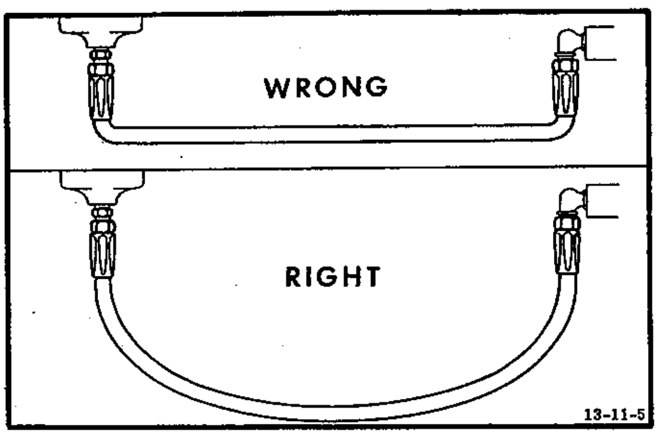


Figure 11-5 Hose Assembly

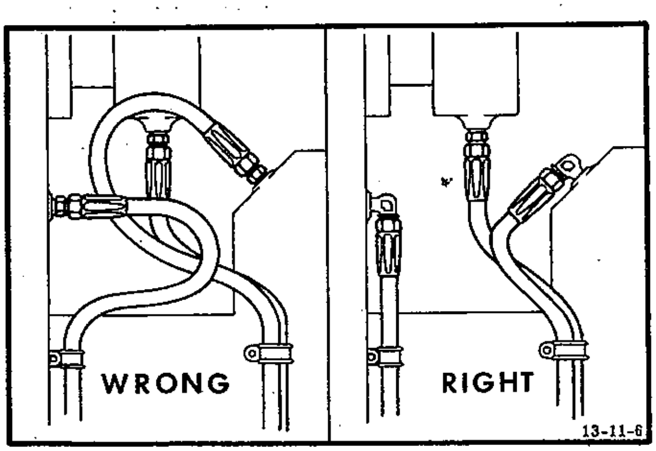


Figure 11-6 Hose Assembly

Torque Wrenches

4 Any type of torque wrench which is adequate for the job may be used for tightening B nuts. Figure 11-8 lists several torque indic-

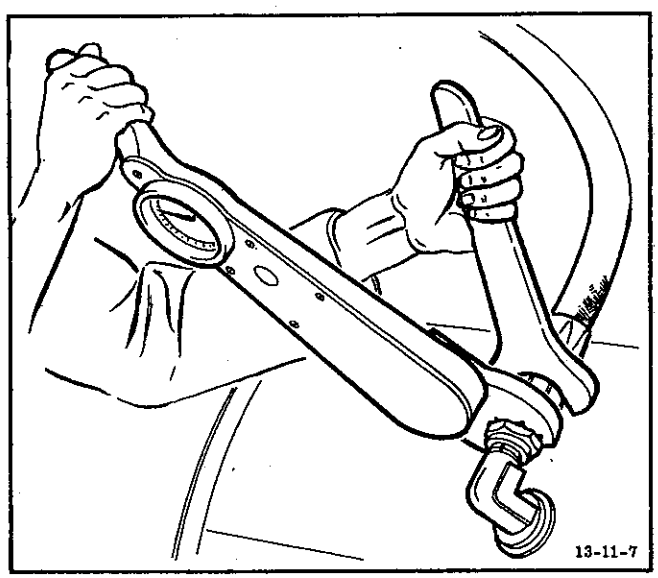


Figure 11-7 Flexible Hose Installation

ating handles that may be used. To tighten any particular B nut, a handle having the correct capacity should be used. Figure 11-9 lists some adapters (AN8508 crowfoot flare nut wrenches) which may be used with the torque indicating handles. The 1200 to 4800 inch-pound and 0 to 3500 inch-pound torque indicating handles listed in Figure 11-8 have 3/4 inch square drives and a square drive adapter must be used when either of these handles is used with any of the AN8508 adapters listed in Figure 11-9. A Proto-tools Part No. 5453 adapter is suitable for adapting a 3/4 inch male drive to a 1/2 inch female drive.

Assembly Instructions for Flange-Elbow Type Hose Assemblies

5 Use corresponding hose, fittings and adapter size when assembling Aeroquip parts. Cut hose to length, using a fine tooth hacksaw or steel cut-off wheel. Screw hose into socket counterclockwise until hose bottoms. Back off 1/4 turn.

Flange Type Ends

6 Drop flange over threaded end of nipple. Nipple shoulder should fit in counter bore of flange. Liberally apply oil (Item 2) to outside of nipple threads. Insert nipple into socket and tighten until hex touches socket.

Swivel Ends

7 Liberally apply oil (Item 2) to inside of hose and outside of nipple assembly threads. Insert nipple assembly into socket and hose by using wrench on hex. Tighten nipple assembly until snug against socket.

Single Wire Braid Assemblies

8 When assembling single wire braid assemblies, proceed as follows:

(a) Cut hose (Item 15) to length with fine tooth hacksaw or steel cut-off wheel. Grind end flat and smooth.

(b) Flare cut end of hose outward all the way around the circumference with a pair of pliers. Flare at 1/2 inch intervals and with a 1/2 inch deep bite.

(c) After the end of the hose has been flared there will still remain a lip of inner-tube at the end of the hose. Slice this lip off with a sharp knife at a 30° angle. This will permit easy entrance of the nipple into the hose.

(d) Apply a very light film of oil (Item 2) on the outside surface of the end of hose.

(e) Place socket in vise. Apply only enough pressure to keep it from falling out of the vise, as internal left-hand buttress threads can be easily deformed on the larger diameters.

(f) Screw end of hose into socket counterclockwise until it bottoms. Make sure socket is not cocked on the end of the hose to eliminate having to straighten afterwards.

Capacity (lb.)	Square Drive	Specification
5-150	1/4	MIL-H-4034
0-600	3/8	50343
100-750	3/8	MIL-H-4034
0-1600	1/2	50343
700-1600	1/2	MIL-H-4034
0-3500	3/4	50343
1200-4800	3/4	MIL-H-4034

Figure 11-8 Table of Socket Wrench Torque Indicating Handles

Hex Size	Square Drive	Part No.
9/16	1/4	AN8508A9
11/16	3/8	AN8508-11
7/8	3/8	AN8508-14
1-1/2	1/2	AN8508-24
2	1/2	AN8508-32
2-1/4	1/2	AN8508-36

Figure 11-9 Table of AN8508 Adapters (Crowfoot Flare Nut Wrenches)

(g) Insert nipple in nut and tighten on assembly tool or mating adapter (Item 18).

(h) Oil inside of hose and nipple threads liberally. Oil (Item 2) or lubricating grease (Item 17) is preferred.

(j) Screw nipple into socket and hose by using wrench on hex of assembly tool or adapter. Leave 1/32 to 1/16 inch clearance between nut and socket so nut will swivel when assembly tool is removed.

Multiple Wire Braid Assemblies

9 When assembling multiple wire braid assemblies, proceed as follows:

(a) Place hose (Item 16) in vise and cut square to length required. Use fine tooth hacksaw or cut-off wheel.

(b) Remove outer cover down to wire braid. (Refer to Paragraph 11, following for suggested method for stripping hose.)

(c) Place socket in vise.

(d) Screw the hose into socket counterclockwise until it bottoms.

(e) Tighten nipple and nut on mating adapter (Item 18).

(f) Oil nipple threads and inside of hose liberally. (On large sizes it is suggested that grease (Item 12) be used as a lubricant.)

(g) Screw nipple into socket and hose by using wrench on hex of adapter. Leave 1/32 inch to 1/16 inch clearance between nut and socket so nut will swivel when adapter is removed.

Dismantling Procedure

10 Dismantle in reverse order of assembly.

WARNING

Do not use oil or grease on oxygen installations.

Stripping of Hose Cover

11 To strip hose cover, use a short bladed knife. Grind a notch where blade enters handle. Keep knife sharp. Proceed as follows:

(a) Locate cutting point of cover to be stripped, using nipple.

(b) Cut around hose through the outer cover at cutting point. Be sure cut is down to wire braid all the way around.

(c) Slit outer cover lengthwise from cutting point to end of hose. Be sure cut is down to wire braid.

(d) Raise flap of cover along lengthwise cut. Grip raised flap firmly with pliers and twist off cover.

(e) Be sure that wire braid is free from rubber particles from the outer cover. In some cases it may be necessary to use a wire brush, soft wire wheel or some other tool to clean the wire braid.

NOTE

Care must be taken that the end of the wire braid is not frayed or flared when brushing.

Fitting Part Number Comparison Table

12 For fitting part number comparison table, see Figure 11-10.

Military Standard Part No.	Superseded AN Part No.	Aeroquip Part No.
MS 28740	AN 782 & 792	491 & 451
MS 28741	AN 6264 & 6271	350, 360 & 390
MS 28742		9333
MS 28743		9345
MS 28744		9390
MS 28745		9444
MS 28746		9445
MS 28747		9490

Figure 11-10
Fitting Part Number Comparison Table

INSTALLATION OF DETACHABLE END FITTINGS ON HIGH PRESSURE HOSE

General

13 When replacing hose assemblies using detachable end fitting assemblies, remove the original end fitting assemblies from defective hose and re-attach to the replacement hose. Where any part of the detachable end fitting assembly (nut, socket or nipple) becomes unserviceable, reduce the remaining parts to produce and install a new assembly. Do not use detachable end fittings (Item 3) with round sockets, as they cannot be held satisfactorily in a vise. These are to be reported immediately for disposal. Use detachable end fittings with hexagon sockets or with flats on the sockets that can be held in a vise.

14 When hose lines with swaged end fittings or detachable end fittings to an AN782-3-4-5 or 6 become unserviceable, replace with medium high pressure hose (Item 4), utilizing detachable end fittings (Item 3). Whenever practical, replace the unserviceable rigid lines by medium high pressure hose using detachable end fittings.

Installation of Detachable End Fittings

15 Determine the hose length by removing and measuring the defective hose. Cut hose to length with a fine tooth hacksaw or cut-off wheel. Clean the inside of the hose by wiping or washing. Use tool kit Hose Coupling Tool, RCAF Ref. 1T/2156. Install as follows:

(a) Place the socket in a vise.

(b) Screw the hose into the socket counter-clockwise (LH thread) until the hose bottoms on the socket shoulder and then back off one-quarter turn.

(c) Select the assembly tool mandrel of the same dash number as the fitting being assembled and apply lubricating oil, Prenc-O-Lub (Item 5), to the mandrel. Prenc-O-Lub is not held in depot stocks and is to be obtained by LPO from manufacturer.

(d) Insert mandrel in the hose and apply a flaring motion, working the mandrel in and out to enlarge the hole in the hose. Repeat until the mandrel moves in and out freely.

(e) Wipe the lubricant off the mandrel.

(f) Insert the nipple in the nut and tighten on the assembly tool.

(g) Lubricate nipple thread and screw the nipple into the socket. Care must be exercised to prevent stripping the thread.

(h) Leave approximately 1/32 inch clearance to permit the nut to swivel.

(j) Loosen nut and remove the mandrel. Wipe off excess lubricant and clean the hose with air pressure.

Disassembly

16 To disassemble, reverse the assembly procedure. To prevent mutilation of parts when removing the swivel-type nipples, remove all oil from the assembly tool mandrel, and both nipple and assembly tool cone angles before inserting the assembly tool in the nipple.

Proof Pressure Test

17 After the hose is assembled, clean inside of the fitting with a brush and blow air through the assembly to ensure that the hose is clean. Pressure test as follows:

(a) Proof test the assembly by plugging one end of the hose assembly and apply pressure by the use of a hydraulic test stand or hand pump. Do not exceed pressures as shown in Figure 11-11. Hold the pressure for at least thirty seconds, during which time the hose and fittings are to be checked for evidence of fluid leakage.

(b) Clean hose interior after completion of proof pressure test.

ASSEMBLY OF DETACHABLE FITTINGS ON LOW PRESSURE HOSE

General

18 There are two different types of AN773 fittings, Type 1 and Type 2, (Items 19 and 20.) Assembly techniques for each type are given. The proof pressure test is common to both types and is to be carried out immediately after assembly is completed.

Replacement of Hose Assemblies

19 Replace unserviceable low pressure hose assemblies made up with flexible hose with swaged end fittings, or rigid lines, by low pressure hose (Item 6) utilizing detachable end fittings (Items 19 and 20) with suitable adapters where required.

20 When replacement of hose with detachable end fittings becomes necessary, remove the original end fittings from the defective hose and re-attach to a replacement length of hose.

Assembly Technique for Type 1 Fittings.

21 Assemble type 1 fittings as follows:

(a) Use a wet knife blade and cut the ends square on a length of new hose (Item 6). Use the unserviceable hose to determine the correct length.

(b) Lock the nipple and nut together with standard tube fitting of the proper dash number and type threads. (See Figure 11-12.)

(c) Lubricate the end of the length of low pressure flexible hose with oil (Item 2) (except for oxygen installation) and insert in the socket. Take care to bottom the hose in the socket.

Rigid Tube Size No.	Hose ID	Proof Pressure PSI
- 3	1/8	4000
- 4	3/16	6000
- 5	1/4	5000
- 6	5/16	4500
- 8	13/32	4000
-10	1/2	3500
-12	5/8	3000
-16	3/4	1600
-20	1-1/8	1250
-24	1-3/8	1000
-32	1-4/5	700

11-11 Table of Proof Pressures
High Pressure Hose

(d) Screw the nipple into hose and socket with a right-hand turn. Use a wrench and pliers with the jaws suitably taped to prevent damage to the socket.

(e) Allow 1/32 inch clearance between the nut and the socket so that the nut will swivel on the nipple after assembly.

(f) Following assembly, clean the inside of the hose thoroughly by running water through the assembly. Blow out with compressed air until thoroughly dry.

Dismantling

22 To dismantle, reverse the assembly instructions.

Proof Pressure Test

23 Proof test the assembly by plugging one

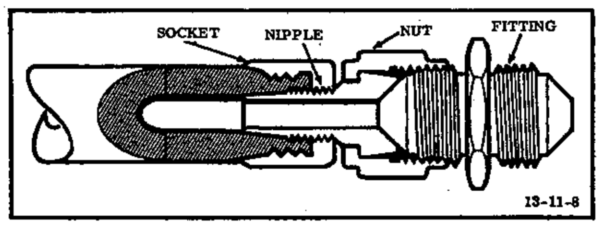


Figure 11-12 Standard Tube Fittings

Rigid Tube Size (Ref. OD)	Hose ID	Dash No.	Proof Pressure PSI
1/8	1/8	- 2	600
3/16	3/16	- 3	500
1/4	1/4	- 4	400
3/8	3/8	- 6	300
1/2	1/2	- 8	250
5/8	5/8	-10	250
3/4	3/4	-12	200
1	1	-16	200
1 1/4	1 1/4	-20	125
1 1/2	1 1/2	-24	125
2	2	-32	80

11-13 Table of Proof Pressures
Low Pressure Hose

end of the hose assembly, and apply air pressure as noted in Figure 11-13. Immerse the assembly in water and hold the pressure for not less than sixty seconds during which time the hose end fittings are to be checked for leakage. Do not confuse entrapped air with leakage.

24 For limitations on the use of low pressure flexible hose (Item 6) and detachable fittings (Items 19 and 20), see Figure 11-14.

Assembly Technique for Type 2 Fittings

25 For the assembly technique for type 2 fittings (Item 20), see Figures 11-15 and 11-16.

Other Types of End Fittings

26 For other types of end fittings, see Figures 11-17 and 11-18.

AIRCRAFT HOSE CLAMPS

General

27 It is not necessary to replace clamps already installed which do not meet the latest specifications. If for any reason, it is necessary to retighten or break a connection, fit the correct type of hose clamp (Item 7). Large size clamps used in aircraft ducting systems, etc., are beyond the scope of this Engineering Order and are included in the orders pertaining to the equipment involved.

Hose ID	Maximum Normal System Pressure Not Over (PSI)
1/8	500
3/16	425
1/4	300
3/8	250
1/2	180
5/8	175

Figure 11-14
Low Pressure Flexible Hose Limitations

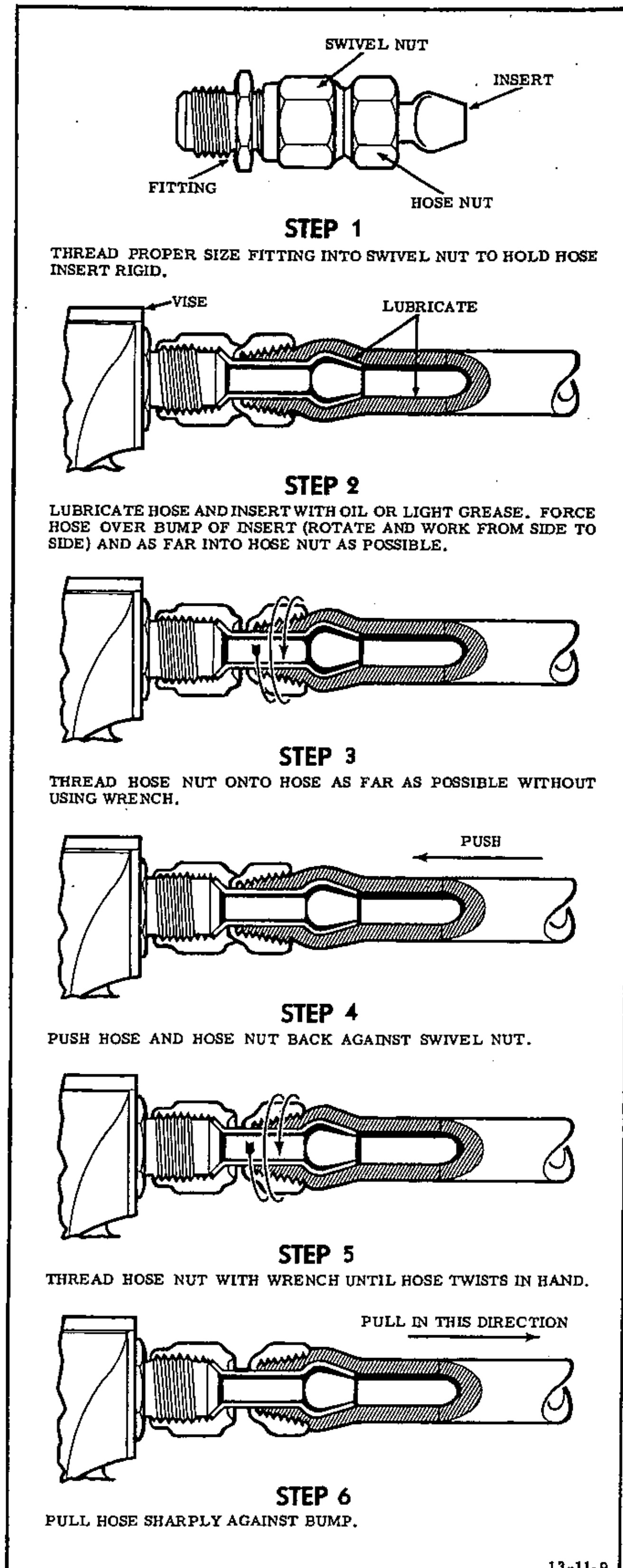
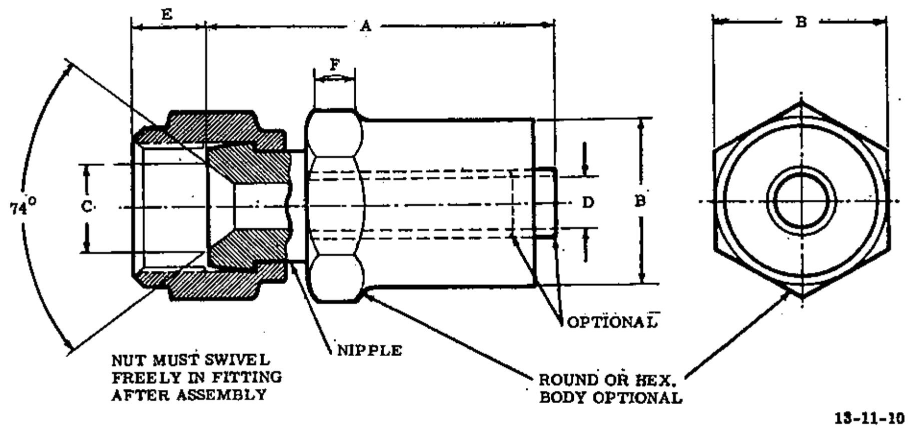


Figure 11-15
Assembly Technique for Type 2 AN773 Fittings



AN Part No.	Tubing OD	A Max.	(a) B Max.	(d) (b) C +.005 -.000	D Min.	E +1/64 -0	F Min.	(c) Nut
AN773-2	1/8	1-5/32	1/2	.189	.052	21/64	3/16	AN818-2D
AN773-3	3/16	1-7/32	9/16	.245	.109	5/16	3/16	AN818-3D
AN773-4	1/4	1-1/4	5/8	.295	.156	11/32	3/16	AN818-4D
AN773-6	3/8	1-5/8	13/16	.435	.281	3/8	1/4	AN818-6D
AN773-8	1/2	1-3/4	1	.570	.375	27/64	1/4	AN818-8D
AN773-10	5/8	1-7/8	1- 1/8	.690	.453	1/2	5/16	AN818-10D

(a) Dimension B shall fit standard wrench openings when hex body is used.

(b) Dimension C applies to machined parts only. When a flared tubing end is used instead of a machined part, the flare shall be in accordance with AND10078.

(c) A non-standard swivel nut may be used provided the hex dimension and the thread dimensions are in accordance with AN818 and provided the nut cannot be removed from the assembly.

(d) Dimension C of conical seat to be concentric with OD of nipple within .005 total indicator reading.

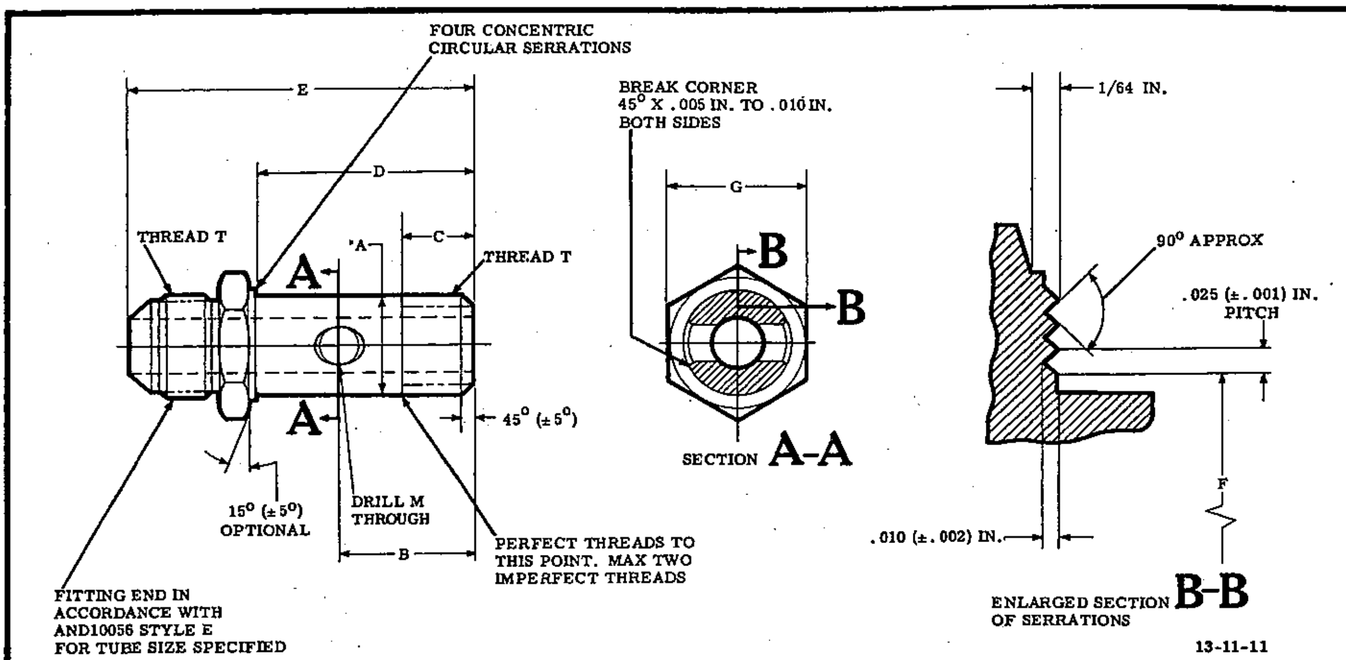
Fitting shall be capable of assembly with hose conforming to Specification MIL-H-5593 without the use of special tools or equipment.

Fitting shall withstand all tests specified in Specification MIL-H-5593 when assembled with hose.

Material: Aluminum alloy - bars, shapes or forgings.

Finish: Anodize.

Figure 11-16 Table of AN773 Fitting Assemblies



Part No. Steel	Part No. AL Alloy	Tubing OD	Thread T	A +.000 -.004 Dia.	B ±.010	C	D	E	G Ref.	M Dia
AN774-4		1/4	7/16-20 NF-3	.435	.781	7/16	1-3/16	1-59/64	.688	3/16
AN774-5		5/16	1/2 -20 NF-3	.498	.781	7/16	1-3/16	1-59/64	.750	7/32
AN774-6		3/8	9/16-18 NF-3	.560	.875	15/32	1-11/32	2- 1/8	.813	1/4
AN774-8	AN774D8	1/2	3/4 -16 NF-3	.748	1.094	9/16	1-11/16	2-19/32	1.000	5/16
AN774-10	AN774D10	5 /8	7/8 -14 NF-3	.873	1.250	19/32	1-31/32	3	1.125	3/8
AN774-12	AN774D12	3/4	1-1/16-12 N-3	1.060	1.468	21/32	2- 5/16	3-31/64	1.375	7/16
AN774-16	AN774D16	1	1-5/16-12 N-3	1.310	1.687	21/32	2-13/16	4- 3/32	1.625	5/8

Unified thread, class 3A, may be used if desired.

Material: Steel - bars, shapes of forgings (SAE 4140, 8740, 1141) 125,000 psi ultimate tensile strength minimum. Corrosion resistant steel - bars, shapes or forgings. Aluminum Alloy - 14S-T, 17S-T, 24S-T.

Finish: Steel - cadmium plate, stainless steel - passivate, aluminum alloy - anodize.

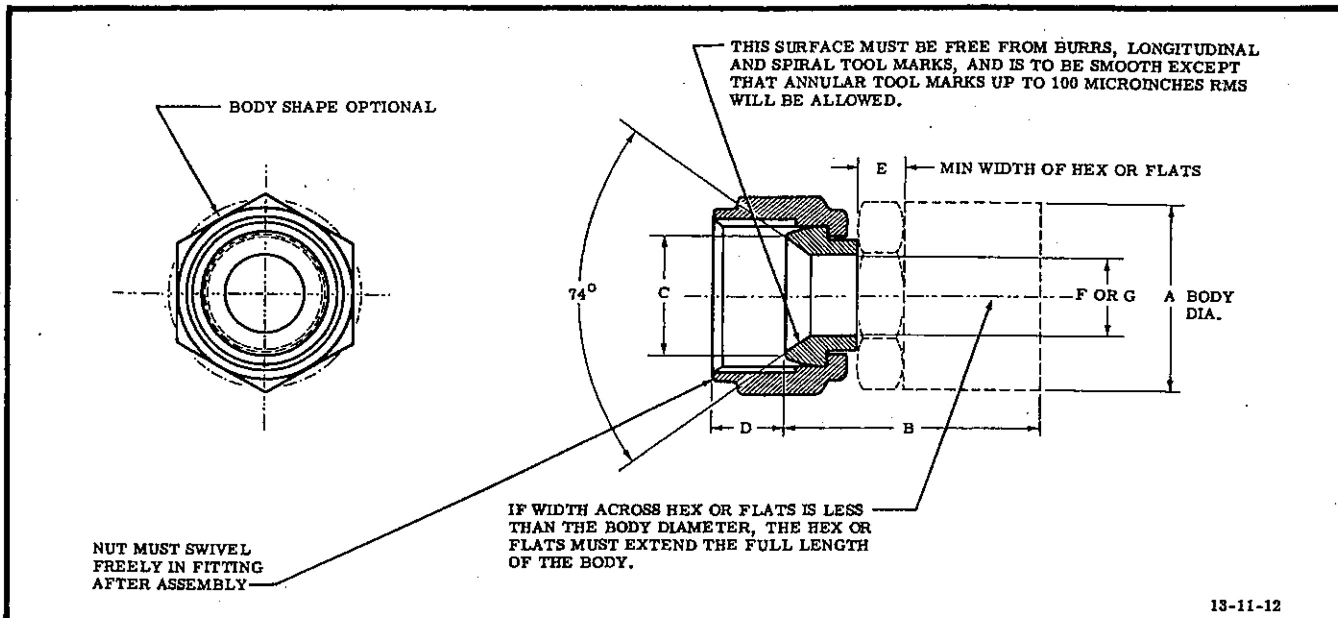
Add S in place of dash for corrosion resistant steel, type 304L and 347.

Add C in place of dash for corrosion resistant steel, type 302, 303, 304, 316 and 321.

Example of Part No: AN774S8 - bolt, 1/2 tubing, corrosion resistant steel, type 304L and 347. AN774C8 - bolt, 1/2 tubing, corrosion resistant steel, type 302, 303, 304, 316 and 321.

Break all sharp edges and remove all hanging burrs and slivers which might become dislodged under usage. Unless otherwise specified, tolerances: fractions ±1/64, decimals ±.005, angles ±1/2°.

Figure 11-17 Table of AN774 Flared Tube Fitting Bolts



AN Part No.	Hose ID (Ref)	Tubing OD	(b) Nut	A Max Dia	B Max	(a) C Dia	D	E Min	F Min Dia	G(c) +.005 -.000 Dia
MS28740-3	1/8	3/16	AN818-3	.687	1.375	.245	.337	.188	.121	.123
MS28740-4	3/16	1/4	AN818-4	.781	1.750	.295	.375	.188	.157	.170
MS28740-5	1/4	5/16	AN818-5	.875	1.781	.355	.375	.188	.219	.232
MS28740-6	5/16	3/8	AN818-6	1.000	1.906	.435	.375	.250	.281	.295
MS28740-8	13/32	1/2	AN818-8D	1.156	2.234	.570	.438	.250	.383	.390
MS28740-10	1/2	5/8	AN818-10D	1.375	2.406	.680	.515	.312	.469	.484
MS28740-12	5/8	3/4	AN818-12D	1.500	2.656	.850	.562	.375	.578	.608
MS28740-16	7/8	1	AN818-16D	1.625	2.395	1.103	.620	.375	.781	
MS28740-20	1-1/8	1-1/4	AN818-20D	2.062	2.705	1.410	.620	.500	1.031	
MS28740-24	1-3/8	1-1/2	AN819-24D	2.312	2.562	1.625	.765	.500	1.276	
MS28740-32	1-13/16	2	AN818-32D	2.812	3.094	2.240	.937	.625	1.745	

(a) Dimension C of conical seat to be concentric with OD of nipple within .005 full indicator reading.

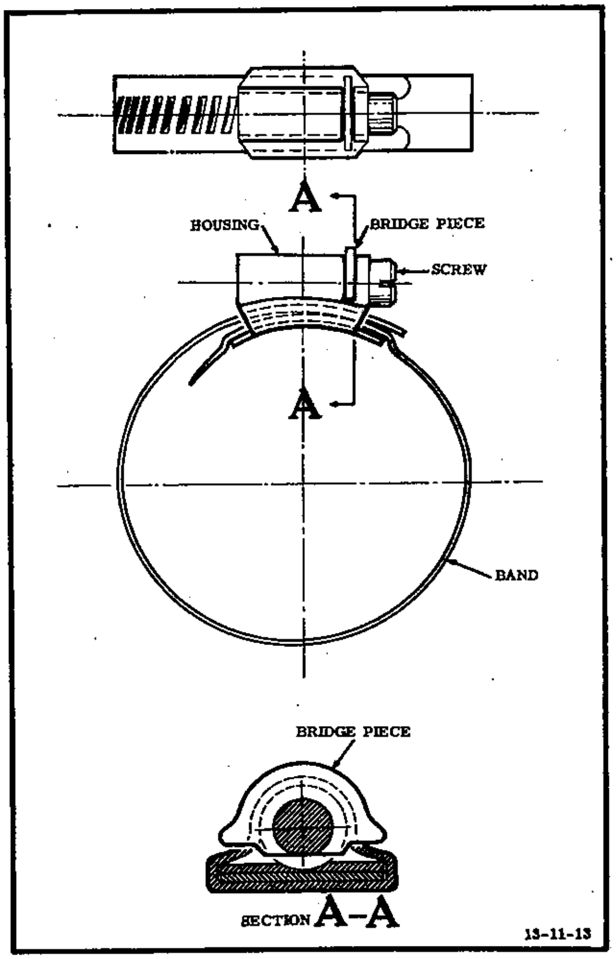
(b) A non-standard swivel nut may be used provided the hex dimension and the thread dimensions are in accordance with AN818 and provided the nut cannot be removed from the assembly.

(c) Dimension G shall be applicable to those end fittings which require a mandrel to assemble end fitting to the hose.

Examples of Part No: MS28740-3, -4, -5 and -6 shall be steel nipple and nut and aluminum alloy body. MS28740-8 and above may be aluminum alloy or steel nipple and aluminum alloy nut and body.

These fittings are for use with MIL-H-5511 hose.

Figure 11-18 Table of MS28740 Hydraulic End Fittings



Clamp Size	Sec. 28 Ref. No.	Outside Diameter of Hose in Inches
M-00	28/25079	7/16 to 9/16
00	28/2129	1/2 to 3/4
0	28/2130	5/8 to 1
1-A	28/25080	7/8 to 1-1/4
1-	28/2131	7/8 to 1-1/2
1-X	28/25081	1-3/8 to 1-5/8
2-A	28/25082	1-3/8 to 1-7/8
2-	28/2132	1-3/8 to 2-1/8
2-X	28/25083	1-3/4 to 2-1/4
3-	28/2133	2 to 2-3/4
4-A	28/25084	2-5/8 to 3-1/4
4-	28/2134	2-5/8 to 3-1/2
4-X	28/25085	3-1/4 to 3-7/8
5-	28/21380	3-3/8 to 4-1/4
6-	28/20741	4-1/8 to 5-1/8

Figure 11-19 Table of AGS605 Hose Clamps

28 Hose clamps (Item 7) to the latest drawing issued (see note) are the only clamps authorized for replacement purposes on RCAF aircraft. Stocks of these hose clamps are available in Supply Depots. An example of this type of hose clamp is shown in Figure 11-19.

NOTE

See latest revision of AGS 605 Sheets 1 to 5 inclusive.

29 Hose clamps other than those described in Figure 11-19 may be used on aircraft installations when approved by engineering authority.

(a) Exhaustive inspection tests 04AGS605 hose clamps confirm that the clamps are of sound construction and materials. Some failures have resulted from overtorquing. The practice on inspection of checking hose clamps by means of turning up each clamp a half turn, regardless of looseness or leakage, results in overtorquing and subsequent failure.

(b) The shelf life of rubber hose is to be strictly adhered to, otherwise deterioration may have set in and the resulting overtightening of clamps will not result in tight joints.

(c) Hose clamps other than those described in Figure 11-19 may be used on aircraft installations when approved by engineering authority.

Installation of Hose Clamps

30 To avoid installing imperfect hose clamps, examine each clamp for security of welding, operation of the tightening screw and extreme hardness of the band as follows:

(a) Examine to ascertain that clamps meet the general requirements as shown in Figure 11-19.

(b) Restore hose clamps that are out of shape through rough handling or previous use to their original shape, or discard. Discard clamp bands that have been taped within the pressure area of the band.

(c) When the strength of a hose clamp is doubtful, install the clamp on a sampel length of hose (Item 11). Use a hose nipple of the correct dimensions and tighten to 50 inch-pounds torque. If clamp does not fail or show other damage, it is serviceable.

(d) The strength of a clamp is affected by the heat treatment of the band. Bands that are too hard may break away or serrations may be torn out. Serrations which are too soft may fail under working tension. Carry out same test if any doubt about the heat treatment exists.

31 Worm screw type clamps are normally designed to accommodate several hose sizes. See Figure 11-19. They are most efficient when the outside diameter of the hose is equal to the largest size to which the clamp can be extended. Whenever possible, use worm screw type clamps in the range of their largest diameter. In order to assure equal pressures throughout the effective band area, when used in their smaller size ranges, tighten these clamps to the outside diameter of the hose and form the band to an approximate circle before installation.

32 Fit hose clamps as shown in Figure 11-20. Ensure that clamps are not installed over the beads and allow proper extension of the hose end to prevent the clamp from sliding off. In the event that a clamp is inadvertently installed over a bead, remove the hose and replace with a new hose, (Item 11).

33 Position clamps to allow maximum space for the use of tools when torquing the screw. Do not reposition hose clamps installed long enough to allow the hose to set unless the clamp torque cannot be obtained.

34 Position hose clamps so that band overhang or tightening screws will not damage or chafe neighbouring parts.

NOTE

Minimum gap G must be 1/4 inch or $\frac{\text{Tube OD}}{2}$, whichever is greater. Maximum gap G is not to exceed one tube diameter or 1 inch whichever is greater. See Figure 11-20. Allow maximum gap for offset connections. To compute minimum hose length for hose fitting to beaded tube use 2-1/8 inch + G + B. Minimum hose length for beaded tube to beaded tube is 1-7/8 inch + G + 2B.

CAUTION

Do not overtighten hose clamps. Ensure hose clamp is not fitted over bead.

35 Hose clamp torque wrench, RCAF Ref. 1T/1719, will eliminate most of the difficulties experienced with hose connections. Tighten hose clamps to approximately 25 inch-pounds. In the absence of torque limiting wrenches, exercise care to prevent over-tightening.

Retightening of Hose Clamps

36 If clamps do not seal at specified torque values, examine connections and replace parts as required. To retighten loose clamps, proceed as follows:

(a) If the clamp screw cannot be tightened with the minimum amount of pressure, do not disturb if no leak is evident.

(b) If leaking tighten one-quarter turn.

37 Tighten hose clamps installed on fuel cell fittings (rubber nipple type) and moulded rubber connections on fuel systems with the minimum

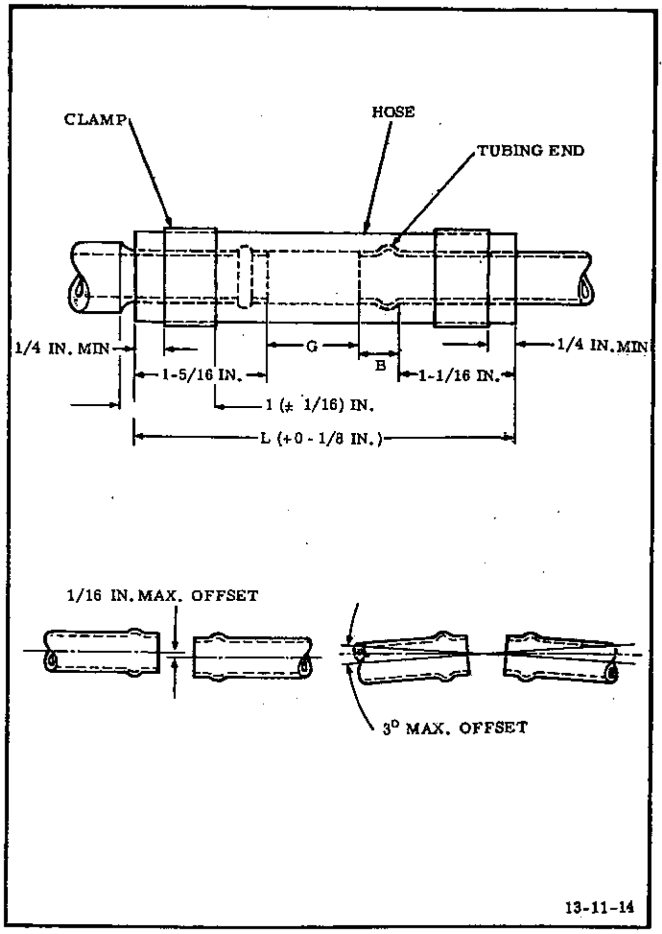


Figure 11-20 Hose Fitting

amount of pressure. Special care is to be observed as these fittings are easily damaged.

38 Aircraft hose (Item 11) constructed with synthetic compound has a tendency to cold flow. When a new hose of this type is installed, retighten the clamps after a period of time in order to maintain the original torque value. This is caused by the synthetic rubber flowing from under the clamping area and not from loosening of the clamps.

39 The reverse torque required to loosen the hose clamp is comparatively low for the worm screw type clamp. This is no indication of the amount of tension on the band nor is it an indication that the clamp has loosened from vibration.

40 Approved types of clamps (Item 7) have sufficient reverse torque to prevent loosening under working band tension and need not be safetied.

Double Hose Clamps

41 Double hose clamps are permitted with approval of engineering authority or when called for by approved drawings, material lists, specifications or engineering orders pertaining to specific installations. For installation, see Figure 11-21.

Inspection After Installation

42 The period from the installation of new hose until the first minor is the critical period for hose clamp connections and special attention is essential during this period. When a hose is installed, inspect:

(a) Hose and clamp positions.

(b) Leakage and tightness of the clamp immediately prior to the first two flights.

(c) All connections for positioning and clamp tightness daily until cold flow ceases.

43 When hose has been in use for sufficient time to allow the hose to set, carry out inspections in accordance with the relevant maintenance schedule.

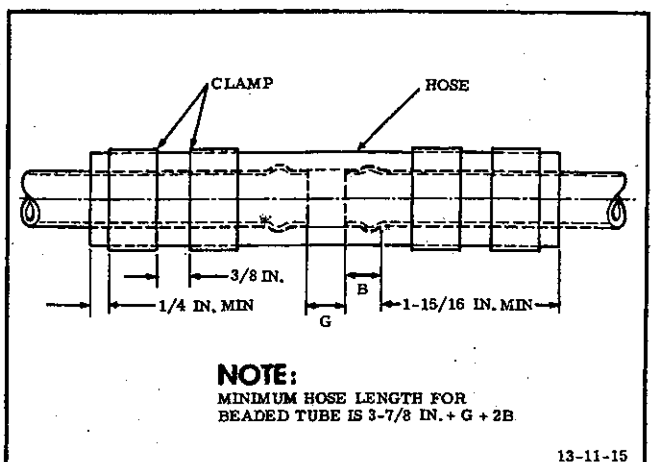


Figure 11-21 Double Clamp Hose Fitting

AIRCRAFT HOSE FITTINGS AND TUBE ENDS

Fitting End Hose Connection

44 When available, utilize hose fittings in accordance with design drawing AND10058 (Item 8). In this design, the section machined to accommodate the hose has a length of 1-1/2 inches, and the inner portion of the bead has a radius to eliminate the possibility of cutting the hose. (See Figure 11-22.) Some aircraft hose fittings will not meet this standard design. These parts are to continue in use. Do not disturb hose connections in service for examination of hose fittings.

NOTE

Do not use with sand cast aluminum. All surfaces are to be smooth machine finished.

Tubing End Hose Connection

45 Beaded tubing is to conform to the dimensions of design drawing AND10060, see Figure 11-23. The tubing must be cylindrical, free from dents, cracks and sharp edges. If possible, there is not to be a bend for a distance of three inches from the tube end.

NOTE

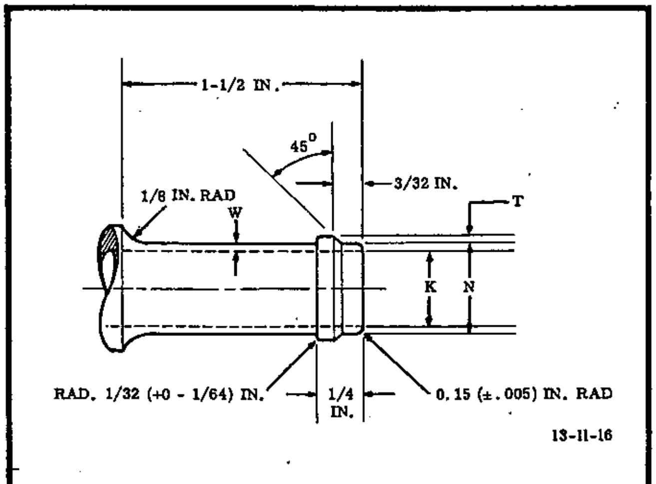
Use of Type A and Type B is optional on corrosion resistant steel and brass tubing of 3/4 inch and over.

46 Cold working of metal, in beading aluminum and copper, may further harden the beaded area to the extent that cracking of the tubing

may occur. When cracks are detected, replace the line or remove the defective bead, anneal the tubing and form a new bead.

47 Carry out annealing of aluminum tubing (Item 10) in accordance with EO 105-10-1. When anodized aluminum tubing is annealed, re-anodize before use. For annealing copper tubing, heat to a temperature of from 1100° to 1200°F and quench in water.

48 When replacement of aluminum tubing pressure line is necessary use 57S-O tubing (Item 10), as soft tubing may cause hose connection failure.



Dash No.	Nose ID	K Dia. (Min)	W (Min)	N Dia. +.010 -.000	T .003
4	1/4	.170	.031	.250	.031
6	3/8	.292	.032	.375	.035
8	1/2	.403	.039	.500	.038
10	5/8	.528	.043	.625	.038
12	3/4	.637	.051	.750	.038
16	1	.887	.051	1.000	.062
20	1-1/4	1.091	.074	1.250	.062
24	1-1/2	1.341	.074	1.500	.072
32	2	1.841	.076	2.000	.088

Figure 11-22 Table of AND10058 Hose Fittings

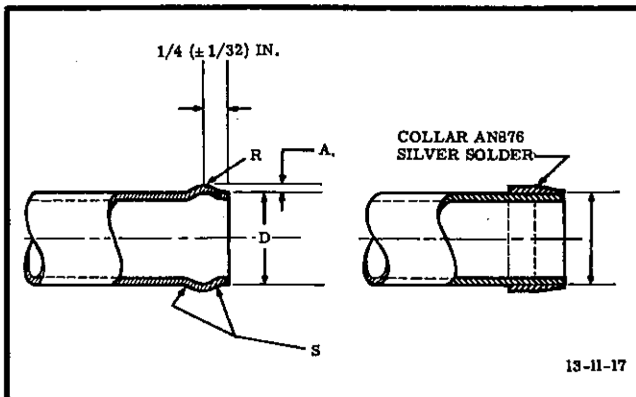
NOTE

Hose liners are not to be used with aircraft hose, (Item 11).

HYDRAULIC SELF-SEALING COUPLINGS

General

49 The Aeroquip (Item 21) and Wiggins (Item 22) hydraulic self-sealing couplings



Tube O.D.	Type A Bead Ht A ±.003	Rad. Max. R	Rad. Max. S	Type B Collar	
				Cor. Res. Steel	Brass
1/4	.031	1/8	1/16		
3/8	.035	1/8	1/16		
1/2	.038	1/8	1/16		
5/8	.038	1/8	1/16		
3/4	.038	1/8	1/16	AN876-12	AN876-12B
1	.062	5/32	3/32	AN876-16	AN876-16B
1-1/4	.062	5/32	3/32	AN876-20	AN876-20B
1-1/2	.072	5/32	3/32	AN876-24	AN876-24B
1-3/4	.072	5/32	3/32	AN876-28	AN876-28B
2	.082	5/32	3/32	AN876-32	AN876-32B
2-1/2	.082	5/32	3/32	AN876-40	AN876-40B
3	.082	5/32	3/32	AN876-48	AN876-48B

Figure 11-23 Table of AND10060 Hose Fittings

are designed to facilitate the service and maintenance of aircraft. With their use, it is possible to separate and reconnect lines without loss of hydraulic fluid or introduction of air into the system.

Aeroquip Self-sealing Coupling

50 This coupling (Item 21) consists of two coupling halves identified as S-1 coupling half and S-4 coupling half, (see Figure .1-24). The hydraulic S-1 coupling half is anodized blue for identification purposes. When connected, these coupling halves are held in place by a union nut and lock spring. The union nut has a quick lead thread which allows for separation and connection of the coupling halves with one turn by hand. Do not use tools on the union nut. The purpose of the lock spring is to keep coupling halves connected even under extreme vibration. Never assemble the coupling without the lock spring. The lock spring will disengage automatically when the union nut is unscrewed. An O-ring packing (Item 23) provides a seal which will effectively prevent external leakage. The standard self-sealing coupling comes equipped with a detachable mounting flange for attaching the S-4 coupling half to bulkheads.

51 This coupling is precision built to very close tolerances and the internal construction is factory assembled. Do not attempt to disassemble or replace parts in the coupling halves. Component parts illustrated in Figure 11-25 may be replaced in the field.

52 In Figure 11-24 the coupling is shown disconnected. The S-1 half consists of a body in which a tubular valve (A) is fixed. A sleeve (D) slides on the outside diameter of the tubular valve. The seat of the sleeve is held against the head of the tubular valve by the force of a spring (B). An O-ring packing (C) provides a seal between the sleeve and the body. The S-4 half consists of a male body in which a poppet valve (F) is held against its seat by spring pressure.

53 In connecting the coupling halves, the protruding portion (E) of the S-4 half makes contact with the sleeve (D) of the S-1 half. Simultaneously, the head of the tubular valve (A) makes contact with the face of the poppet valve (E), thus preventing air from entering the system. Tightening of the union nut causes the S-4 half to move axially in relation to the fixed tubular valve, carrying the sleeve away from the tubular valve seat. When the coupling halves are completely connected, the valve members have reached the positions shown in Figure 11-26 and the protruding portion (E) of the S-4 body has engaged the O-ring packing (C) of the S-1 half, providing a positive seal.

Installation of Aeroquip Self-Sealing Coupling

54 Use the following procedure for bulkhead installations:

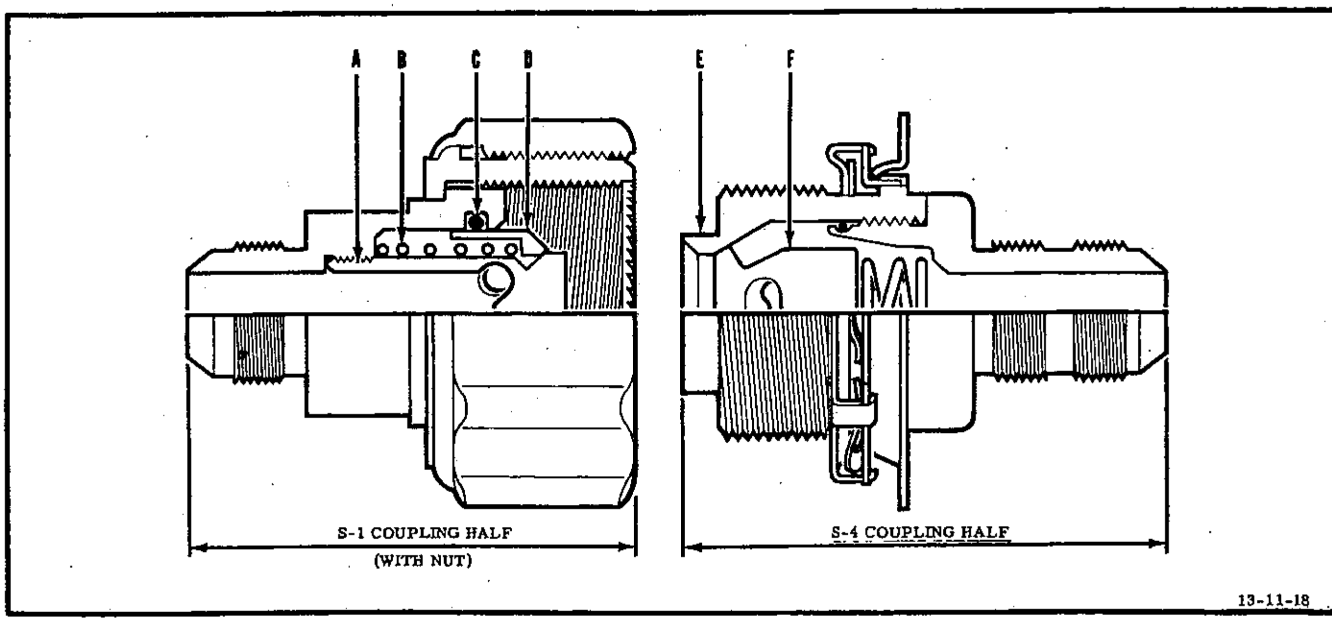


Figure 11-24 Self-sealing Coupling - Disconnected

(a) Disconnect the S-1 half from the S-4 half, unscrewing the union nut by hand. Do not use tools on the union nut.

(b) Remove lock spring by disengaging spring leaves. To accomplish this, pull spring leaves out and up, clearing the holding tabs. Slip lock spring over threads.

(c) Insert S-4 half into bulkhead opening and fasten detachable mounting flange with six bolts. Be certain that slots in hex of flange are aligned with milled slots in hex on S-4 body before fastening.

(d) Replace lock spring, aligning retaining tab on lock spring with slots in flange and hex of S-4 body. Return spring leaves to locked position. Make certain spring leaves are under holding tabs.

(e) When plumbing of both halves of the coupling has been completed, connect the S-1 half to the S-4 half with the union nut.

55 For installations where the coupling is not attached to the bulkhead, disassemble coupling as outlined in Paragraph 54, preceding. Remove the mounting flange. Complete installation as outlined in Paragraph 54, preceding.

WIGGINS QUICK-DISCONNECT COUPLING

General

56 The primary seal in the socket portion of a Wiggins quick-disconnect coupling (Item 22) may cause difficulty in coupling the socket and nipple together. This is the square rubber seal in the socket that engages with the end of the nipple. (See Figure 11-27.) The end of the nipple has a small step or shoulder on it and is tapered to slide into the hole of the primary seal. The shoulder or step depresses the outer side of the seal. The seal is then enclosed on all sides and prevents fluid leakage. If the primary seal is damaged, the secondary O-ring seal will prevent fluid leakage, provided that it too is not damaged. The primary seal will swell slightly when in contact with hydraulic oil. In some cases this may cause the nipple end to contact the seal, forcing the seal out of its seat and ahead of the nipple. This will be evidenced by the large hand force required to complete the coupling operation. To remedy this condition, the seal may be reseated in its groove with a smooth tool, taking care not to

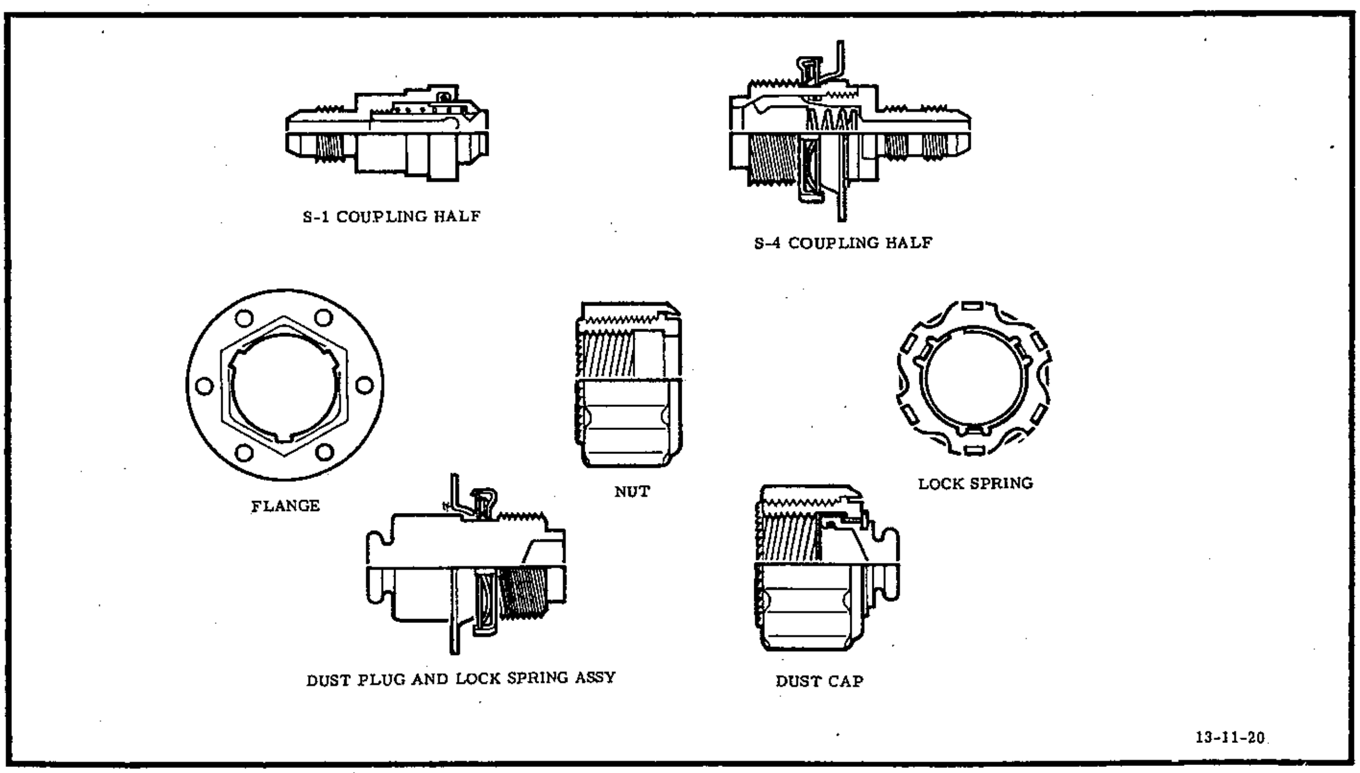


Figure 11-25 Self-sealing Coupling Parts

damage it. Even though a considerable force may be required to align and mate the nipple into the socket, the coupling is satisfactory if the locking dogs are properly engaged and completely covered by the collar so that parting of the coupling halves cannot occur.

NOTE

If there is evidence of damage to any seal or part of the coupling, it must be replaced with a serviceable item.

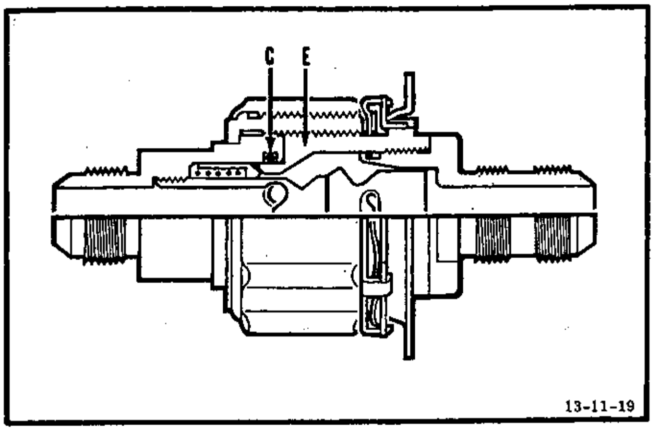


Figure 11-26 Self-sealing Coupling - Connected

Inspection Procedure

57 Inspect as follows:

(a) Visually check to determine that the coupling is completely engaged. The actuating collar must completely cover the locking dogs.

(b) It is permissible to move the locking collar into place by hand.

(c) No force should be necessary to install pin. If pin is binding on the locking collar, the coupling is not engaged properly.

Replacement of Couplings

58 Replace couplings as follows:

(a) Replace the socket assembly with an assembly that functions properly if actuating collar does not return and completely cover the locking dogs by spring action alone.

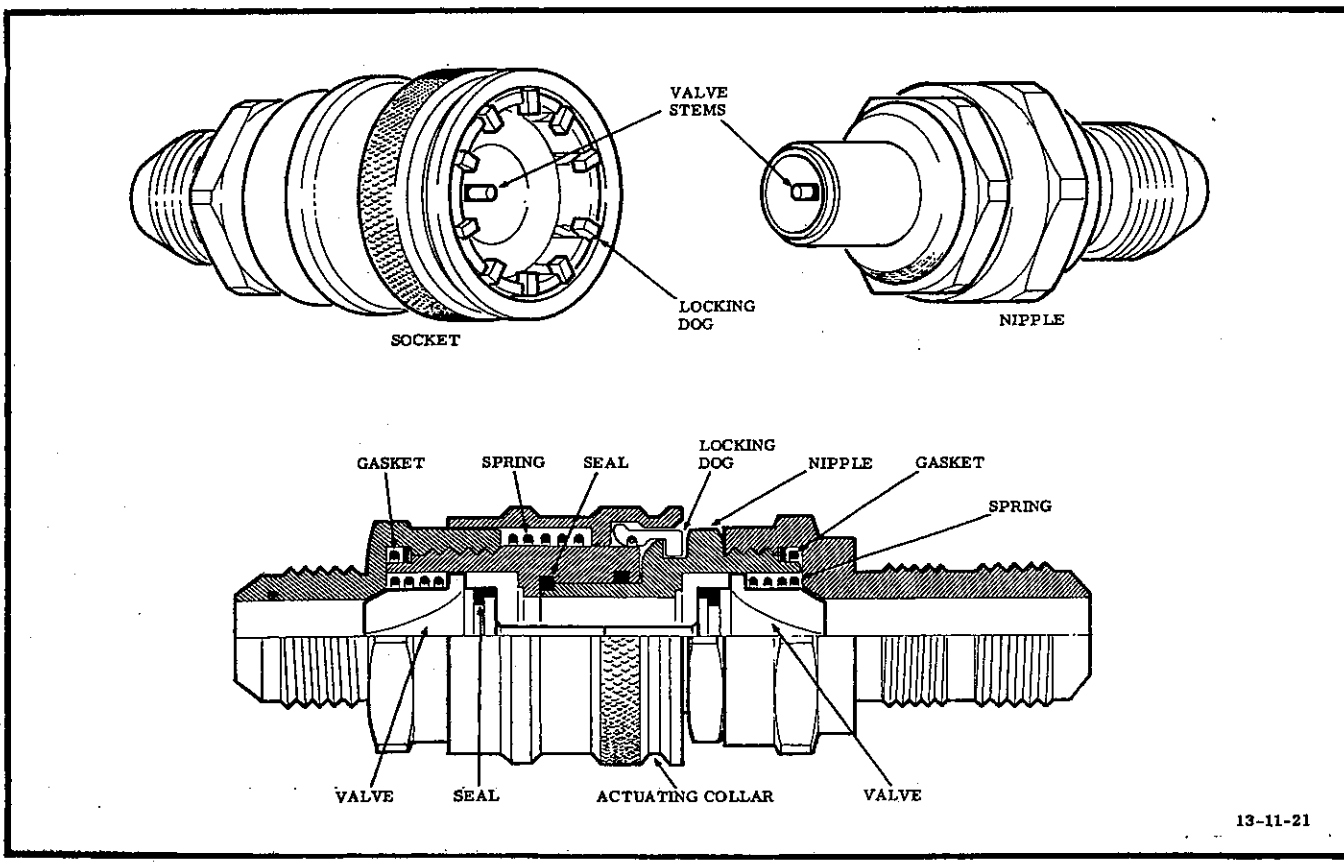


Figure 11-27 Wiggins Quick-disconnect Coupling

Item No.	Material	RCAF Ref	Specification	Manufacturer
1	Compound, Anti-seize	34A/164	3-GP-801	
2	Oil, Lubricating SAE 40	34A/23	3-GP-75	
3	Assembly, End fitting	28/	MIL-F-5070	
4	Hose, Flexible, Medium high pressure	32C as listed	MIL-H-5511	
5				
6	Hose, Flexible, Low pressure	32C as listed	MIL-H-5593	
7	Clamp, Hose AGS605	28/		
8	Fitting, Hose AND10058		MIL-F-5509	
9	Tube End AND10060		MIL-F-5509	
10	Tubing, Aluminum 52SO	30B/	WW-T-787	
11	Hose, Aircraft	32C as listed	MIL-H-6000	
12	Hose, Flexible fuel line	32C/	MIL-H-5512	
13	Clamp, Hose supporting	28/		Procured by assemblies only.
14	Fitting, Aeroquip	28NS/		Progress & Engineering Co. Ltd. 72 Stafford St. Toronto, Ont.
15				
16				
17	Grease, Lubricating	34A/167	MIL-L-6032	
18	Adapter AN815	28/	MIL-F-5509	
19	Fitting AN773 Type 1	28/	MIL-F-5509	
20	Fitting AN773 Type 2	28/	MIL-F-5509	
21	Coupling, Hydraulic, Self-sealing, Aeroquip	28NS/		Progress & Engineering Co. Ltd. 72 Stafford St. Toronto, Ont.
22	Coupling, Hydraulic, Self-sealing, Wiggins	28NS/		E. B. Wiggins Oil Tool Co. 2424 E Olympic Blvd. Los Angeles.
23	Packing, O-ring AN6227B	28/	MIL-P-5516	

Figure 11-28 Table of Material Specifications

(b) Immediately replace defective couplings on which the collar will not return and completely cover locking dogs.

(c) Replace, as soon as possible but not later than the next scheduled periodic inspection, defective couplings on which the collar does not return and completely cover the locking dogs by spring action alone, but will return by pushing on collar with the fingers. Difficulty in connecting the subject coupling is often caused by fluid lock in the lines. The line pressure holds the poppet valve closed with enough force to prevent complete insertion of the forward half of the coupling. To overcome this difficulty, back off the flex hose B nut from the Wiggins coupling enough to dissipate line pressure prior to making connection. Retighten B nut.

Material Specifications

59 For table showing item numbers, materials, specifications and manufacturers, see Figure 11-28.

PART 12

RIGID FLUID TUBING REPAIR AND REPLACEMENT

PART 12

RIGID FLUID TUBING REPAIR AND REPLACEMENT

TABLE OF CONTENTS

(Continued)

LIST OF ILLUSTRATIONS

PART 12

RIGID FLUID TUBING REPAIR AND REPLACEMENT

REPAIR AND FABRICATION OF RIGID LINES

General

1 Maintenance of rigid tubing lines is mainly a matter of replacement of tubing damaged due to mishandling; the rerouting of lines due to design changes, and the tightening of joints to stop or prevent leakage of fluids in the system.

JOINTS AND FITTINGS

General

2 Two types of joints are used at tubing connections, solid type using nipple and nut fittings, and beaded type using flexible hose and clamps. The solid joints used are of two types, flared and flareless.

Beaded Tube Joints

3 Beaded joints are used on low pressure lines. The most practical and rapid way of forming beads is by using a tool with a rolling action. Figure 12-1 shows the operation of the beading tool. For beading dimensions, see Figure 12-2. Instructions governing the use of hose clamps and restrictions on installations are detailed in Part 11, preceding.

Solid Joints

4 Solid joints are of two types, flared and flareless. Both types of joints use fittings consisting of a body, nut and usually a ferrule or sleeve.

Tube Connections

5 There are two general types of AN tube connectors commonly used, the three-piece and the two-piece shown in Figure 12-3.

6 In the past, fittings have been manufactured to three different specifications, as follows: (See Figure 12-4.)

(a) NAF (no longer in use).

(b) AN (this type is standard).

(c) AC (still frequently used).

AN Fittings

7 For typical AN fittings, see Figure 12-5. For threads and dimensions of AN816 fittings, see Figure 12-6.

Code of AN Fittings

8 For AN fitting code, see Figure 12-7.

Size

9 The dash number following the AN number indicates the size of the tubing (or hose) for which the fitting is made, in sixteenths of an inch. This size measures the outside diameter of tubing and the inside diameter of hose. Fittings having pipe threads are coded by

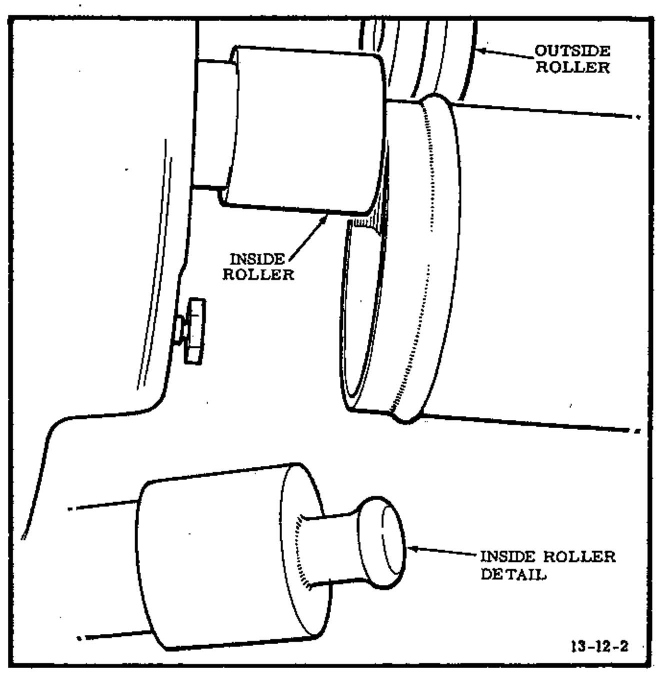
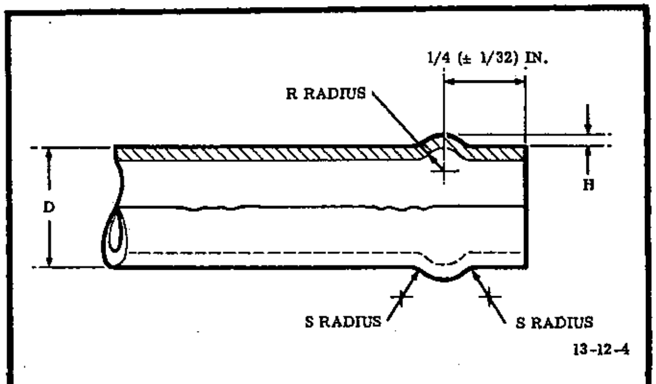


Figure 12-1 Use of Beading Tool

a dash number indicating the pipe size in eighths of an inch. The material code letter, (see Figure 12-7), follows the dash number.

Interchangeability

10 Certain fittings are interchangeable, although in most cases the pitch of the threads is different. Combinations of end connections, nuts, sleeves and tube flares make up a complete fitting assembly. The interchangeable parts, thread sizes, and tube fittings are shown in Figure 12-8. Where possible, avoid the use of dissimilar metals, especially brass, copper or steel, in contact with aluminum or aluminum alloys as this will cause corrosion.



D Outside Diameter of Tube	H Height of Bead	R Radius Max.	S Radii Max.
1/4	.034 - .028	1/8	1/16
5/16	.036 - .030	1/8	1/16
3/8	.038 - .032	1/8	1/16
1/2	.041 - .035	1/8	1/16
5/8	.041 - .035	1/8	1/16
3/4	.041 - .035	1/8	1/16
1	.065 - .059	5/32	3/32
1-/4	.065 - .059	5/32	3/32
1-1/2	.075 - .069	5/32	3/32
1-3/4	.075 - .069	5/32	3/32
2	.085 - .079	5/32	3/32
2-1/2	.085 - .079	5/32	3/32
3	.085 - .079	5/32	3/32

Figure 12-2 Dimensions of Rigid Tubing Hose Connection Beads

Approved Combinations of AN and AC811 Type Fittings

11 AN and AC811 sleeves, nuts, tube fittings and tubing flares may be satisfactorily interchanged in cases where the sleeve will fit properly in the nut, where the nut will not bottom on the fitting body and where sufficient thread engagement will result. In sizes 5 and smaller, the pitch of the thread on each size is the same for the two styles of fittings and can be interchanged with certain conditions as shown in Figure 12-8. In sizes 6 and larger, except sizes 28 and 32, comparable AN and AC811 fittings are not interchangeable since the pitch of the threads on the two types is not the same.

Torquing of Fitting Nuts

12 It is important to tighten or torque the fitting nuts to the correct tension when

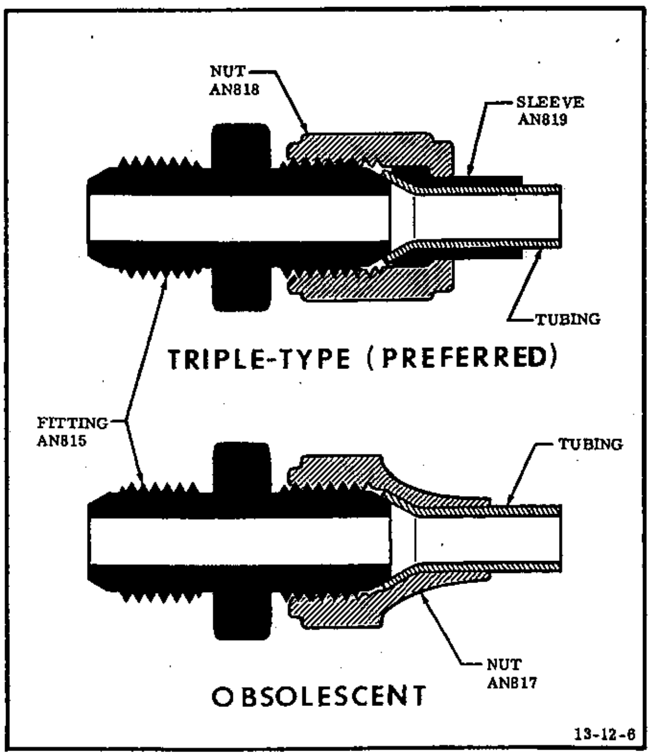


Figure 12-3 Tube Connectors

installing the tube assembly within the aircraft. Pliers must never be used to tighten fittings and crescent or monkey wrenches are not desirable. A fitting or open end wrench of the indicating torque type is best. Overtightening of the nuts may severely damage or completely cut off the tube flares, and may also result in damage to sleeve or nut of fitting. If, upon removal of the nut and sleeve, the flare is found to retain less than 50% of the original wall thickness of the tube, it should be rejected. The use of torque wrenches prevents such incorrect torquing.

13 A nut should never be tightened when there is pressure in the line, as this will tend to cut the flare without adding any appreciable torque to the fitting. If tightened properly, a tube fitting assembly may be removed and retorqued many times before reflaring is necessary. Undertightening may be equally serious, as this may allow the line to blow out or leak under system pressure. For torque tables and limitations refer to Part 25, following.

FLARED TUBE JOINTS

General

14 Flared joints are used on high-pressure lines. A taper tool is used for producing the flare.

Tube Cutting

15 To ensure a good flared tube connection, the tube must be cut off squarely. The end must be squared and any burrs removed before it is flared.

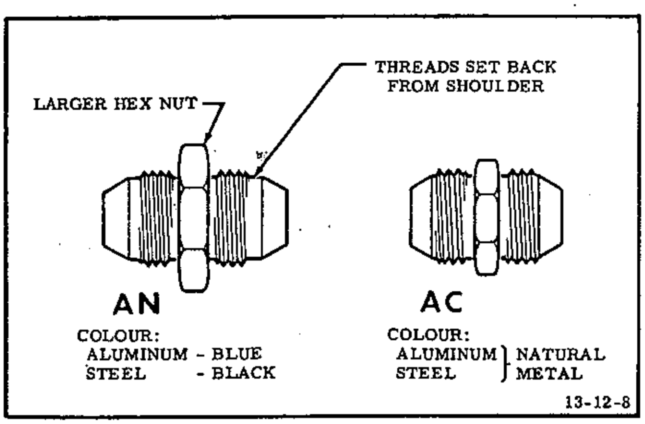


Figure 12-4 Comparison of AN and AC Unions

(a) Clamp the tube cutter over the tube, see Figure 12-9.

(b) Rotate the cutter towards its open side, gradually feeding the cutting wheel downward by turning the thumbscrew. Do not feed the wheel too rapidly. The cutting wheel should only be fed while the cutter is being rotated, as dents will be caused in tubing when the wheel is fed while the cutter is not moving. Moderate or light tension on the thumbscrew will maintain an even tension on the cutting wheel. This prevents bending and avoids excessive burrs on the tubing.

(c) If a cutter is not available, use a hacksaw blade with 32 teeth per inch.

Preparation for Tube Flaring

16 After tube has been cut off, file the end square with any fine-toothed flat file. If a hacksaw has been used, file the end of the tube

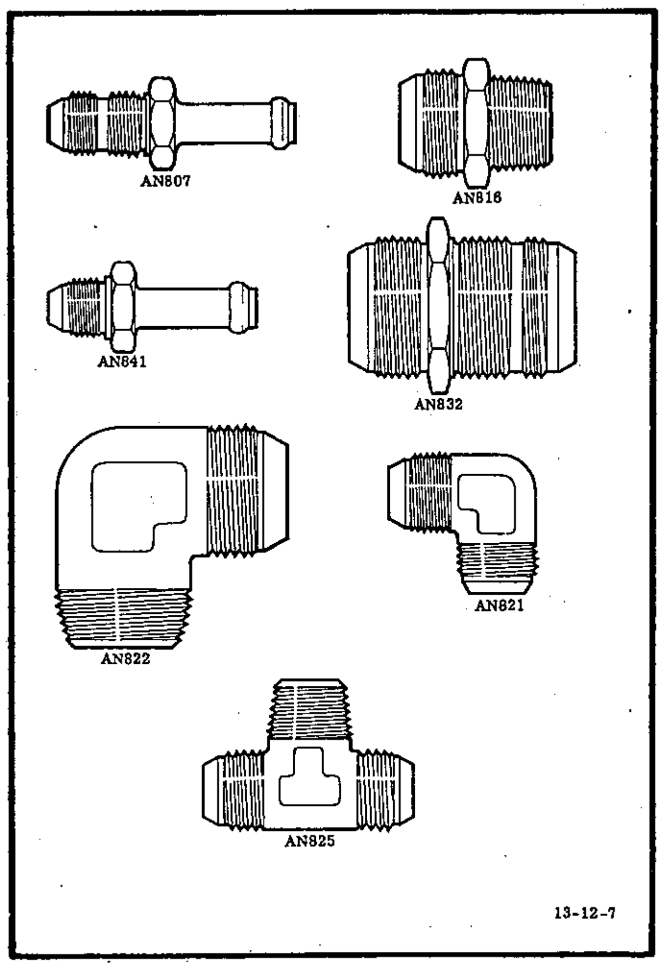
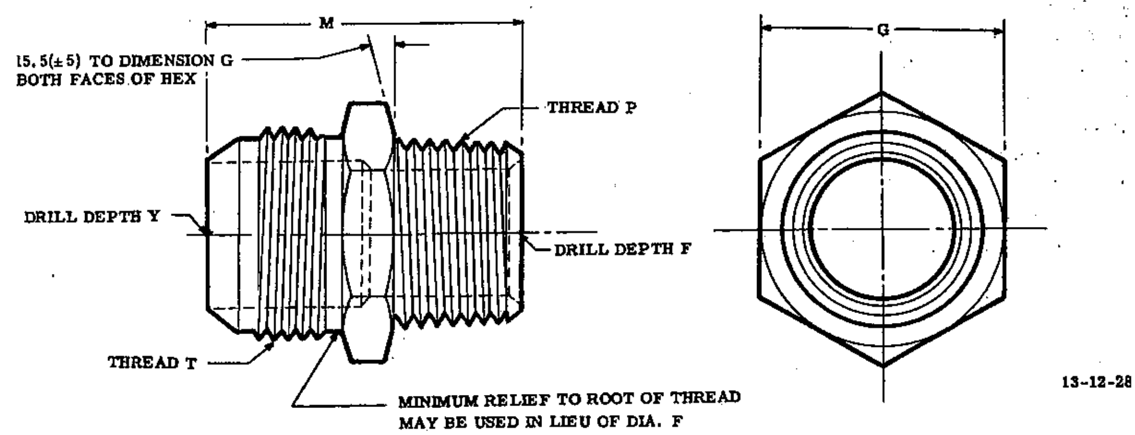


Figure 12-5 AN Fittings



Dash Number			Tubing OD	Thd P ANPT	Thread T Ref	F	G		M	Y
Steel	Al Alloy	Copper Alloy								
-2	-2D	-2B	1/8	1/8	5/16-24 NF-3	15/32	.438	+.003 -.004	1-1/64	
-3	-3D	-3B	3/16		3/8-24 NF-3				1-3/64	
-4	-4D	-4B	1/4		7/16-20 NF-3		.500		1-7/64	
-4-4	-4-4D	-4-4B		1/4		11/16	.563	±.004	1-3/8	
-5	-5D	-5B	5/16	1/8	1/2-20 NF-3		.562		1-9/64	5/8
-5-4	-5-4D	-5-4B		1/4		11/16	.563		1-3/8	
-6-2	-6-2D	-6-2B	3/8	1/8	9/16-18 NF-3		.625		1-3/16	11/16
-6	-6D	-6B		1/4		11/16			1-3/8	
-6-6	-6-6D	-6-6B		3/8			.750		1-13/32	
-6-8	-6-8D	-6-8B		1/2		7/8	.875		1-5/8	
-7	-7D	-7B	1/2	1/4	3/4-16 NF-3		.813		1-1/2	27/32
-8	-8D	-8B		3/8		11/16				
-10	-10D	-10B	5/8	1/2	7/8-14 NF-3	29/32	.938		1-53/64	
-10-12	-10-12D	-10-12B		3/4			1.125	±.005	1-27/32	
-12-8	-12-8D	-12-8B	3/4	1/2	1-1/16-12 N-3				1-61/64	1-1/16
-12	-12D	-12B		3/4		29/32				
-12-16	-12-16D	-12-16B		1		1-1/16	1.375		2-3/16	
-16-12	-16-12D	-16-12B	1	3/4	1-5/16-12 N-3				2-1/32	1-3/32
-16	-16D	-16B		1		1-1/8			2-7/32	
-20	-20D	-20B	1-1/4	1-1/4	1-5/8-12 N-3	1-3/16	1.688	±.016	2-23/64	
-21	-21D	-21B		1					2-21/64	1-1/4
-25	-25D	-25B	1-1/2	1-1/4	1-7/8-12 N-3		2.000		2-35/64	1-11/32
-28	-28D	-28B	1-3/4	1-1/2	2-1/4-12 N-3		2.375	±.020	2-53/64	1-7/16
-32	-32D	-32B	2	2	2-1/2-12 N-3	1-7/16	2.625		3-7/64	

Figure 12-6 (Sheet 1 of 2) Nipple, Flared Tube and Pipe Thread AN816

Specification	Material
QQ-A-354	Aluminum Alloy (AL-24).
QQ-A-355	Aluminum Alloy (AL-24)
QQ-A-367	Aluminum Alloy Forgings
QQ-B-611	Brass, (Commercial)
QQ-B-721	Bronze, Manganese
QQ-S-633	Steel, Carbon Bars
QQ-S-624	Steel, Alloy Bars
QQ-A-266	Aluminum Alloy, (14 S)
QQ-A-351	Aluminum Alloy, (AL-17)
MIL-B-6946	Bronze, Aluminum
MIL-S-6050	Steel, Chrome-Nickel-Molybdenum (SAE 8630)
MIL-S-6049	Steel, Chrome-Nickel-Molybdenum (SAE 8740)
MIL-S-6758	Steel,Chrome-Molybdenum (SAE 4130)
MIL-T-6732	Tubing, Chrome-Nickel-Molybdenum (SAE 8630)
MIL-S-5626	Steel (SAE 4140)
AN-S-9	Steel, Molybdenum (SAE 4037)

Finish: Aluminum Alloy: Anodic Treatment. Steel and other metals: Cadmium Plate. Add S after dash number for corrosion resistant steel, type 304L and 347. Add C after dash number for corrosion resistant steel, type 302, 303, 304 and 321. Examples of part nos: AN816-4: nipple 1/4 tube OD to 1/8 pipe, steel. AN816-4D: nipple 1/4 tube OD to 1/8 pipe, aluminum alloy. AN816-4B: nipple 1/4 tube OD to 1/8 pipe, copper alloy. AN816-8S: nipple 1/2 tubing and 3/8 pipe, corrosion resistant steel, type 304L and 347. AN816-8C: nipple 1/2 tubing and 3/8 pipe, corrosion resistant steel, type 302, 303, 304, 316 and 321.

Figure 12-6 (Sheet 2 of 2)
Nipple, Flared Tube and Pipe Thread AN816

Material	Colour Code	Callout Code
Aluminum Alloy	Light Blue	D
Steel	Black	No letter
Aluminum Bronze	Natural cad plate	B
Copper Base Alloys	Natural cad plate	Z (for AN819 Sleeve)

Figure 12-7 Code of AN Fittings

Tube Sizes OD	Male Fitting Thread	Female Nut Thread	Sleeve	Tube Flare
All Sizes*	AN	AN	AN	AN
All Sizes**	811	811	811	811
All Sizes	AN	AN	AN	811
	AN	AN	811	811
	AN	AN	811	AN
	811	811	AN	811
	811	811	AN	AN
	811	811	811	AN
#2, #3, #4, #5, #28, #32	AN	811	AN	811
	AN	811	AN	AN
	AN	811	811	811
	AN	811	811	AN

* Normal assembly of AN fittings.
** Normal assembly of 811 fittings.

NOTE

Combinations other than those listed will not seal satisfactorily and will not be used. Wherever possible endeavour to use either complete assemblies of AC811 or AN fittings on a system or particular installation.

Figure 12-8 Table of Approved Combinations of AN and AC811 Fittings until all saw marks have been removed. A tube vise or a flaring block makes a good clamp for holding the tube while filing. If a flaring block is used, avoid file marks on the top surface. To square the tube let it protrude only slightly from the block or vise, and file until the file runs flatly across the face of the block. Remove burrs and clean as follows:

(a) Remove burrs from both the inside and the outside of the tube by means of a burring tool. If a burring tool is not available, remove the inside burrs with a knife or scraper and the outside burrs with a flat file. Do not round the edges. Leakage will result if the burrs are not properly removed.

(b) Remove all filings, chips, burrs and grit from the inside of the tube in order to avoid pockmarks or scratches on the inner surface of the flare.

(c) Clean the tube thoroughly by blowing out with dry, filtered compressed air.

(d) Inspect the tube end to be sure it is round, square and clean, free of draw marks, mill scale and scratches. Scratches and draw marks are likely to spread and split the tube when it is flared.

Flaring Restrictions

17 The following restrictions apply to flaring:

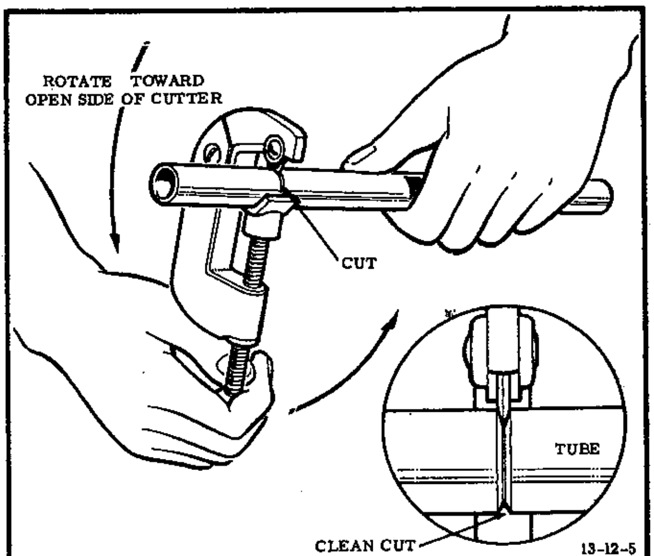
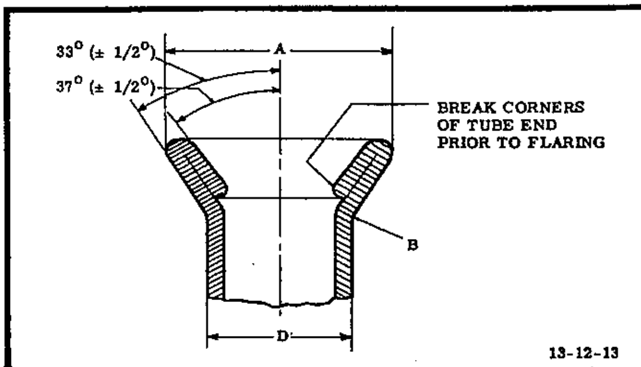


Figure 12-9 Tube Cutting

(a) Aluminum alloy tubing of 1/4 inch, 5/16 inch and 3/8 inch outside diameter generally, and all diameters for oxygen systems, must be double flared.

(b) Copper tubing for high pressure oxygen systems must not be flared. Use solder type fittings.

18 The tubing should be flared to conform to the flare seat of the fitting. For dimensions of flares see Figures 12-10 and 12-11.



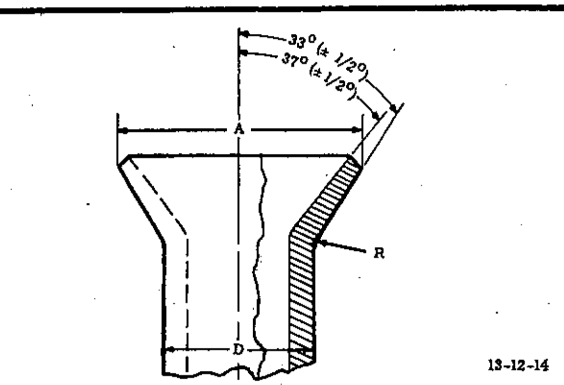
D Outside Dia. of Tube	A Diameter +.000 -.010	B Radius ±.010	Wall Thick-ness	Minimum Inside Diameter of Flare Lip
3/16	0.302	0.032	0.028 0.035	0.114 0.100
1/4	0.359	0.032	0.028 0.035	0.178 0.159
5/16	0.421	0.032	0.035 0.049	0.224 0.198
3/8	0.484	0.046	0.028 0.035 0.049	0.310 0.288 0.261

NOTE

Maximum diameter of return lip of flare must not exceed largest tube OD plus .040 minus twice the thinnest permissible wall. (See column 4.)

Minimum diameter of return lip; see column 5.

Figure 12-10 Double Flare Dimensions



D Outside Dia. of Tube	A Diameter	R Radius ±.010
1/8	.224 - .214	.032
3/16	See Note	.032
1/4	.359 - .349	.032
5/16	.421 - .411	.032
3/8	.484 - .474	.046
1/2	.656 - .646	.062
5/8	.781 - .771	.062
3/4	.937 - .927	.078
1	1.187 - 1.172	.093
1-1/4	1.500 - 1.485	.093
1-1/2	1.721 - 1.706	.109
1-3/4	2.106 - 2.091	.109
2	2.356 - 2.341	.109
2-1/2	2.856 - 2.841	.109
3	3.356 - 3.341	.109

NOTE

For 3/16" outside diameter tubing, diameter D - .312" - .302" for aluminum alloy and .290" - 280" for steel.

Check the flare by placing an AN819 sleeve (4) over the tube; the outside diameter of the flare should extend approximately 1/16 inch beyond the end of the sleeve, but should not be larger than the largest outside diameter of the sleeve.

Figure 12-11 Single Flare Dimensions

19 Aluminum alloy tubing does not have to be annealed for flaring or forming. It is easily flared, is soft enough to be formed by hand tools, and must be handled with care to prevent scratches, dents and nicks.

20 Flares in tubing must conform to the following requirements:

(a) Flares must be concentric and in alignment with the tube. On double flares, the concentricity with the outside diameter of the tube must be within .005 inch full indicator reading.

(b) Flares must be free of cracks, burrs and sharp edges, and the inside surface finished smooth and free from grooves, tool marks and other surface defects.

(c) Superficial marks and checks on the outside surface are not cause for rejection.

(d) The flared area must retain not less than 80% of the original wall thickness.

(e) Form flares so that, when assembling the sleeve, the sleeve contacts the flared surface on pushing together by hand, and does not jam back at the radius.

Flaring Methods

21 The flare is usually made by pressure from a conical swage. With earlier flaring tools, the pressure was applied with a hammer. Later tooling uses screw pressure.

Hammer Pressure Flaring

22 The hammer type flaring tool, (see Figure 12-12), consists of a sliding flaring pin with external thread on guide. A separate tool is provided with each size of tubing. To flare tubing with hammer tool, proceed as follows:

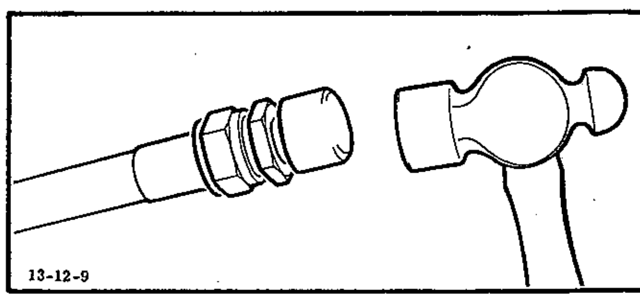


Figure 12-12 Hammer Flaring Tool

(a) Select the proper flaring tool for the tube to be worked.

(b) With a hammer, first tap the tool lightly, then use more force. Avoid cracking tube ends.

Combination Type Flaring Tool

23. To flare tubing with combination type tool, (see Figure 12-13), proceed as follows:

(a) Spread the flaring block by moving yoke aside. Insert tubing flush or with no more than 1/16 inch above top of flaring die jaws.

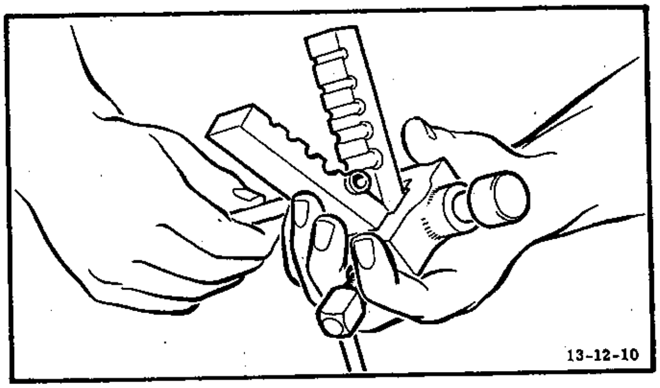


Figure 12-13
Combination Flaring Tool No. 410

(b) Slide yoke over tubing and clamp tightly in place with adjusting screw.

(c) Lower flaring pin to tube by light tap of hammer.

(d) Start flare with light hammer blows and continue until completed.

NOTE

For stainless steel tubing insert tubing in combination tool. Grip tubing in one hand and strike the pin sharply so that as few blows as possible will be required to obtain a completed flare.

Screw Pressure Flaring

24 In this method the conical swaging tool, or flaring cone, is screwed down into the mouth of the tube to make the flare. The tube is supported by a flaring die block similar to that used in the hammer combination tool. Various improvements have been made in this tooling. In the tool illustrated, (see Figure 12-14), rollers are set in the flaring cone, the size of the flare is preset, and the finished flare is burnished.

25 The operation is as follows:

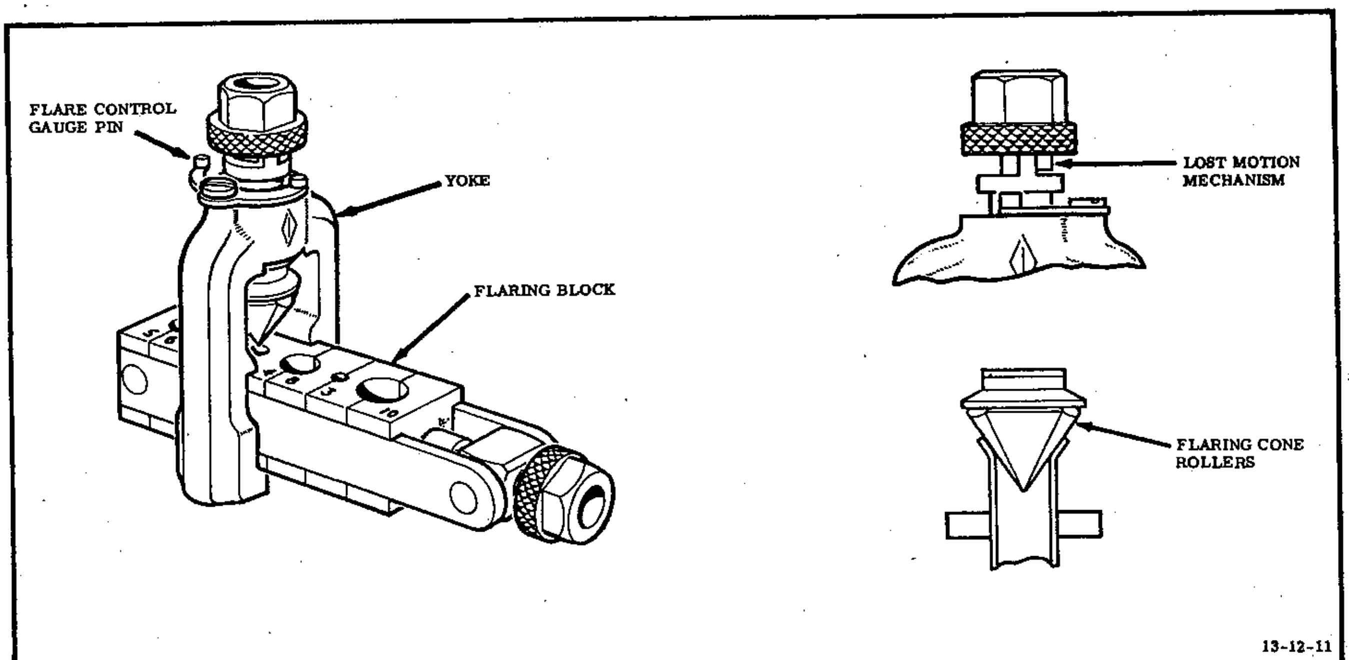


Figure 12-14 Roller Flaring Tool

(a) The correct spacer leg of the flare control gauge is pivoted into position and the cone feed screw is turned down until a shoulder contacts the gauge.

(b) The yoke is slipped over the flaring die block and tubing is inserted in the proper opening, using the flaring cone as a stop.

(c) The flare control gauge is then pivoted to a neutral position and the compressor screw turned down as far as it will go. The flare is formed above the die block.

(d) When backing off flaring cone after flare is made, a lost-motion mechanism disengages the feed during the first revolution, causing the three rollers in the cone to burnish the flare.

Double Flaring

26 Double flaring is generally required in aluminum alloy tubing 1/4 to 3/8 inch outside diameter and is required on all diameters of aluminum alloy tubing used in oxygen systems. A double flaring operation by the screw pressure method is shown in Figure 12-15. Double

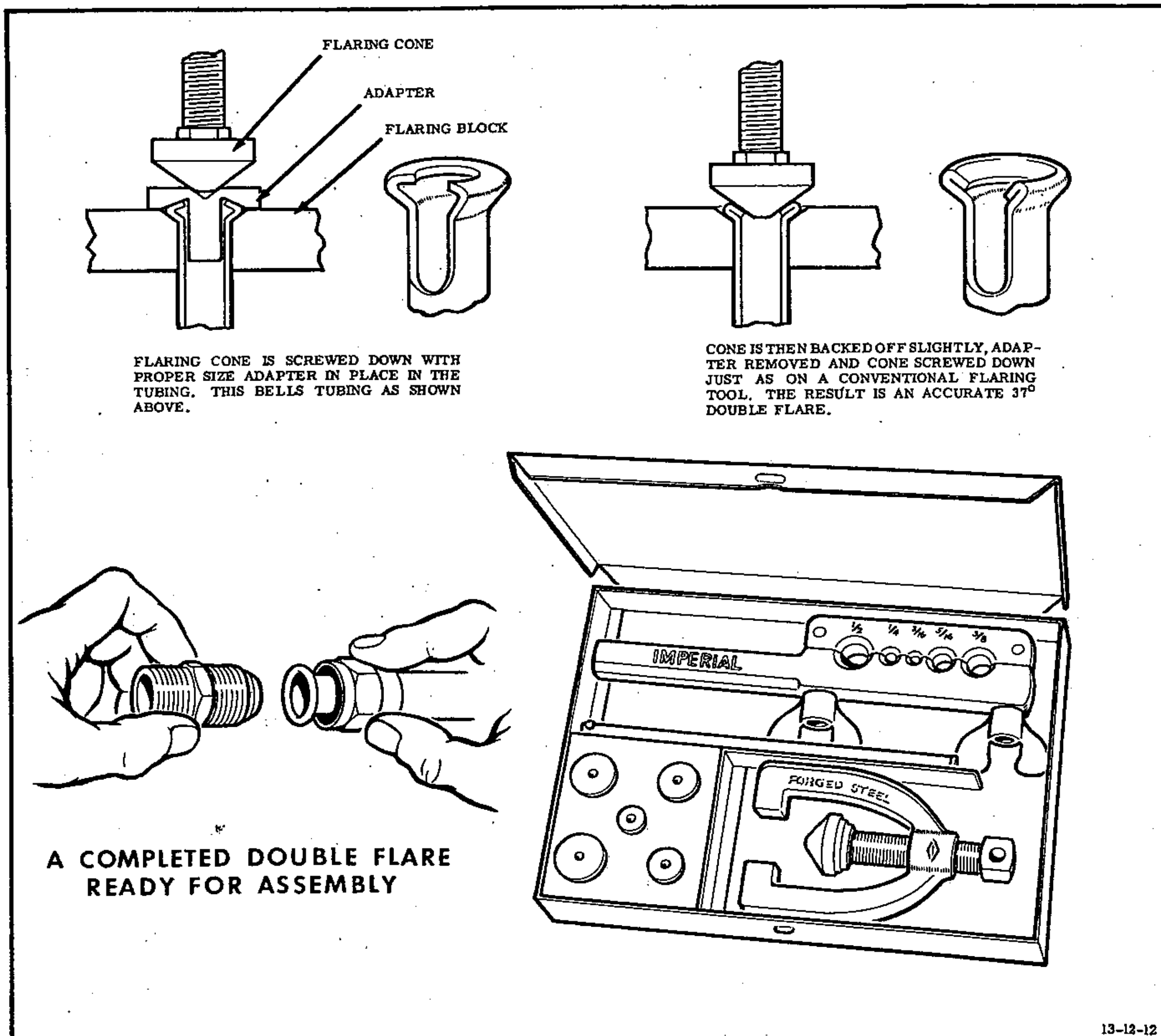


Figure 12-15 Double Flaring Tool Kit

flaring can also be done by the hammer pressure method. To make a double flare, proceed as follows:

(a) Prepare the tube as for a single flare.

(b) Make the initial flare. The size of the initial flare and the length that the tube must project from the die block (or flaring bar) is found by trial.

(c) Back off flaring cone, install correct adapter and bellmouth the tube.

(d) Remove adapter and complete flare with flaring cone. Flaring must conform to dimensions shown in Figure 12-10.

NOTE

Before flaring, make certain that the clamping surfaces are free from oil, grease or aluminum alloy particles. An occasional cleaning with a solvent (Item 1) and a stiff fibre brush is recommended. A wire brush or steel wool should not be used. If the tubing slips in the tool and the cleaning procedure does not work, dip the clamping blocks in a 20% solution (by weight) of sodium hydroxide, (Item 2) or potassium hydroxide (Item 3) in water. This will remove aluminum alloy particles. Do not sandpaper, grind or refinish the inner surfaces of the tool as this will render the tool unsatisfactory for use.

27 Check the flare by placing a sleeve (Item 4) over the tube. The outside diameter of the flare should extend approximately 1/16 inch beyond the end of the sleeve, but should not be larger than the largest outside diameter of the sleeve.

Assembly of Flareless Fitting

28 The flareless fitting (Item 5) gives a positive sealing action when assembled. Use the following assembly procedure:

(a) Cut tube square and deburr. Do not radius ends.

(b) Clean tube. Refer to Paragraph 16, preceding.

(c) Slip nut and ferrule on tube. Ensure ferrule cutting edge is toward end of tube.

(d) Insert end of tube into fitting body, bringing tube end tight up against body shoulder.

(e) Bring nut and ferrule to body and screw up finger tight, then tighten with wrench until ferrule bites into tube. If in doubt about extent of bite, disassemble and examine. For completed assembly see Figures 12-16 and 12-17.

Assembly of Flared Fittings

29 Rigid tubing assemblies having AN fittings are to be assembled as follows:

(a) Immediately prior to installation, lubricate the male threads of fittings in accordance with Paragraph 38, following.

(b) Place the assembly in the installed position, making certain that the tubing is not scratched during installation.

(c) Align the tubing, flares and fittings accurately, then press the flares and cones tightly together to make full contact.

(d) Using fingers only, start the nuts on the fittings and turn until the flares and sleeves are firmly seated. Ensure that the flares are snugly pressed against the cones by attempting to shake the tube. Do not use the nut to draw the flare onto the cone. Do not use a wrench until the nut is finger tight.

(e) When the nuts are finger tight (hand tight on oxygen lines), place a wrench on the hexagon or flat of the body of the fittings to prevent turning and use a torque wrench on

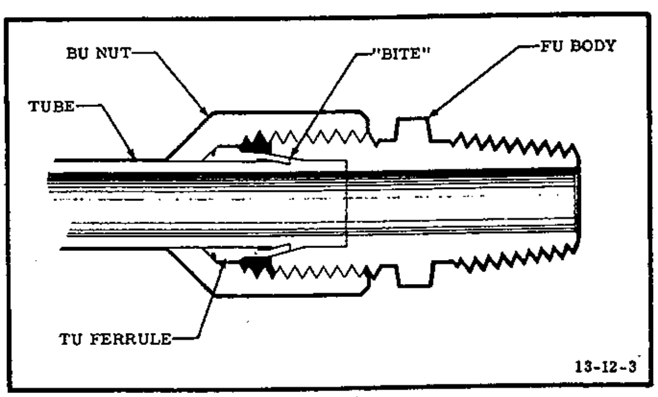


Figure 12-16 Flareless Fitting Assembly

the nuts to tighten the nuts to the torque values specified in Part 25, following.

30 When a straight threaded fitting is screwed into a component, such as a pump or filter, an O-ring or similar gasket is required. Frequently no recess is provided in the component and the O-ring is compressed between the component boss and the fitting hexagonal face.

31 With taper threads, no gasket is used. Thread compounds for both straight and taper threads are listed in Figure 12-18.

Bulkhead Fittings using O-rings.

32 Install as follows:

(a) Spin nut (Item 6), on fitting (Item 7), past the waisted portion and on to second threads.

(b) Lubricate threads with hydraulic fluid and work on ring (Item 8), until it touches the nut.

(c) Work on gasket until it is against the ring (Item 8).

(d) Turn nut down against the back-up ring (Item 8) until the back-up ring forces the gasket (Item 9) firmly against the threads.

(e) Install fitting (Item 7) in boss, letting the nut turn with fitting until the gasket contacts the face of the boss. This can be determined by a sudden increase in torque. With the fitting in this position, place a wrench on the nut to prevent it from turning and at the same time turn the fitting 1-1/2 turns.

(f) Position fitting by turning it not more than one additional turn.

Bulkhead Assembly using Washer

33 At least one washer is required between the web of the bulkhead and the bulkhead fitting nut. See Figure 12-19 for proper installation of AN elbows, tee fittings and adapters.

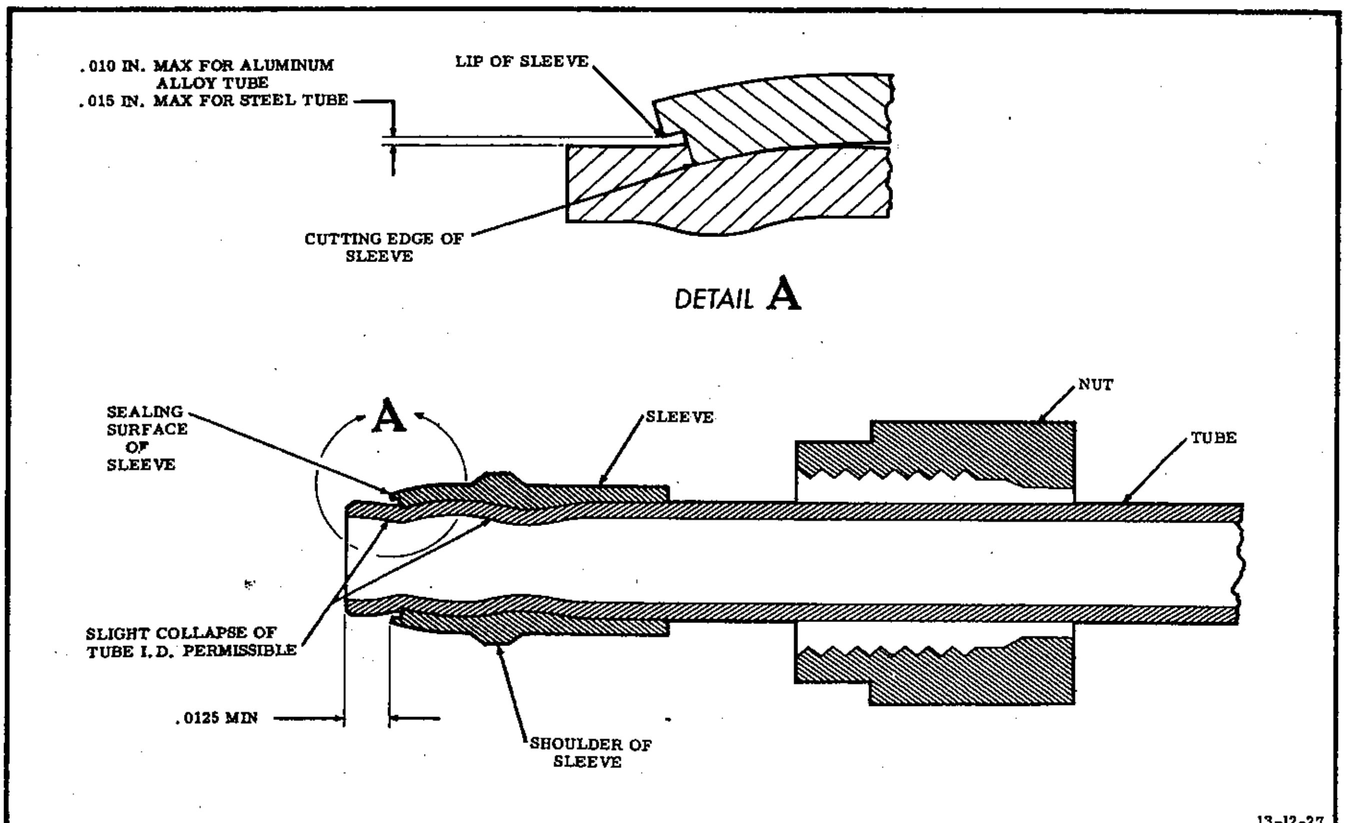


Figure 12-17 Flareless Fitting Assembly Dimensions

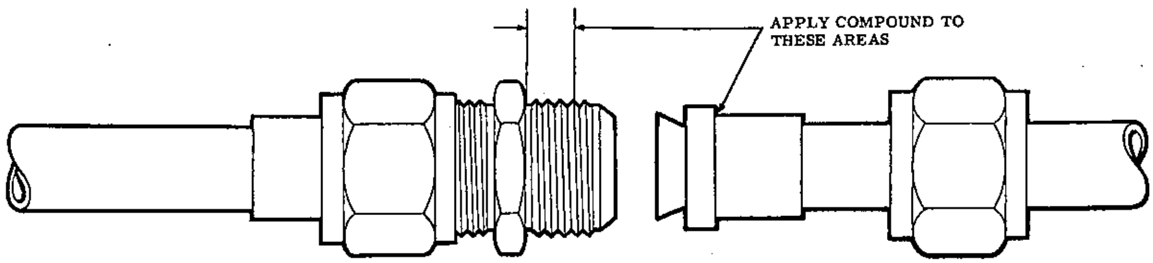
Sealing of Gaskets

34 Gaskets (Item 11) used in fuel lines are sealed on assembly with grease, (Item 10).

35 Install O-rings in fuel cell interconnectors as follows:

(a) Prior to installation, examine the O-rings for imperfections such as tears, cracks and incomplete sections.

(b) Lubricate each O-ring with petrolatum (Item 12) and carefully slide into the groove.



Type of Installation		Thread Compound Specification: Straight Threads	Thread Compound Specification: Tapered Threads
Engine Fuel and Oil Pressure Instruments (Transmitter Type)	A-1 Type Transmitter	Gasoila Varnish	Gasoila Varnish
	Autosyn Type Transmitter	JAN-A-669	JAN-A-669
Fuel		JAN-A-669	Gasoila Varnish and JAN-A-669. Refer to Paragraph 36.
Hot Air		Wingo RBI	Wingo RB1
Hydraulic		AN-P-51 or MIL-O-5606	JAN-A-669
Pneumatic		MIL-L-4343	MIL-L-4343
Oxygen		MIL-T-5542 B	MIL-T-5542 B
All Other Systems Not Covered Above		JAN-A-669	JAN-A-669

NOTE

On threads in oxygen systems, the compounds specified are used only to prevent seizure and not for sealing.

Figure 12-18 Thread Compound Application

(c) Apply petrolatum to the surface of the fuel line tube which contacts the O-ring and complete the installation.

(d) Before using Lock-O-Seal washers in fuel cell installations, remove the O-ring portion of the washer, examine for imperfections and lubricate with petrolatum. Slide the O-ring onto the bolt and add the metal retaining washer, making sure the ring is well nested in the washer.

NOTE

Lock-O-Seal washers must not be used in fuel systems, fuel cells or tanks, unless used in original installation.

Lubrication of Tapered Thread in Fuel System

36 To lubricate tapered threads in fuel systems, proceed as follows:

(a) Apply varnish (Item 14) sparingly and carefully to the male threads only, but not to the first two male threads to engage the female threads.

(b) Allow the sealing compound to dry.

(c) Apply a thin coat of anti-seize compound (Item 15) to all male threads including those threads already coated with sealing compound and the first two bare threads.

(d) Assemble the threaded fittings and torque. For torque tables, refer to Part 25, following.

(e) Pressure test all assemblies with aircraft fuel.

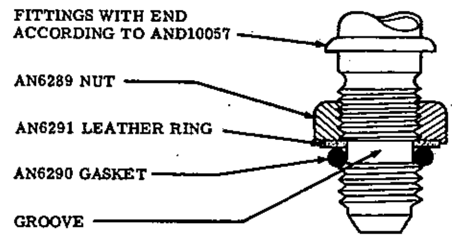
Galling in Tapered Threads of Soft Aluminum Bosses.

37 Where galling is encountered on screwing fittings with tapered (pipe) threads into soft aluminum bosses, proceed as follows:

(a) Apply petrolatum (Item 12), to the male threads in accordance with Paragraph 36, preceding and secure the male fitting into the boss by hand.

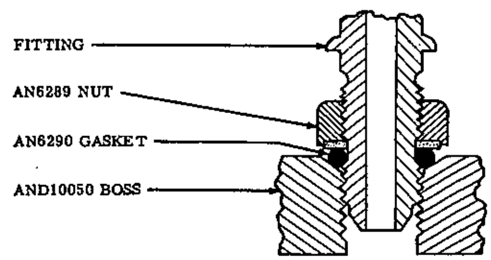
(b) Back out the fitting and apply compound (Item 15), to the male threads in accordance with Paragraph 36, preceding.

STEP 1



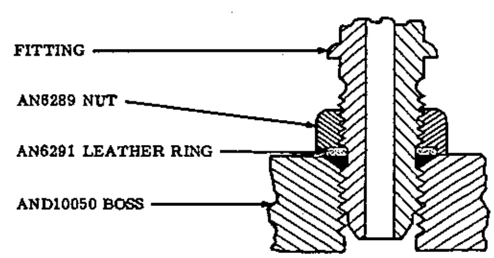
COAT MALE THREADS OF FITTING, AN6291 LEATHER RING, AND AN6290 GASKET SPARINGLY WITH PETROLATUM, SPECIFICATION AN-P-51 (VASELINE), OR HYDRAULIC FLUID AND ASSEMBLE AS SHOWN. WORK THE AN6291 LEATHER RING INTO THE COUNTERBORE OF THE AN6289 NUT; THEN TURN THE AN6289 NUT DOWN UNTIL THE AN6290 GASKET IS PUSHED FIRMLY AGAINST THE LOWER THREADED SECTION OF THE FITTING.

STEP 2



INSTALL THE FITTING INTO THE AND10050 BOSS AND, AT THE SAME TIME, KEEP THE AN6289 NUT TURNING WITH THE FITTING UNTIL THE AN6290 GASKET CONTACTS THE AND10050 BOSS. THE POINT CAN BE DETERMINED BY A SUDDEN INCREASE IN TORQUE. WITH THE FITTING IN THIS POSITION, PUT A WRENCH ON THE AN6289 NUT TO PREVENT ITS TURNING AND, AT THE SAME TIME, TURN THE FITTING IN 1-1/2 TURNS. POSITION FITTING BY TURNING IN NOT MORE THAN ONE ADDITIONAL TURN.

STEP 3



HOLD FITTING AND TURN AN6289 NUT DOWN TIGHTLY AGAINST AND10050 BOSS. SLIGHT EXTRUSION OF THE AN6291 LEATHER RING IS NOT DETRIMENTAL.

13-12-25

Figure 12-19
Nut, Gasket and Ring Assembly Instructions

(c) Screw the fitting into the boss and tighten.

WARNING

This procedure must not be used in oxygen systems.

Lubrication of Threaded Tube Connections

38 To lubricate threaded tube connections, proceed as follows:

(a) Apply the selected compound sparingly and carefully to the male threads only, but not to the first two male threads to engage the female threads (see Figure 12-18).

(b) Where connections are of the type using a coupling sleeve (Item 17), or similar, apply a thin coat of the selected compound to the back of the shoulder of the sleeve, (see Figure 12-18). Use a small stiff brush for this purpose.

NOTE

Do not apply or allow compound to remain on the end of a fitting where it may enter the system and cause contamination or malfunction. Do not apply compound to female threads.

SOLDERING PROCEDURE - HIGH PRESSURE OXYGEN TUBING

General

39 Soft solder (Item 16) only is to be used for making soldered joints on high pressure oxygen copper tubing for replacement or repair. The solder is to be melted in a container sufficiently large to allow the ends of the tubing to be dipped into the liquid solder. A stainless steel container should be used. If none is available mild steel may be used provided the inside is perfectly clean and free from scale or rust.

Flux

40 Two types of flux are required to carry out the soldering operation, one to cover the top of the liquid solder in the container to prevent oxidization and another to be applied to the solder joint itself.

41 Use soldering flux (Item 19) to cover the surface of the liquid solder in the container. If this type of flux is not available, clean tallow may be used as a substitute.

42 Use flux (Item 20), on solder joints themselves. This flux may be made up locally by mixing 5 pounds of zinc chloride, 1/2 pound of ammonium chloride (Item 21), and up to 4 ounces of hydrochloric acid (Item 22) (having a specific gravity of 1.16), with sufficient water to make one gallon of solution.

Degreasing before Soldering

43 Ensure that tubing is cut to length and ends are square. To degrease before soldering, proceed as follows:

(a) Clean for tinning and remove the burrs.

(b) Blow the tubes through with compressed air to remove any filings and wash with clear solvent (Item 17), which has been kept at room temperature. A reasonable amount of the degreasing liquid must be passed through the pipes at least twice.

(c) Wash a third time using clean liquid.

(d) Dry the piping with clean dry air or oxygen until no smell of the cleaning agent remains. This degreasing process is necessary, as hydraulic tests on piping are often done with paraffin.

(e) Degrease nipples by rinsing three times in solvent (Item 17) and dry using clean dry air or oxygen.

Inspection of Nipples for Defects

44 Before nipples are soldered on tubing, they are to be inspected for cracks or breaks as follows:

(a) Prepare a solution of one part concentrated nitric acid (Item 18), and three parts water.

(b) Immerse nipples in the above solution for a period of two minutes.

(c) Remove nipples from solution and rinse first with cold water, then with warm water. Dry thoroughly.

(d) Inspect the nipple carefully for any signs of cracks or breaks in the metal.

Method of Soldering

45 For soldering, use the following procedure:

(a) Melt solder under cover of flux (Item 19) and maintain at 255° (±10°)C (490° (±18°)F).

(b) Dip tube end and immerse nipples for two minutes in boiling 120°C (250°F) flux (Item 20).

(c) Plug fluxed tube end with wood and dip tube in solder (Item 16), remove and wipe with steel wool immediately to ensure tinning.

(d) Inspect tinning and dip tube again in solder.

(e) Take the nipple out of the boiling flux and place it on the end of the tube.

(f) Dip both in flux (Item 20).

(g) Heat the nipple gently until solder starts to melt and immediately remove from flame.

(h) Press the nipple into position on the tube.

(j) Clean off excess solder with steel wool, cool and remove plug.

Cleaning after Soldering

46 When soldering is complete, all traces of flux or foreign matter are to be removed as follows:

(a) Using clean solvent (Item 17), wash off any flux from the nipples and tubing end. Pass a small quantity of the liquid through the tubing towards the end which has been soldered so that none of the residue will be washed into the tube.

(b) Dry the tubing with clean dry air or oxygen until no odour from the solvent remains.

(c) Repeat the process outlined in Subparagraph (a), using detergent (Item 23).

(d) Rinse the tubing and nipple with hot water.

(e) Dry the tubing thoroughly using clean dry air or oxygen.

(f) If pipes are not installed immediately after cleaning, protect the open ends with rubber caps or bind up to prevent ingress of dirt or moisture.

Drying and Testing

47 Use air or oxygen only for drying and testing oxygen lines. If air is used, it must be entirely free from oil, oil vapour, grease or other organic matter and as dry as possible.

Brazing

48 Copper tubing for high pressure oxygen systems must not be flared. Solder type fittings are to be used instead.

49 For method of cleaning and brazing, refer to Part 20, following.

50 After brazing, dip the soldered parts in a 10% sulphuric acid (Item 24) solution for 20 minutes at room temperature. Rinse in hot water and dry with compressed air, or by placing in an oven not hotter than 250°F.

Soft Soldering

51 Where requirements call for hydraulic parts to be joined and sealed by sweat soldering observe the following:

(a) Perform operations quickly to prevent corrosion on all unplated parts.

(b) Tin all surfaces to be joined prior to assembly.

(c) Where threaded areas or press fits are joined, preheat the parts to melt the solder on the tinned surfaces. Assemble the parts, tighten fully (threaded joints) and seal by the addition of sufficient solder to fill the joints. Do not add an excess. Apply torch heat during the above operations to keep the solder molten, but do not overheat.

(d) Flux the joint edge using paste flux to ensure perfect sealing.

(e) Allow the parts to cool and clean thoroughly.

52 For methods of cleaning, soft soldering and flux removal, refer to Part 20, following.

TUBE BENDING

General

53 Tube bending can be done with any one of a variety of hand bending tools, (see Figure 12-20) or power bending tools. Avoid bending to smaller radii than the limits shown in Part 25, following, or forming flattened, kinked or wrinkled bends. Bending tube without the aid of tools can be accomplished by carefully forming the desired radius by hand, but this method should be used only in the absence of the proper tools. Flattened, wrinkled or irregular bends should not be installed. Wrinkled bends usually result from trying to bend thin-walled tubing without using a tube bender. Aluminum alloy tubing for oxygen systems should never be hand bent. To make acceptable bends use the hand tube bender.

NOTE

Make certain that forming wheel and follow bar are of correct size.

Plastic Tubing

54 For bending of plastic tubing, refer to Part 13, following.

Bend Limitations

55 When bending tube, observe the following limitations:

(a) Minimum bend radii must conform to dimensions shown in Part 25, following.

(b) Bends must be uniform without kinks and the outside diameter of the tubing at the bend must not vary more than 5% from the outside diameter of the adjacent straight section.

(c) Embossed marks caused by pits and other minor imperfections in bend blocks are permissible in tubing used for conduit or air ducting, provided that the height of such defects does not exceed approximately 10% of the tubing wall thickness.

(d) Mandrel bumps, flat spots and dents without abrupt change in section are not cause for rejection provided that such defects do not increase nor decrease the nominal tube diameter by more than 5% or .030 inch, whichever is greater.

(e) Wrinkles are acceptable on the inside

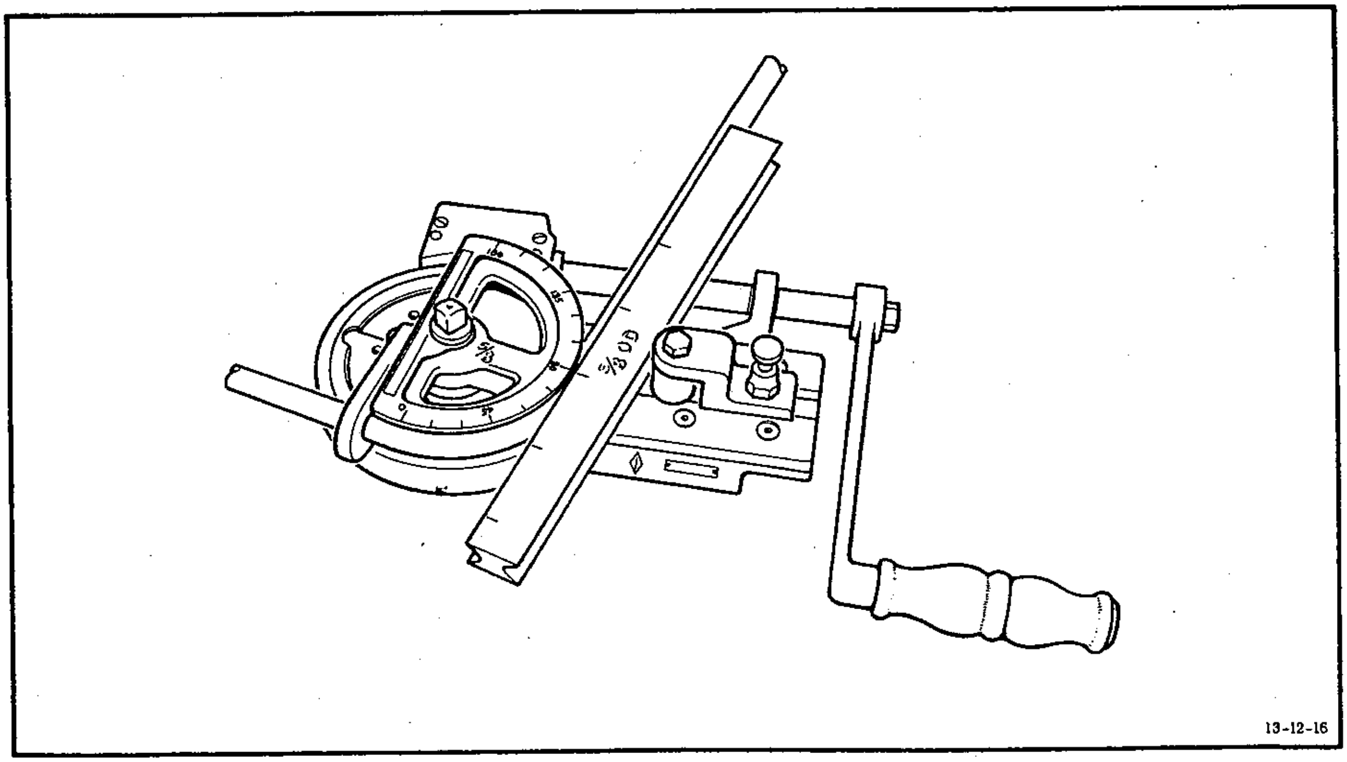


Figure 12-20 Hand Tube Bender

radius of a bent tube provided that the depths shown in Part 25, following, are not exceeded.

(f) On assemblies using sleeves, the minimum distance between the tube bend at the point of tangency and the sleeve end must not be less than that specified in Part 25, following, except where specifically approved by engineering authority.

(g) Copper tubing in oxygen systems must be annealed after bending or forming. After annealing, the tubing is to be bright dipped in accordance with Part 20, following.

USE OF FUSIBLE ALLOYS FOR BENDING TUBES

General

56 The use of fusible alloys (Items 25 and 26) is permitted as fillers to assist in the bending of tubes, with the exception of tubes to B.S.I. Specification T.2 (85-ton Nickel Chromium Steel Tubes), DTD.254 (75-ton Nickel Chromium Steel Tubes) and DTD.199 (50-ton High Chromium Non-corrodible Steel Tubes) and DTD. 211 (50-ton Chromium Nickel Non-corrodible Steel Tubes.)

Procedure

57 Before using one of these alloys as a filler, the inside of the tube should be lightly oiled to minimize the risk of the alloy sticking to the walls of the tube and thus rendering complete removal doubtful.

58 Suitable alloys are those which melt at a temperature below 100°C (212°F). Loading and unloading can then be carried out by aid of boiling water. After the tube is oiled, plug one end and preheat the tube in boiling water. Run in molten alloy and quench the filled tube in cold water, quickly but progressively, from the plugged end.

59 After bending, unload the tube by removing the plug and immersing tube in boiling water, thus allowing the molten alloy to run out.

Cleaning

60 Clean the tube internally to ensure the complete removal of any adherent alloy. Use a suitable brush of the pull-through or rotary type or blow through with wet steam.

61 Do not omit this cleaning process. Residual alloy in aluminum alloy tubes will cause early corrosion. In steel tubes which are subsequently heat treated, residual alloy would attack the steel and cause intergranular cracking.

Aluminum Alloy Tubes

62 In the case of aluminum alloy tubes, the material of which may be susceptible to accelerated age-hardening, take the following precautions:

(a) Perform the filling and bending operations as soon as possible after normalizing.

(b) Immerse the tubes in boiling water for preheating before filling, only for such time as is necessary for the tubes to attain the temperature of the water. The bending operation should take place immediately after cooling the filled tube.

(c) During preheating or unloading the aluminum alloy tubes do not allow the temperature to exceed 100°C.

Special Mandrels

63 Special mandrels to fit the inside or outside diameter of tubing have been produced and are available for use when bending pipes. The use of the inside mandrel is not recommended as this may mar the wall of soft tubing. The mandrel must be of the proper size to fit the tubing and tooling used.

TUBING REPAIR

General

64 With ordinary care, accidents such as nicking and scratching can be avoided, as a large part of such damage occurs from careless handling of tools.

Minor Repairs

65 Any dent less than 20% of the tube diameter, by visual inspection, is not objectionable unless it is on the heel of a sharp bend radius. A nick no deeper than 10% of the wall thickness may be reworked by burnishing with hand tools. Since aluminum and its alloys or copper are the only materials easily worked, these alone are burnished. Severe die marks,

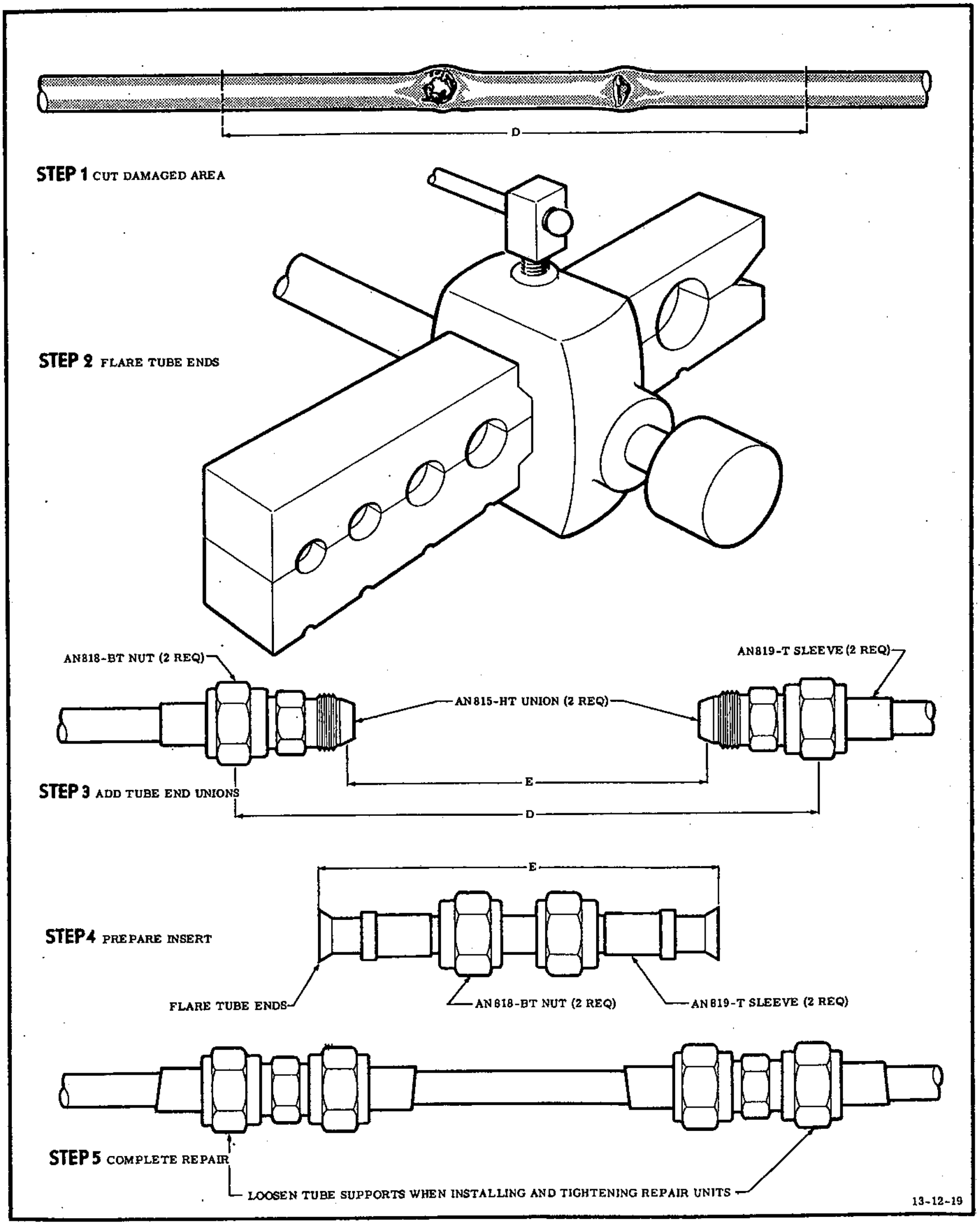


Figure 12-21 High-pressure Line Repairs

ADVANCE REVISION

Serial #2 dated 26 Feb 59
(Sheet 1 of 5)

The sheets of this Advance Revision are to be inserted in the EO as follows:-

Sheet 1 facing page 21
Sheet 2 facing page 29
Sheet 3 facing page 29
Sheet 4 facing page 29
Sheet 5 facing page 29

Part 12 Para. 69(c):

Delete: Assembly.

Insert: Installation

Delete: at (thru)pressure

Insert: in accordance with pressures shown in Figure 12-32

ISSUED ON AUTHORITY OF THE CHIEF OF THE AIR STAFF

seams or splits in the tube are cause for immediate rejection, as they cannot be repaired.

66 In the heel of bends, when the material has already been stretched thin in forming, burnishing is not allowed. Such a tube should be rejected if it is a medium or high pressure line. Where the tube is used for fluids at atmospheric pressure or less, the bursting strength of the tube is unimportant, but it must be leak-tight at all times.

67 Dents can be removed from tubing by drawing a bullet, attached to a flexible cable, through the tube. The diameter of the bullet must be equal to or slightly less than the internal diameter of the tube.

Repair of Low-pressure Lines

68 To repair low-pressure lines, carry out the following procedure:

(a) Remove the damaged portion of the tube, deburr the remaining tube ends and remove cuttings from the tube interior.

(b) Bead the remaining tube ends.

(c) Cut a repair section 1/2 inch shorter than the length of the removed damaged portion. Burr the section, bead and clean the tube.

(d) Cut hose connections of proper length and diameter from synthetic rubber hose (Item 27) and slip two hose clamps (Item 28) over the ends of each. Slip one hose connection well back over original tube before positioning repair insert.

NOTE

Exercise care in positioning of hose clamps in order to prevent band overhang or tightening screws from chafing or damaging neighbouring parts. Where the possibility exists, reposition the clamp.

(e) Slip hose connections midway over the junction formed by the original tube and the repair section. Glycerine (Item 29), applied to a metal pipe aids the sliding of the rubber hose.

(f) Tighten hose clamps. (Refer to Part 11, preceding.)

NOTE

Two hose clamps on each end of a connection are normal on some beaded oil lines, as these lines maintain a relatively high pressure.

Repair of High-pressure Lines

69 To repair high-pressure lines, carry out the following procedure: (See Figure 12-21.)

(a) Cut out and remove damaged portion of the tube. Remove the burr from the ends of undamaged tube portions and clean. Slip nut (Item 30) and sleeve (Item 4) of proper size and and material onto the remaining tube ends. Flare the tube ends.

(b) Insert union coupling (Item 31) of proper diameter and material into the flared tube ends. Apply hydraulic oil (Item 32), to threads except when working with oxygen systems and slip sleeve down against flared tube end. Oxygen system tube assemblies must not be lubricated. Measure accurately the distance between the union faces. If the length of the damage is several inches or the damaged tubing is to be removed to the nearest fitting, a repair insert must be used. Cut a repair length of similar tubing, clean and remove the burr. Flare the tube ends as indicated in Paragraph 21, preceding. The section of tubing into which the repair section is to be installed should be loosened in order to permit ease of alignment upon re-installation.

(c) Carry out a pressure test on all newly fabricated pressure lines used for replacement prior to assembly. Test the line at a safety factor of three, that is, three times the maximum operating pressure.

(d) Place the repair section between the unions, thread on the two nuts and tighten. Use torque wrench so that no damage will result from tightening the nut. Refer to Part 25, following, for torque values.

(e) If the damaged portion of the line does not exceed the length of the union, a repair section is not needed. Cut out the damage so that after the tube ends are flared and a union is inserted, a leak-tight joint will result. (See Figure 12-21.)

Routing and Clearance of Lines

70 Liquid and gas lines must be routed at least six inches away from electrical cable.

71 A minimum of 1/8 inch clearance is to be maintained between tubing or hose and the structure adjoining a supporting clamp, as shown in Figure 12-22.

72 Sufficient clearance must be provided between a tube or hose and a projection, such as a bolt or nut, to prevent contact in service. Where a tube or hose is supported close enough to such a projection that no relative motion will exist, a minimum clearance of 1/8 inch must be maintained. Where relative motion will exist, an initial clearance is to be allowed which will provide a minimum clearance of 1/8 inch under the relative motion. (See Figure 12-23.)

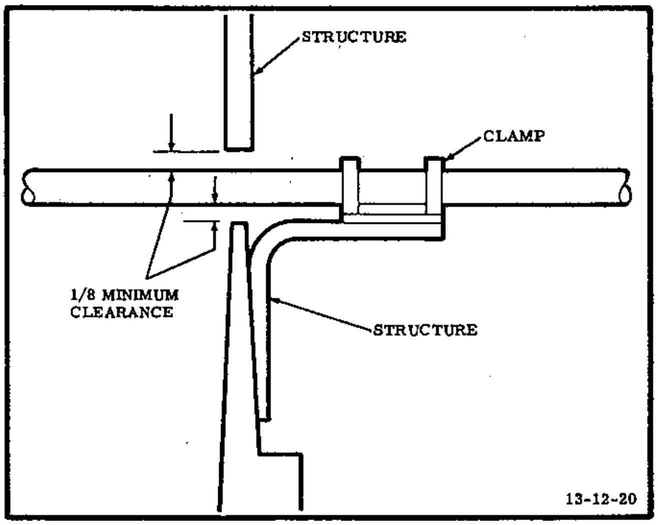


Figure 12-22 Tube or Hose Installation

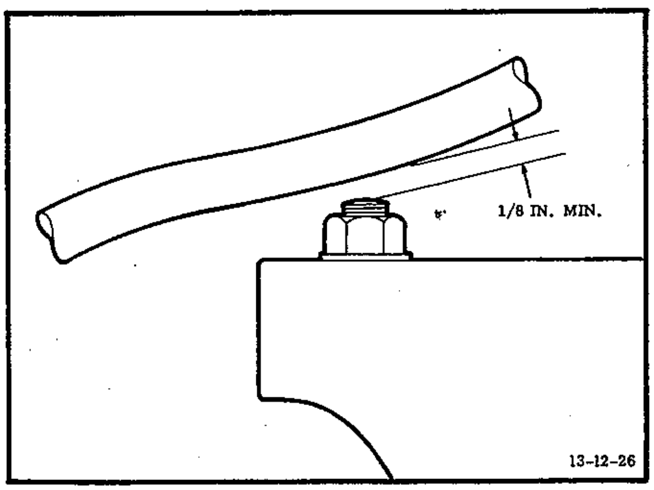


Figure 12-23 Tube or Hose Clearance

73 The clearance of 1/8 minimum specified in Figure 12-22 and in Paragraphs 71 and 72, preceding, may be reduced as follows for rigid lines only:

(a) The clearance on short line assemblies may be cut down to 1/16 inch where space is not available to make 1/8 inch clearance practical. This applies mainly to closely spaced line groups and to bends close to end flares.

(b) Parallel runs of lines become more rigid when clipped together. In these cases the space available, and more often the design of the clips, does not permit more than 1/16 inch spacing. This is acceptable.

(c) Lines clipped to flat panels free from adjacent rivet heads or stiffening angles are acceptable at 1/16 inch clearance, provided that the installation is rigidly clipped to prevent any possible line movement due to vibration and hydraulic loads.

74 Recommended maximum spacing between supports for rigid line assemblies is shown in Figure 12-24.

75 Where a tube passes through a grommet, the tube must not bear on the grommet in such

Outer Diameter of Tubing	Recommended Maximum Support Spacing	
	For Aluminum Tubing	For Steel Tubing
1/4	15	18
5/16	15	18
3/8	15	18
1/2	22	25-1/2
5/8	22	25-1/2
3/4	22	25-1/2
1 and over	26-1/2	30

Figure 12-24 Table of Recommended Maximum Support Spacing

a way as to cause cutting of the grommet in service. (See Figure 12-25.)

76 Tubing or flexible hose must be installed without tension between supports which might cause the pad of a clamp to work out as shown in Figure 12-26. On hose installations, clamps and supports must be so located that the hose will not be pulled or twisted in service, nor forced to bend sharper than the minimum allowable radius.

77 Lines running through cutouts should be installed with care so that the tube is not scarred in being worked through the hole. The edges of the cutout should be taped before the lines are installed, especially if the line assembly is long.

Pipe Line Identification

78 Pipe line identification symbols are to be installed on all new and repaired systems in accordance with instructions contained in EO 05-1-2Y.

Replacement

79 Damaged tubing should be replaced with new parts. If a line assembly is to be replaced, the fittings can be salvaged so that replacing the assembly usually amounts to tube replacement only. In replacing a damaged tube, select a tube of the same size and material, if possible. Cut the piece of tubing approximately 10% longer than the length of the tube to be replaced. After required bends have been made, the new tube may be 1/2 to 2 inches longer than the old tube. Allowances should be made for the flaring operation to follow. The amount of tubing in excess of these required dimensions should be cut off.

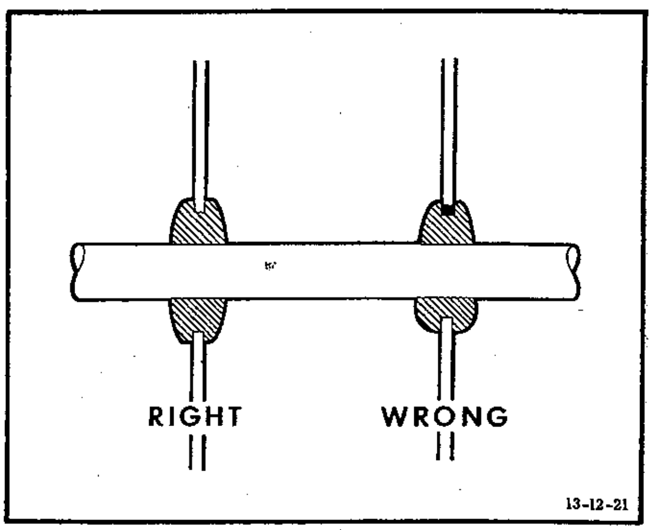


Figure 12-25 Tube and Grommet Installation

Tube Template

80 If the old tube is intact and the bends have not been changed, use it as a template or pattern from which to bend a new tube. If rerouting is required and a new model or template must be made, select a soft iron wire and proceed as follows:

(a) Place the wire into one of the fittings where the tube is to be connected. Form the necessary bends. When the template is satisfactorily formed to span the area between the fittings, remove and use the pattern to bend the new tube.

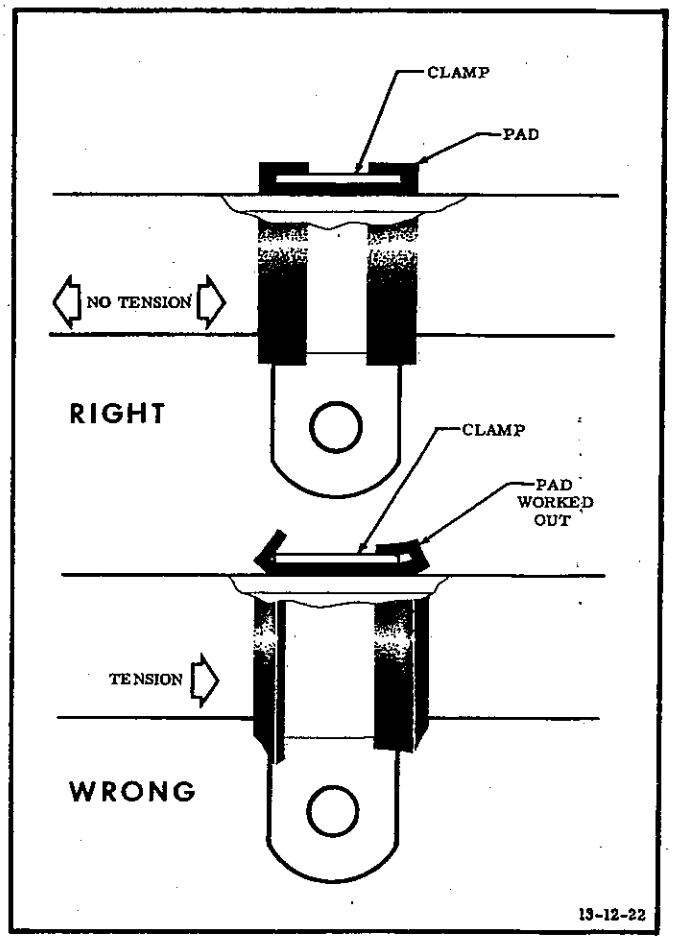


Figure 12-26
Tube or Hose Installation between Supports

(b) Select a path with the least total degrees of bend as this reduces the flow loss and simplifies bending.

(c) Use a path, if possible, with all bends in the same plane.

NOTE

Do not select a path that requires no bends. A tube cannot be cut or flared accurately enough so that it can be installed without bends and still avoid initial mechanical strain on the tube.

81 If the tubing is small in diameter (below 1/4 inch) and can be hand formed, casual bends may be made to allow for this. If the tube must be machine formed, definite bends must be made to avoid a perfectly straight assembly. This is not necessary if the replaced tube assembly is to be used to repair a damaged section of a continuous line. Care must also be taken to start all bends a reasonable distance

Wall Thickness	Outside Diameter										
	1/4	3/8	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
0.022	574										
0.028	745	481	355	281	232	198	173				
0.035	951	611	449	355	293	250	217	193	173	157	143
0.049	1381	882	644	507	417	355	308	273	245	221	203
0.065			877	687	564	479	415	367	328	297	271
0.083					735	622	539	475	425	384	350
0.109											
0.134											
0.165											

Wall Thickness	Outside Diameter										
	1-5/8	1-3/4	1-7/8	2	2-1/4	2-1/2	2-3/4	3	3-1/4	3-1/2	3-3/4	4
0.022												
0.028												
0.035	132	122	114	107								
0.049	186	173	161	151								
0.065	250	231	215	201	178	160						
0.083	322	298	277	259	230	206	187	171	157			
0.109					305	273	247	226	208			
0.134					378	339	306	280	257	239	222	208
0.165								348	320	296	276	258

Figure 12-27 Table of Typical Working Pressures for 1S-O Tubing in PSI

from the end fittings, as the sleeves and nuts must be slipped back along the tube for inspection and to prevent binding of the tube against the coupling sleeve. (Refer to Part 25, following.) In all cases the new tube assembly should be so formed prior to installing that it is not necessary to pull the assembly into alignment by means of the coupling nuts.

Replacement Material

82 Tubing replacement should be made with tubing of the same material and heat treat, outside diameter and wall thickness. Replacement with another material cannot be made without approved engineering authority and after consideration of strength, vibration resistance, formability and, if of another size, flow and volume characteristics, bend radii and clearances.

Internal Pressure

83 The internal working pressure for aluminum alloy tubing may be computed from Figures 12-27 and 12-28. The factor of safety used in compiling the table is approximately four at normal temperature. Figure 12-27 shows the internal working pressure for various diameters and wall thicknesses of 1S-O tubing. By multiplying the given value for the diameter and wall thickness factor for the alloy being used, (Figure 12-28), the internal working pressure of the tubing may be determined.

Alloy and Temper	Conversion Factor
1S-1/2H	1.4
1S-H	1.8
24S-O	2.5
24S-T	5.8
50S-O	1.3
50S-W	2.0
50S-T	2.9
57S-O	2.5
57S-1/2H	3.2
57S-H	3.4
65S-O	1.5
65S-W	3.0
65S-T	3.8

Figure 12-28 Conversion Factors of Typical Internal Working Pressures

Example

84 It is desired to determine the internal working pressure of a 1 inch outside diameter x .035 inch wall tubing of 57S-1/2H aluminum alloy. From Figure 12-27, the internal working pressure of 1 inch outside diameter x .035 inch wall tubing of 1S-O alloy is 217 psi. The conversion factor for 57S-1/2H is 3.2. The internal working pressure, then, of a 1 inch outside diameter x .035 inch wall tubing of 57S-1/2H alloy is 3.2 x 217 psi or 694.4 psi.

CAUTION

Figures 12-27 and 12-28 are not be used to compute aircraft plumbing requirements. Surge pressures must be considered in any pressure system.

Layout

85 Locate terminal points where the tube starts and ends to determine path of tubing. Check for vibration effects on layout. Avoid obstructions and possibility of abuse from other equipment. Establish supporting points with due regard to flexibility. Ensure that tubing does not obstruct or chafe on other equipment.

86 A tubing line may be installed by several different routes, but there is usually a preferred path. See Figure 12-29 for a sample installation giving alternate routes. The reason for using tube (C) as the preferred route is as follows:

(a) Tube (A) obstructs the access door.

(b) Tube (B) obstructs access to adjoining equipment.

(c) Tube (C) is the best direct path for this particular tubing layout.

Determination of Tubing Length

87 For determination of proper tubing length, dimensions should be taken as follows:

(a) From end to end or, for first bend, from end to centre line of tube.

(b) For succeeding bends, from centre line to centre line. (See Figure 12-30.)

88 On the Triple-lok type of fitting (Item 33), measure from base of machined flare. On Ferulok type (Item 34) measure to face of equipment as indicated by dimension A, (see Figure 12-30). Dimension B is clearance between face of equipment and centre line of tube. Then A + B dimension is measurement from end of tube to centre line of first bend. Dimension C is measurement between centre lines of first and second bends. This is obtained by measurement of dummy tubes supported at the points of the proposed layout. Dimension D is obtained from centre of terminal fitting to face of equipment. Then D + B is distance between second and third bends. To obtain elevation between terminals place straightedge across equipment. Measure dimension E to centre line of tubing and dimension F to end of terminal fitting. Then F - E = length of tubing from centre line of third bend to final terminal connection. Add these dimensions to obtain total length of tubing necessary and cut to length. Assemble nut and sleeve of flare fitting on tube and form flare on end of tube.

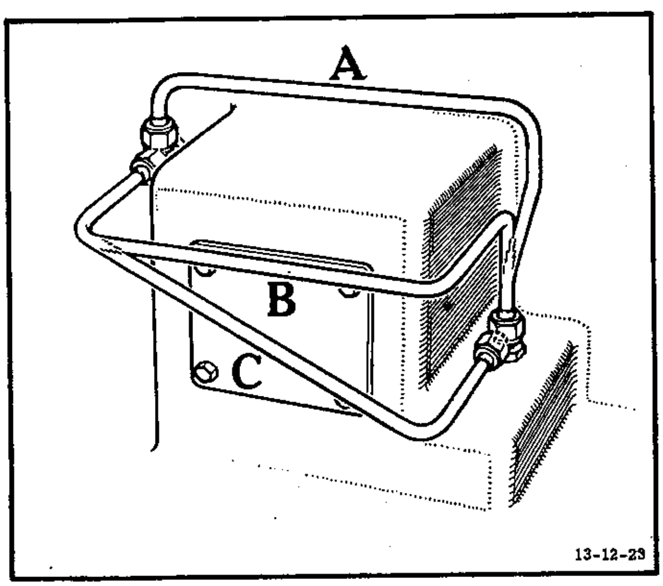


Figure 12-29 Routing of Tubing

NOTE

If Ferulok type fittings are used, flaring is unnecessary.

Tube Bending before Installation

89 Mark dimension A + B on tube, using soft pencil. Place tube in bender, lining up pencil mark with outside edge of bender radius block. Use bender of correct radius and bend to required angle. To locate second bend, transfer dimension C to tube. Make bend in proper direction and transfer next dimension, D + B. Recheck layout and bend tube in proper direction. Complete flaring operation after assembling fittings to tube.

NOTE

It may be advantageous in some cases to leave extra material on both ends of tube until all bending is completed and then trim off to fit final connections.

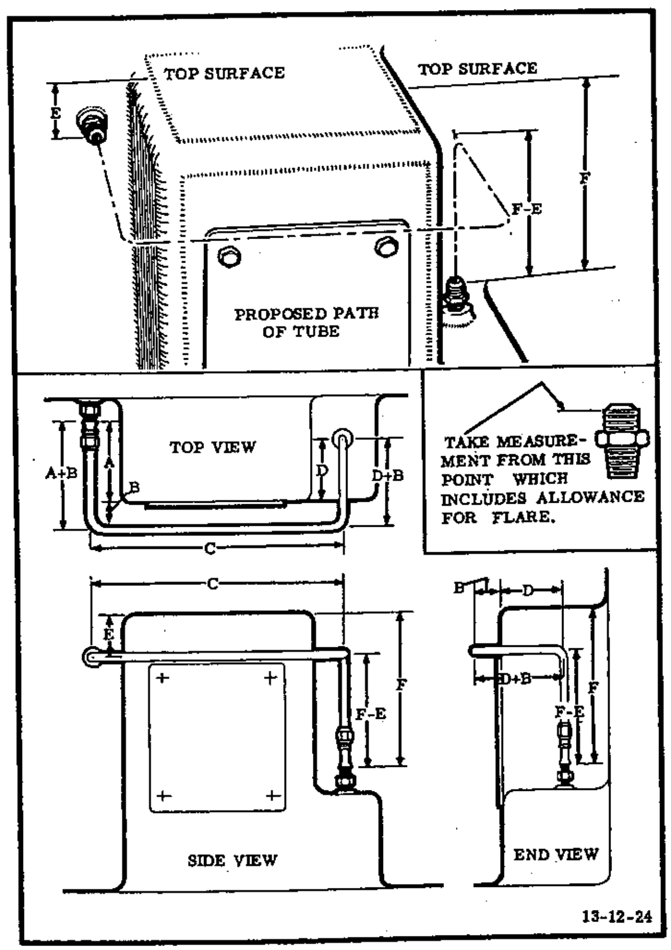


Figure 12-30
Measurement of Tubing for Layout

Cleaning Lines

90 All tubing must be cleaned before installation. Clean lines and fittings, other than in the oxygen system, by blowing out with clean dry compressed air.

Cleaning of Oxygen Lines

91 Clean oxygen lines as follows:

(a) Flush the inside of all lines thoroughly with hot stabilized solvent (Item 17).

(b) After flushing, drain the lines thoroughly and bake in an oven at a temperature of 250 to 300°F for approximately two hours.

(c) Allow to cool from the baking operation and blow out each line with nitrogen (Item 35). Allow the nitrogen to flow through the line for about five seconds to remove all traces of solvent or other vapours.

Sealing of Lines

92 Between each of the above cleaning operations and immediately after the final operation, all lines must be sealed. Any line left open at any time except during actual cleaning operations is to be recleaned and resealed, using an approved cap. Caps must not be removed until immediately prior to final installation.

93 Completed lines and fittings for the oxygen system must not be placed nor stored near machinery or in any other location where they may become contaminated with oil, grease, water or other foreign substances.

INSPECTION OF HYDRAULIC LINES AND INSTALLATIONS

General

94 A detailed inspection during periodic maintenance is recommended as the most satisfactory method of obtaining trouble-free operation. Particular attention should be paid to congested areas, especially in the engine bay and nose wheel wells.

Inspection

95 Inspect line routing and clearances as follows:

(a) All lines must clear adjacent structure and other installations by at least 1/8 inch. Refer to Paragraphs 70 to 77 inclusive, preceding.

(b) Flexing of hydraulic lines and aircraft structure may reduce clearances. Broken clamps or damaged attaching points usually indicate improper routing and inadequate allowance for flexing.

NOTE

A practical check for line chafing due to improper routing or inadequate clearances consists of setting the system relief valve slightly above system pressure to promote line chatter and indicate abnormal conditions.

96 Check connecting fittings as follows:

(a) Check base of flare for cracks and distortion.

(b) Flared ends of line must seat freely and squarely on connecting flare.

(c) Line must be concentric with sleeves.

(d) Bulkhead fittings must be properly positioned in bulkhead without causing local distortion of the web of the bulkhead. Extra washers may be used on either side of the bulkhead to compensate for variations in line length.

Material Specifications

97 For table showing item numbers, materials, specifications and manufacturers, see Figure 12-31.

Item No.	Material	RCAF Ref	Specification	Manufacturer
1	Carbon Tetrachloride	33C/102	O-C-141	
2	Sodium Hydroxide	33C/672	15-GP-7a	
3	Potassium Hydroxide			Technical grade
4	Sleeve	28/	MIL-F-5509	
5	Fitting, Flareless MS21921 & MS21922	28/	MIL-F-5509	
6	Nut	28/	MIL-F-5509	
7	Fitting	28/	MIL-F-5509	
8	Ring, Gasket back-up AN6291	28/	AN-R-22	
9	Gasket AN6290	28/	MIL-G-5510	
10	Grease, General purpose	34A/178	3-GP-682	
11	Gasket	32E/	HH-P-96	
12	Petrolatum	34A/165	3-GP-665	
13	Washer, Lock-O-Seal	28NS/		Franklin C. Wolfe, 3644 Eastham Dr., Culver City, Calif.
14	Varnish, Gasoila	33G/		Federal Process Co. 2133 E 9th Street, Cleveland, Ohio
15	Compound, Anti-seize	34A/164	3-GP-801	
16	Solder, Soft		QQ-S-571 comp Sn50	
17	Trichlorethylene	33C/163	MIL-T-7003	
18	Acid, Nitric	33C/2	O-C-303	
19	Flux, Soldering	32C/	MIL-F-12784A	
20	Flux, Soldering		DTD-81	
21	Ammonium Chloride	33C/107 14B/1695		
22	Acid, Hydrochloric	33C/1		
23	Detergent	33C/667	2-GP-103	

Figure 12-31 (Sheet 1 of 2) Table of Material Specifications

Item No.	Material	RCAF Ref	Specification	Manufacturer
24	Acid, Sulphuric	33C/4	15-GP-8a	
25	Wood's Metal			
26	Cerrobend			
27	Hose, Rubber, Synthetic	32C/	MIL-H-6000	
28	Clamp, Hose AGS605	28/		
29	Glycerine	14B/43		
30	Nut AN818	28/	MIL-F-5509	
31	Union	28/	MIL-F-5509	
32	Oil, Hydraulic	34A/100	3-GP-26a	
33	Fitting, Triple-lok	28NS/		Parker Appliance Co. 17325 Euclid Ave., Cleveland
34	Fitting, Ferulok	28NS/		Parker Appliance Co. 17325 Euclid Ave., Cleveland
35	Nitrogen		MIL-N-6001-A-1	

Figure 12-31 (Sheet 2 of 2) Table of Material Specifications

PRE-SET AND PROOF TEST DATA (Cont'd)

TUBING		HAND PRE - SET TURNS	PROOF TEST PRESSURE psi
MATERIAL	SIZE INCHES		
	1/4 - .022	1.1/6	1000
	1/4 - .028	1.1/6	1000
	1/4 - .035	1.1/6	1000
	5/16 - .035	1.1/6	1000
5052-0	3/8 - .038	1.1/6	1000
Aluminum	3/8 - .035	1.1/6	1000
Alloy	1/2 - .035	1.1/6	1000
WW-T-787	1/2 - .042	1.1/6	1000
Temper O	5/8 - .042	1.1/6	1000
	3/4 - .042	1.1/6	1000
	1.0 - .035	1.1/6	500
	1.0 - .049	1.1/6	500
	1-1/4 - .049	1.1/6	500
	1-1/2 - .035	1.1/6	500
	1-1/2 - .049	1.1/6	500

Figure 12-32

ISSUED ON AUTHORITY OF THE CHIEF OF THE AIR STAFF

PRE-SET AND PROOF TEST DATA (Cont'd)

TUBING		HAND PRE - SET TURNS	PROOF TEST PRESSURE psi
MATERIAL	SIZE INCHES		
6061-0			
Aluminum	3/16 - .022	1.1/6	1000
Alloy	1/4 - .035	1.1/6	1000
WW-T-789			
Temper O	1.0 - .049	1.1/6	500
MIL-T-7081	1.0 - .065	1.1/6	500
Temper O	1-1/2 - .058	1.1/6	500

Figure 12-32

ISSUED ON AUTHORITY OF THE CHIEF OF THE AIR STAFF

PRE-SET AND PROOF TEST DATA (Cont'd)

TUBING		HAND PRE - SET TURNS	PROOF TEST PRESSURE psi
MATERIAL	SIZE INCHES		
	1/4 - .020	1.0	2000
	1/4 - .028	1.1/6	2000
6061 - T6	1/4 - .035	1.1/6	2000
Aluminum	5/16 - .028	1.1/6	2000
Alloy	3/8 - .035	1.1/6	2000
WW-T-789	3/8 - .049	1.0	2000
Temper T6	1/2 - .028	1.1/6	2000
MIL-T-7081	1/2 - .035	1.1/6	2000
Temper T6	1/2 - .049	1.0	2000
	5/8 - .049	1.1/6	2000
	5/8 - .065	1.1/6	2000
	3/4 - .049	1.1/6	2000
	1.0 - .049	1.1/6	2000
	1-1/2 - .058	1.1/6	1500

Figure 12-32

ISSUED ON AUTHORITY OF THE CHIEF OF THE AIR STAFF

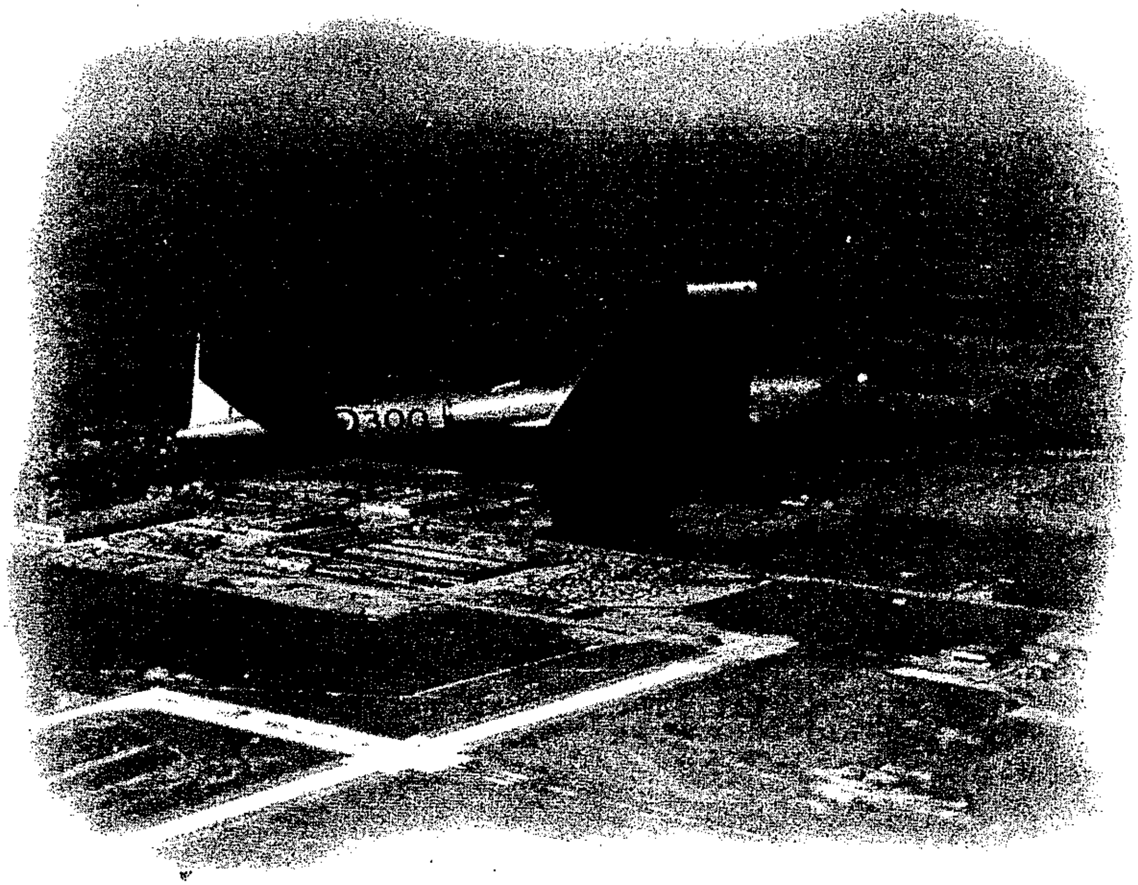
PRE-SET AND PROOF TEST DATA

TUBING		HAND PRE - SET TURNS	PROOF TEST PRESSURE psi
MATERIAL	SIZE INCHES		
AISI 304	1/4 - .020	1. 1/6	6000
1/8 hard	1/4 - .028	1. 1/6	6000
Corrosion	1/4 - .035	1. 1/6	6000
Resistant	3/8 - .028	1.0	6000
Steel	1/2 - .035	1. 1/6	6000
MIL-T-6845	5/8 - .049	1.0	6000
AMS 5566	3/4 - .058	1.0	6000
AISI 321 or 347, annealed corrosion	1/4 - .028	1. 1/6	5000
Resistant	1/4 - .035	1. 1/6	5000
Steel	5/16 - .028	1. 1/6	5000
MIL-T-8606	3/8 - .028	1.0	5000
AN-WW-T-858			

Figure 12-32

PART 13

PLASTIC AND GLASS FABRIC REPAIR



PART 13

PLASTIC AND GLASS FABRIC REPAIR

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(Continued)

LIST OF ILLUSTRATIONS

PART 13

PLASTIC AND GLASS FABRIC REPAIR

PLASTICS

General

1 There are three types of transparent plastic commonly used in military aircraft; acrylic plastics (also known as acrylate or methacrylate base plastics), laminated acrylic plastic, and cellulose acetate base plastics.

Acrylic Plastics

2 Acrylic plastics only are used for replacement of transparent plastic on all RCAF aircraft. They are manufactured under the trade names of Lucite (Item 65), Plexiglass (Item 66) and Perspex (Item 67).

Laminated Acrylic Plastics

3 Laminated acrylic plastics are made from acrylic plastic bonded by a vinyl resin interlayer but are not characterized by specific trade names.

Cellulose Acetate Base Plastics

4 Cellulose acetate base plastics are manufactured under the trade names of:

Fibestos (Item 68), Lumarith (Item 69),

Plastacele (Item 70) and Nixonite (Item 71).

5 Cellulose acetate base plastic is not to be used as a substitute for acrylic plastic. Take precautions to correctly identify the original and replacement or repair materials. Acrylic plastics contract about five times as much as light alloy and ten times as much as steel and their thermal conductivity is about 1/1000 that of metal.

Identification of Plastics

6 Since the methods of working the two common plastic materials (acrylic plastic and cellulose acetate base plastic) differ, it is important that the material to be worked is properly identified. Use a known piece of equal size and thickness for comparison in attempting to establish the identity of an unknown material. There are several means of identification, some of which are as follows:

(a) View the light transmitted through the edge of the panel. The cellulose acetate base plastics appear relatively dark and generally are tinted pink, green or blue. The acrylic plastics are quite transparent and colourless. This test is useful only on clear colourless panels.

(b) Rap the cellulose acetate material with the knuckles. A dull sound is emitted in comparison with the ringing note given off by the acrylic plastic. This method is reliable only when direct comparison of two materials is possible.

(c) Both acrylic and cellulose acetate base plastics have characteristic odours when burned. Cellulose acetate base plastic burns with a smoky flame which will not propagate downward, and can be identified by a smell of vinegar which is detected in the smoke immediately after the flame is extinguished. Acrylic plastic ignites more easily and burns with a clear, smokeless flame which will propagate downward. The acrylic plastics are more rigid than cellulose acetate base material, and will bend less readily.

Storage and Care of Plastic Panels

7 Keep plastic sheets away from heating coils, radiators, hot water and steam pipes. Store in a cool, dry location away from solvent fumes such as may exist near paint spray and paint storage areas. Keep masked sheets out of the direct rays of the sun, as this may accelerate deterioration of the masking paper adhesive, causing it to cling to the plastic and making removal difficult. Store the sheets on solid shelves. Do not store small sheets between large sheets, thus leaving unsupported sections. If the sheets are stored

vertically, they must be well supported. If plastic sheets become bowed, remove masking paper, heat to forming temperature, place on a flat surface protected by a layer of soft flannel and allow to cool. Storage of acrylic sheets presents no special fire hazard since the materials are slow burning. Leave masking paper in place as long as possible.

8 Stack washed sheets with wads of cotton wool separating the surfaces. Support curved or formed sections so that there is no tendency for them to lose their shape. Avoid vertical supports except in specially designed racks. Simple frames or supports are necessary to relieve strain or unusual pressure on curved parts. Always cover parts with cloth or soft paper to protect from dust. Protect formed parts from temperatures higher than 120°F which might tend to cause loss of shape.

Masking

9 Transparent plastic sheets are supplied with a coating of masking paper. Leave this paper in place as long as possible and do all work on the sheets with the paper in position. If masking paper hardens to the surface of plastic sheets, making removal difficult, moisten the paper with kerosene (Item 2) or hexane (Item 5). The liquid will loosen the adhesive and free the paper from the plastic. Wash sheets so treated with soap (Item 3) and water and rinse with distilled water before attempting forming operations.

CAUTION

Use only liquids specified. The use of other materials may soften or craze the plastic.

10 For formed parts, use protective coatings which are applied by spraying. Since many compounds are inadequate or definitely harmful, use only approved material (Item 1). To remove masking from the plastic, peel off or lift the corner of the film and blow a jet of compressed air under it. Sometimes a paper tab embedded in the film to assist in its removal is advisable, otherwise it is impossible to lift the corner and peel the masking off.

Use of Coating Compound

11 Instructions governing the use of coating compound are as follows:

(a) The application of coating compound (Item 1) is mandatory during fabrication and manufacture on all canopies and windows used for vision in flight, and on all parts and materials prior to storage and prior to shipment, except as stated in Sub-paragraph (c), following.

(b) The application of coating compound is recommended on all parts not used for vision in flight such as junction box covers, and emergency door handle shields, during fabrication and installation.

(c) Coating compound is not required on parts and materials protected with kraft paper or other suitable covering upon receipt from the supply depot. Such protective covering is to remain in place as long as possible.

12 During fabrication, transparent plastic parts should be left bare only when necessary for forming, buffing and polishing. Carry out all other operations such as routing, drilling, sawing etc., with either the original protective covering or coating compound.

Preparation of Plastic Parts and Materials

13 Clean the surfaces of plastics which are to be covered with coating compound. (Refer to Paragraph 23, following.)

Preparation of Coating Compound

14 Clean off the top of compound containers or drums before opening. Where coating compound is received in small (5 gallon) containers, stir the compound thoroughly in the container until a smooth uniform consistency is obtained. If, after stirring, the compound is too thick, add from one pint to a maximum of one quart of tepid water per 10 gallons of compound, and continue stirring until the water is dispersed throughout the compound. Do not use any other solvents at any time for thinning. After stirring, and thinning if required, filter the compound into the spray gun cup through a fine cheese cloth.

Application of Coating Compound

15 The spray gun recommended for use in applying the coating is a Type MBC-510, fitted with external mix spray head, one quart capacity suction feed cup, type E nozzle and needle, and No. 30 air cap, manufactured by

the DeVilbiss Manufacturing Co. Ltd., Windsor, Ontario. To apply the compound, proceed as follows:

(a) Spray coating compound (Item 1) onto all surfaces of plastic parts. The applied coating should not be less than 006 inch in thickness. Air pressure through the gun should not be less than 60 psi; 70 psi is recommended. (Refer to EO 50-20A-2.)

(b) Room temperature during spraying operations should be between 65° and 90° F.

(c) After spraying, allow the coating to dry at room temperature for 12 hours.

(d) Any tackiness remaining on the film after drying may be removed by sprinkling with a light coating of talc (Item 7). Where parts are to be stored face to face or shipped in wrappings, use talc to prevent possible sticking of parts to each other or to the wrappings.

(e) Where the coating compound is torn during subsequent handling, remove the damaged portion, (refer to Paragraph 18, following). Spray a second coating onto the damaged area overlapping at least 1 inch onto the surrounding undamaged coating. (Refer to EO 50-20A-2.)

NOTE

Do not store coating compound in freezing temperatures or excessive heat. Storage temperature should be within the range of 60° to 80° F.

Maintenance of Spray Guns and Accessories

16 Maintain spray guns and accessories as follows:

(a) Clean spray guns and accessories thoroughly, with water only, after each day's operations. Do not use any other solvents for cleaning. Clean spray gun air caps more frequently or uneven coatings will result.

(b) Air lines supplying the spray guns must include filters to exclude oil and foreign matter. Keep filters clean.

(c) Where it is desired to use the spray gun specified with a pressure tank feed, use a type FX or FF nozzle and needle and a No. 765 air cap.

Installation of Coated Parts

17 When installing coated parts, remove the coating only from contact areas where the parts fit into frames, channels, etc., (refer to Paragraph 18, following). In critical areas where extra protection is desired, spray a second coating onto that portion of the contact areas remaining bare after installation and overlap at least 1 inch onto the surrounding parts or structure and onto the original coating. Retain coating in position on parts installed in aircraft until immediately prior to the first flight.

Removal of Coating Compound

18 Remove coating from parts by lifting at one edge with a finger nail and peeling off. If the coating has been applied correctly and the minimum thickness of .006 inch maintained, a steady pull will remove it easily and in one piece. Do not attempt to remove the coating at any time with tools, solvents or air hoses. Where a central portion of the coating is to be removed, break the film with a fingernail and peel the coating off as required. Take care not to scratch the underlying plastic surface.

General Precautions

19 Optical quality is of paramount importance. Avoid scratching or otherwise damaging the plastic surface while servicing the aircraft. Take the following general precautions in all maintenance and repair operations:

(a) Do not rub the surface with a dry cloth, as frequently the cloth does not clean perfectly and scratching and/or marring of windscreens results. Refer to Paragraph 23, following.

(b) Handle transparent plastic material with clean gloves at all times.

(c) Do not use harmful liquids, such as gasoline, paint, dope solvents, alcohol, thinners or dopes as cleaning agents.

(d) Fabrication, repair and maintenance instructions must be followed closely.

(e) Avoid operations which tend to scratch or distort the plastic surface.

(f) Clean plastic surfaces by washing with warm, soapy water, using a soft cloth which is free from grit.

Crazing

20 Liquids which cause crazing can be generally classified as those which either swell or dissolve the material. In some cases vapours from open containers of solvents have been found to cause crazing. The material as it is cast gives a random crazing pattern, whilst heat-treated material exhibits craze lines lying in the direction perpendicular to the direction of the applied tensile stress. The only type of crazing which is considered acceptable is the very fine variety which has no visible depth when viewed with the naked eye. Refer to Paragraphs 26 and 27, following. Slight crazing occurs in such a large proportion of components at the present time that some have to be accepted until means of preventing it is found. If crazing is of the directional variety and has visible depth, it should definitely be rejected.

Scribing and Edge Sanding

21 This method of cutting is generally employed on flat sections or two dimensional curved pieces. The sheet is first cut to approximate shape on a band saw, using a scribed line as a guide and cutting approximately 1/16 inch oversize. The choice of abrasive and successive grades of abrasive depends on the amount of material to be removed, and the finish desired, and must of necessity be left to judgement. For the best results, abrasive wheels, discs, drums and belts should operate at about 3000 surface feet per minute. Wet sanding is preferred to dry sanding, as water dissipates frictional heat, eliminates loading of the abrasive, settles dust, increases the speed of cutting and extends the life of the wheel. For surface sanding procedure used in finishing acrylic plastics, refer to Paragraphs 109 to 117 following.

Scribe Cutting

22 Where extreme accuracy is not required, thin acrylic plastic sheeting may be cut in a straight line in the same manner as glass, by scribing a line on the surface and breaking the sheet along the line. This method should not be used on thickness over about 0.080 inch. Acrylic plastics cannot be cut with shears or scissors.

Cleaning Exterior Plastic Surfaces

23 Flush with plenty of clean water. Use the bare hand gently to feel and dislodge any dirt, salt or mud. Wash with detergents (Item 3 or 4) and clean water. A soft cloth, sponge or chamois may be used in washing, but only as a means of carrying sudsy water to the plastic. Go over the surface only with the bare hand, so that any dirt can be quickly detected and removed before it scratches the plastic surface.

24 Dry with a clean, damp chamois. A soft, clean, cloth or soft tissue may be used if care is taken not to continue rubbing the acrylic plastic after it is dry. Remove oil and grease by rubbing lightly with a cloth wet with kerosene (Item 2) or hexane (Item 5).

CAUTION

Use only specified liquids. The use of other liquids may soften or craze the plastic.

25 Do not rub the acrylic plastic with a dry cloth, since this will cause scratches and build up an electrostatic charge which attracts dust particles to the surface. If the surface does become charged, patting or gently blotting with a clean, damp chamois will remove this charge as well as the dust.

26 If, after removing dirt and grease, no great amount of scratching is visible, polish the plastic with wax (Item 8). The wax will fill in minor scratches and help prevent further scratching. Apply the wax in a thin even coat and bring to a high polish by light rubbing with a soft, dry cloth.

27 If, after removing dirt and grease, the plastic surface is found marred by scratches, apply an approved polish (Item 8) by hand. If buffing equipment is available, buff out the scratches as described in Paragraph 112, following.

CAUTION

Do not attempt either hand polishing or buffing until the surface is clean. Dirt, grit and sand present during these operations may cause more serious damage than the original scratches. Since even skilful sanding, buffing and polishing introduce slight optical distortions, do not perform these operations on navigator astrodromes, gun turret sighting panels and similar critical optical parts.

Wash and wax these parts. If they are damaged by a number of deep scratches, replace them.

Cleaning Interior Surfaces

28 Dust the plastic surface lightly with a soft, damp cloth or sponge. Keep the cloth or sponge free from grit by rinsing frequently in clean water. Apply wax as described in Paragraph 26, preceding. Do not wipe the surface with a dry cloth.

Hot Climate Precautions

29 To prevent distortion of plastic enclosures in hot climates, open doors and windows of aircraft slightly to permit free circulation of air through the cabin when the aircraft is parked out under the direct rays of the sun. This will assist in preventing a high temperature condition on the inside that might soften the plastic sheets.

30 In general, sunlight has very little effect on acrylic plastic. Covers need not be used as a protective measure unless there is a danger of sand storms which will cause abrasion of the plastic sheets, or unless covers are required for camouflage purposes. Covers should not be drawn tightly over the enclosure since the pressure may distort the panel. If possible, allow room for the circulation of air between the cover and plastic.

31 There are a number of methods of installing plastic panels in aircraft. When installing a replacement panel, follow the same mounting method used by the manufacturer of the aircraft.

NOTE

Where difficulty is encountered in rivet installation, bolts may be used in installing replacements when the original design permits.

32 When subjected to large stresses (over 1000 psi), acrylic plastics are apt to craze, lowering the transparency and strength of the panel. It is important that these plastics be mounted and installed so that such stresses are avoided.

Installation

33 Never force any acrylic plastic panel out of shape to make it fit a frame. Acrylic panels are reasonably flexible, but if they are forced into a frame, high or unequal stresses will be set up in certain areas of the panel. If a replacement part does not fit easily into the mounting, obtain a replacement or heat and reform the panel.

CAUTION

Do not heat and reform limited areas of the panel, since local heating methods are apt to be only superficial and not thorough enough to reduce stress concentrations.

34 In clamping or bolting acrylic panels into their mountings, do not place the plastic under excessive compressive stress. It is easy to develop more than 1000 psi on the plastic by drawing up bolts tightly. Tighten each nut to a firm fit then back it off one full turn.

35 Use spacers, collars, shoulders or stop nuts in bolt installations to prevent tightening the bolt excessively. Wherever such devices are used by the aircraft manufacturer they should be retained in the replacement installation.

36 Mount acrylic plastic panels between rubber, cork or other gaskets to make the installation waterproof, to reduce vibration and to help to distribute compressive stresses on the plastic.

37 Since acrylic plastics expand and contract approximately three times as much as the metal channels in which they are mounted, suitable allowance for dimensional changes with temperatures must be made, as follows:

(a) Clearances of 1/8 inch minimum should be allowed all around the edges of the panel.

(b) If the installation involves bolts or rivets, make holes through the plastic oversize by 1/8 inch and centre so that plastic will not bind at these parts. In large self-supporting parts, such as nose sections, gun turrets, etc., elongate old holes radially.

(c) Mount panel to a sufficient depth in the channel to avoid danger of falling out when it contracts at extremely low temperatures or

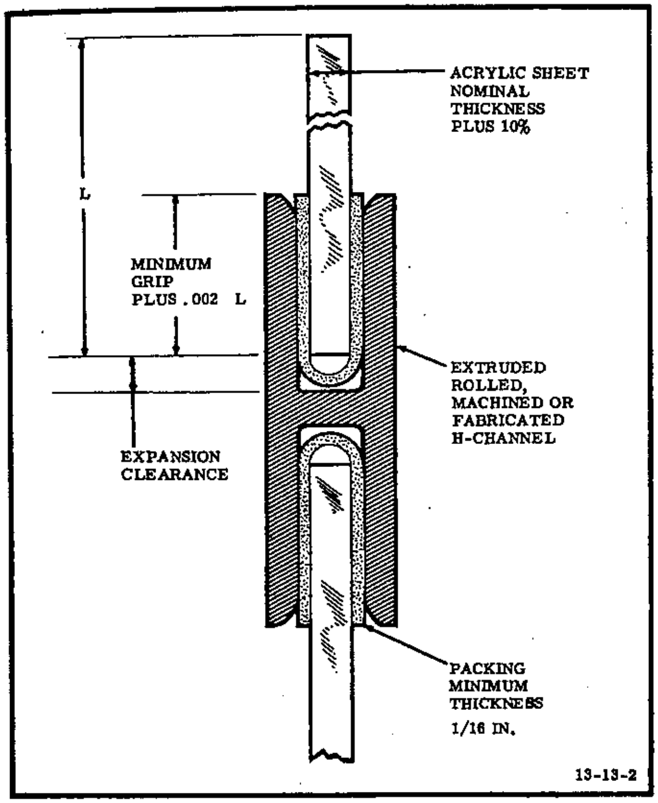


Figure 13-1 Simple Channel Installation

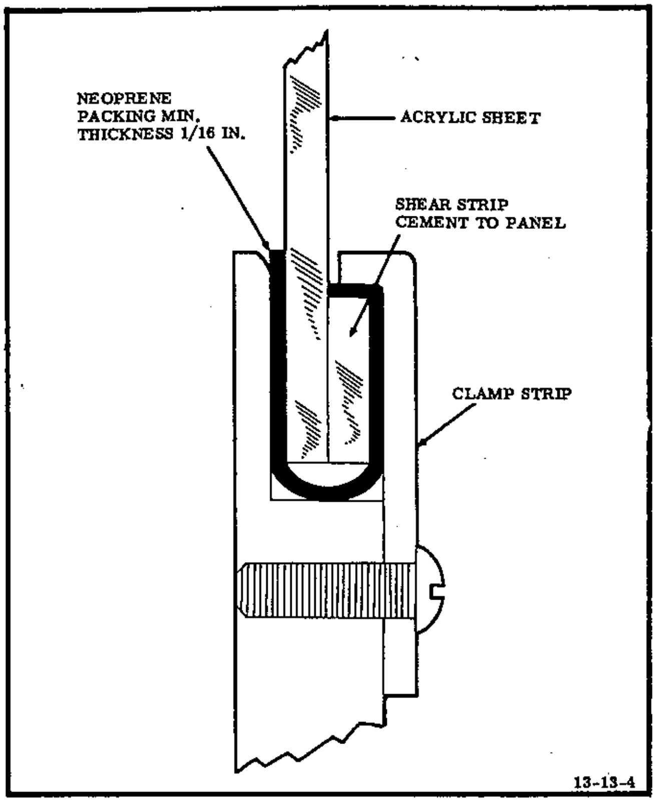


Figure 13-3 Clamp Installation with Reinforcing Rib

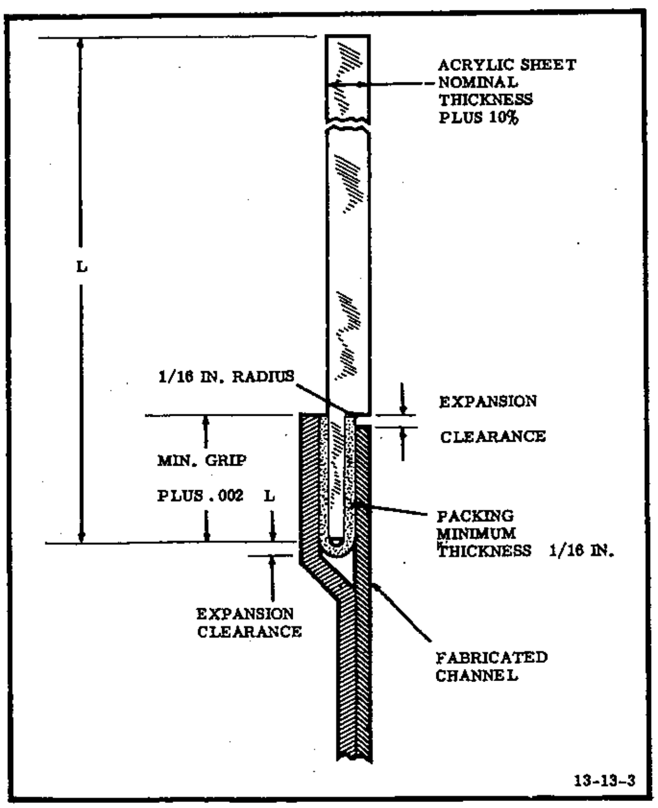


Figure 13-2 Channel Installation with Routed Edge

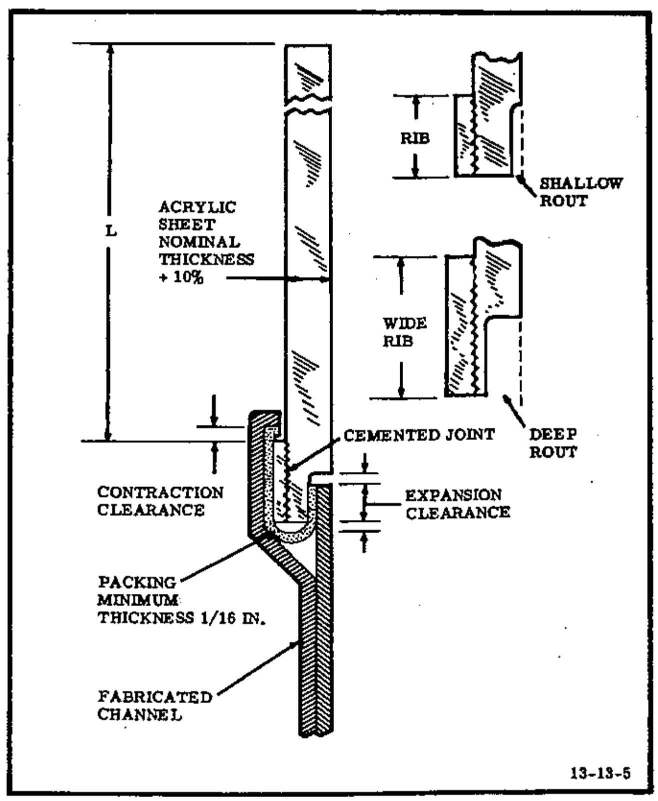


Figure 13-4 Flush Mounted Clamp Installation with Reinforcing Rib

when it is flexed. When the original design permits, panels up to twelve inches on either side should be mounted to a minimum depth of 3/4 of an inch; larger panels to a minimum depth of 1-1/8 inches.

Channel and Clamp Mountings

38 Wherever possible, avoid bolting or rivetting through holes drilled in the channel for the plastic. Clamp installations are definitely superior in distributing stresses. In this type of mounting, the principal precautions are:

(a) Make channel oversize to permit free linear expansion and contraction of the plastic relative to the frame.

(b) When installing acrylic plastics, ensure that clamping action is uniform.

(c) Make channels deep enough to hold the plastic securely despite flexing and thermal contraction. A safe rule is that plastic panels up to twelve inches on either side should extend into the channel a minimum of 3/4 inch; larger panels to a minimum of 1-1/8 inches.

(d) In calculating these allowances, note that linear sawing tolerances for acrylic plastics are usually ± .060 inch. Tolerances of ± .030 inch have been maintained when necessary on panels under twelve inches in length.

(e) Approved channel and clamp mountings are shown in Figures 13-1 to 13-5.

Bolt and Rivet Mountings

39 When special considerations make channel and clamp mountings impractical, holes may be drilled in the plastic for bolt or rivet installations. Because of difficulties experienced with rivet installations, bolt mounting is preferable. Give special consideration to the following factors:

(a) Use as many bolts or rivets as practical. Distribute the total stress as equally as possible among these bolts or rivets.

(b) Make holes drilled in plastic sufficiently larger than the diameter of the bolt to permit expansion and contraction of the plastic relative to the frame.

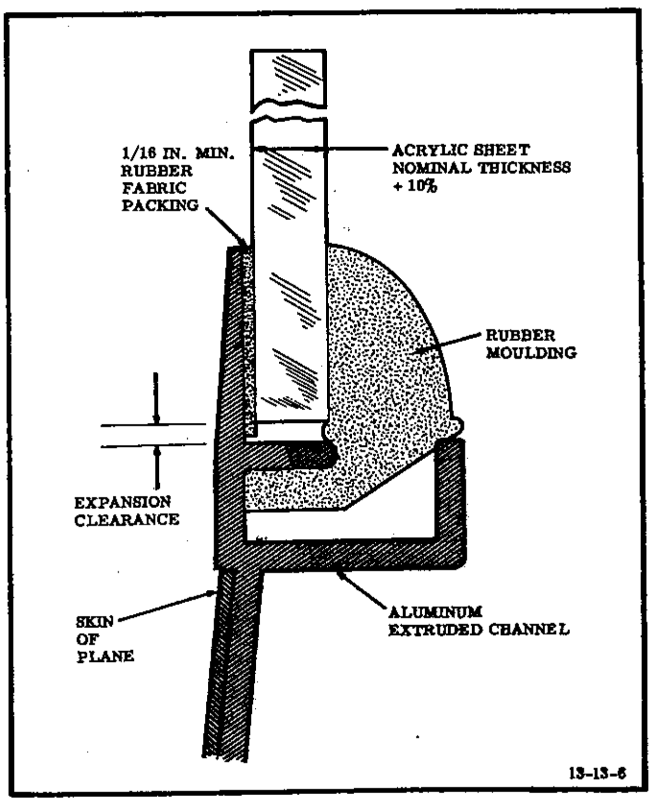


Figure 13-5 Hunter Sash Mounting

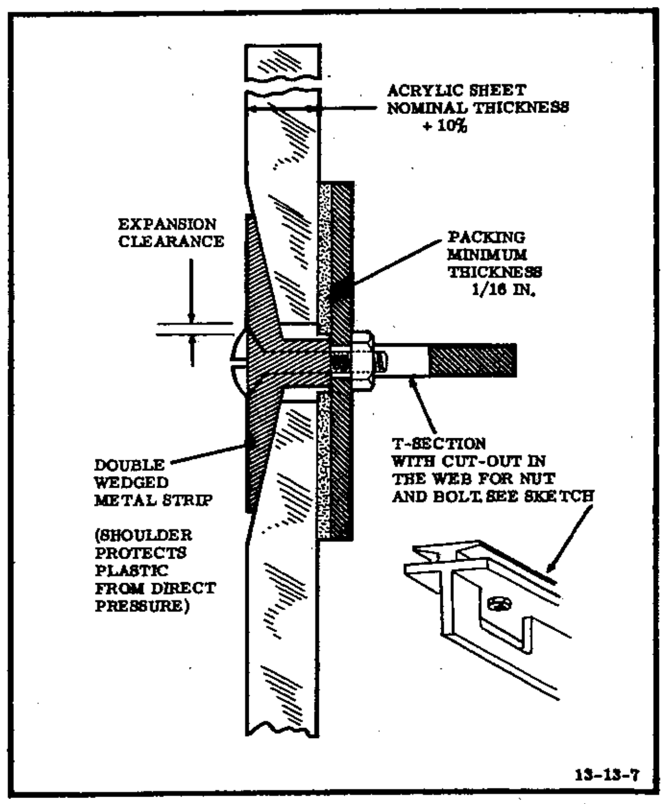


Figure 13-6 Wedge Section Installation

(c) Make holes in the plastic concentric with the holes in the frame so that greater relative expansion of the plastic will not cause binding at one edge of the hole.

(d) Use oversize tube spacers, shoulder bolts or rivets, cap nuts or some other device to protect the plastic from direct pressure.

40 Possible bolt and rivet installations are shown in Figures 13-6 and 13-7.

Cellulose Acetate Base Materials

41 The coefficient of expansion of cellulose acetate base plastic is greater than that of metals commonly employed for mounting structures and exceeds the coefficient of expansion of acrylic plastics. Cellulose acetate base plastics are affected by moisture and will change dimensionally as they absorb water. Allowance must be made in mounting acetate plastic if wide variations of temperature and humidity are to be encountered. In general, an allowance of about 1/8 inch per foot of panel length must be made for expansion and 3/16 inch per foot for contraction.

CEMENTING

General

42 The recommended cement (Item 26) for acrylic plastics consists of solvents or mixtures of solvents which soften the plastic, permitting the two surfaces to be joined to intermingle. When the solvent penetrates and evaporates, a hard clear joint is obtained.

Fitting

43 For a satisfactory joint, the two pieces to be cemented together should fit accurately. In butt joints, both edges must be made true and square before starting a cementing operation. It is also preferable to cement flat surfaces rather than curved and it is advisable to rout or sand curved sections to present flat surfaces before cementing. Where two curved surfaces must be cemented, the curves of both should be of the same radius.

Finish

44 The two surfaces should have a smooth finish. It is not necessary that they be polished

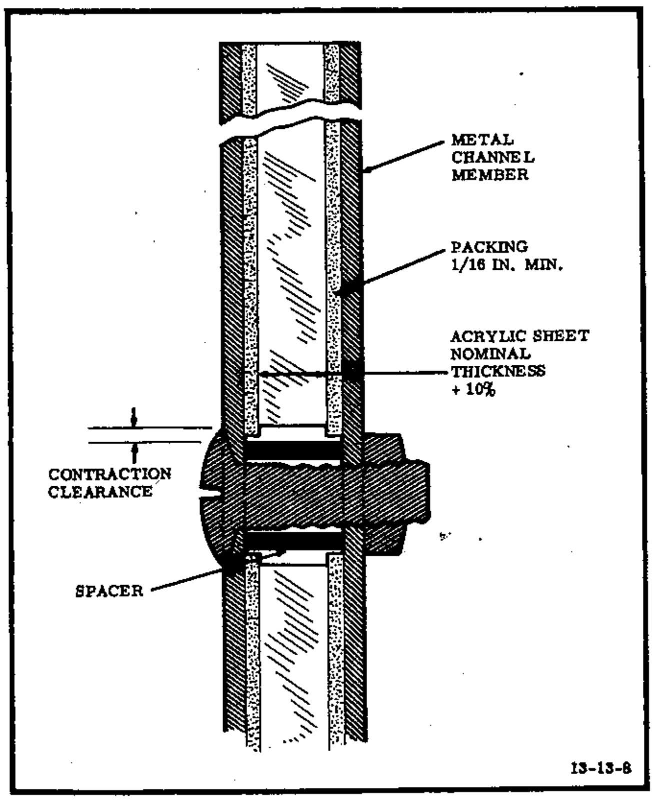


Figure 13-7 Bolt and Spacer Installation

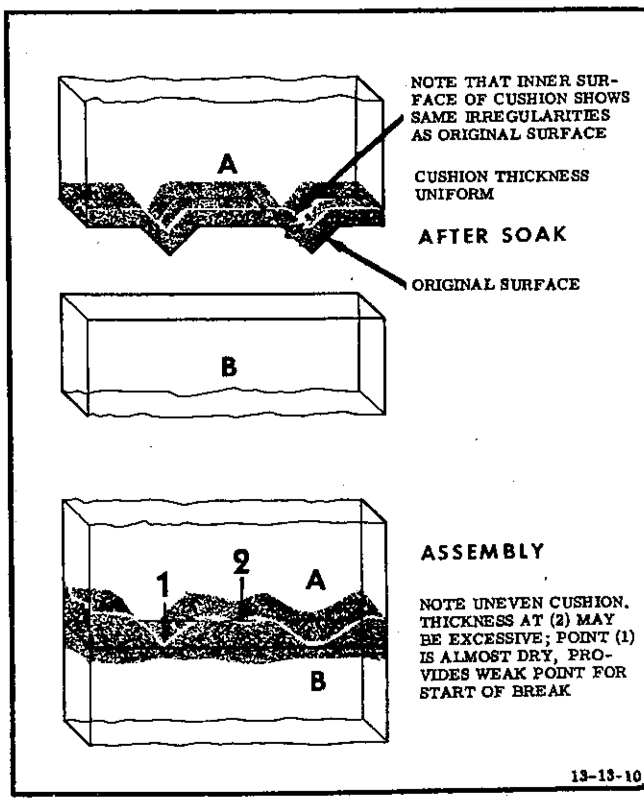


Figure 13-8 Cementing of Rough Surfaces

but they should at least be sanded smooth. The reason for this is that the solvent penetrates at an even rate on every point on the exterior surface and translates the texture of the original surface to the inner limit of the cushion. If the exterior surface is irregular, the cushion will be uneven in thickness when pressed against a smooth surface. (See Figure 13-8.)

Masking

45 To confine the softening action of the cement to the area of the joint, it is necessary to mask the surrounding plastic. Use a pressure sensitive adhesive tape (Item 12) impervious to the action of the cement.

Soaking

46 The function of the cushion formed by the cement is to permit intermingling of the two surfaces to be bonded. The liquid on the cushion surface is the bonding agent. The size of the cushion need be no greater than is necessary to obtain intimate contact. Although no arbitrary soaking time can be set, an average of about fifteen minutes in normal cement will form a cushion deep enough to take care of normal permissible irregularities of fit, (see Figure 13-9). It should be remembered that the deeper the cushion, the longer the drying time and the more of the solvent will be trapped in the joint. On the other hand, too thin a cushion may not give good contact of the surfaces and the joint may have dry spots and vapour bubbles in it. The cushion, therefore, should be somewhat deeper than the maximum allowable irregularities of fit.

47 Sometimes it is more convenient to use the syrup method, which consists of dissolving clean acrylic shavings, (about 3% by volume), in the solvent to make a viscous cement which can be handled like glue. The cement acts only as a carrier for the solvent. (See Figure 13-10.)

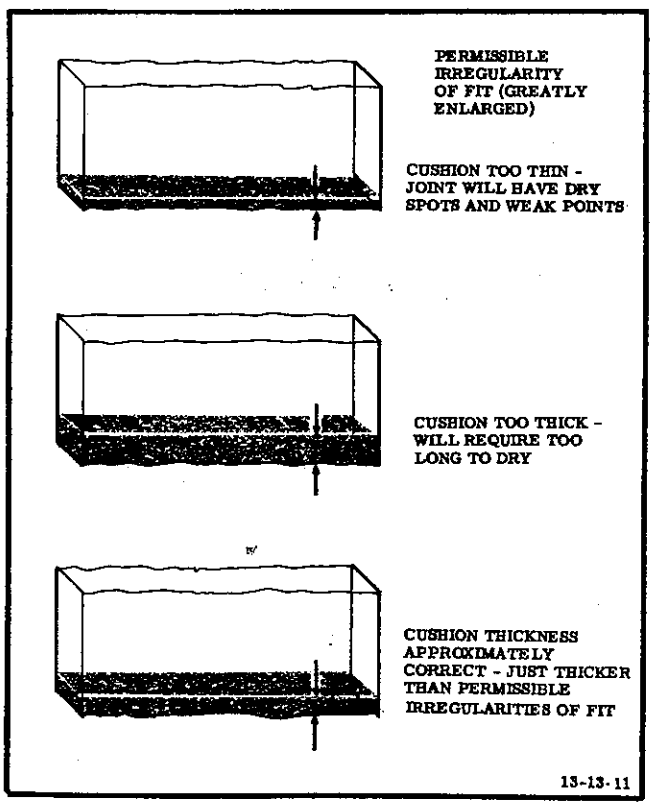


Figure 13-9 Cushion Thickness

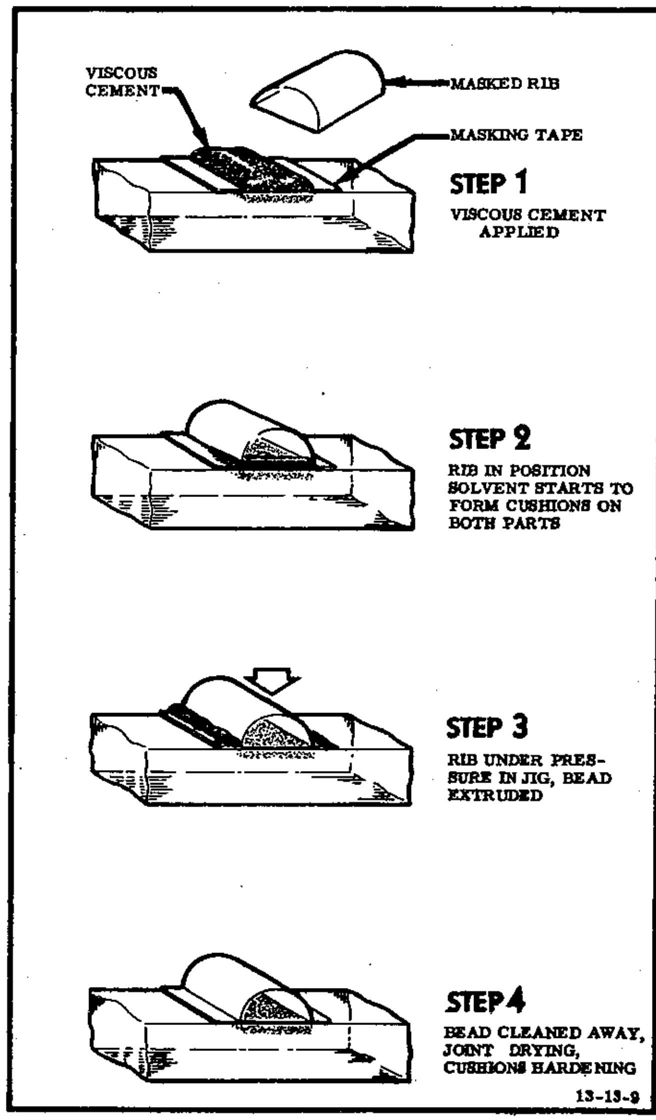


Figure 13-10 Cementing Using Syrup Cement

Assembly

48 The interval between removal from solvent container and the assembly of the joint is perhaps the most critical of the whole cementing operation. Since these liquid cements evaporate quickly, it is necessary that the joint be assembled as quickly as possible. The container should be near the cementing operation and the job or jigs should be so arranged that the operator can assemble the two parts accurately with a minimum of delay. If the interval between soaking and assembly is too long and the cushion surface dries or crusts over, it should be wet again with solvent, using a small pan of solvent and a brush placed near the cementing jig. It is important to allow a slight interval between the time the two pieces are placed in contact and the time pressure is applied. During this interval, the liquid surface of the cushion will be absorbed by the opposite dry surface. If pressure is applied immediately, this liquid is at least partially squeezed out of the joint, (see Figure 13-11). Ordinarily fifteen to thirty seconds is a sufficient interval.

Jigs

49 The success of a cementing job depends on the design of the jigs holding the two sections in place until the joint is hard. The jig should keep the two pieces firmly together but should not force either of them out of shape. Under the latter condition, the action of the cement on the stressed part is almost certain to cause objectionable crazing.

50 The pressure should be great enough to squeeze all air bubbles from the joint and assure thorough intermingling of the cushions. It should be applied evenly all along the joint to avoid stress concentration at any point, and be maintained to compensate for the shrinkage that takes place in the joint during setting or hardening. If the two pieces are attached so rigidly that they cannot move together while drying, the cushion, as it shrinks, will draw the cushion material back into the joint. The joint will then be marked with a curve or dimple, or by air bubbles. The three vital conditions are best met by using spring clips (spring clothes pins or battery clamps) either alone or in conjunction with wood or metal jigs, (see Figure 13-12). In order to avoid localized stress concentration which would cause crazing, avoid excessive pressure.

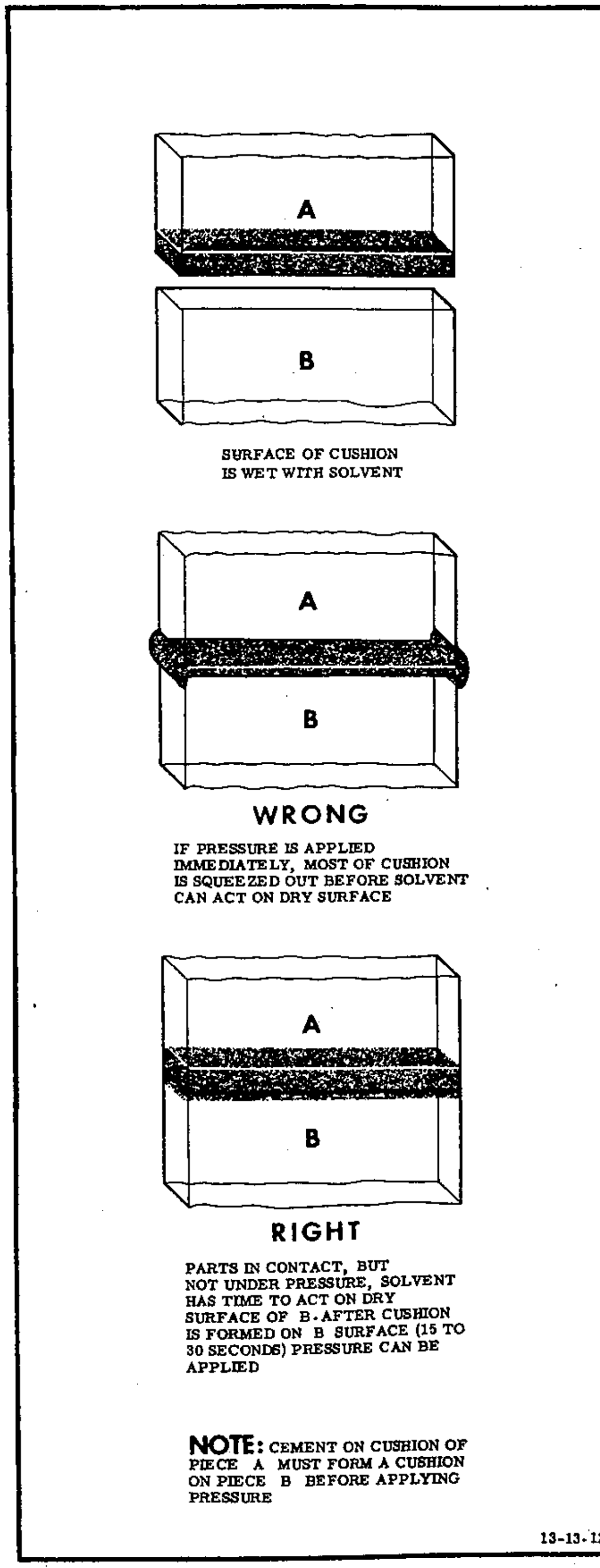


Figure 13-11 Cementing Methods

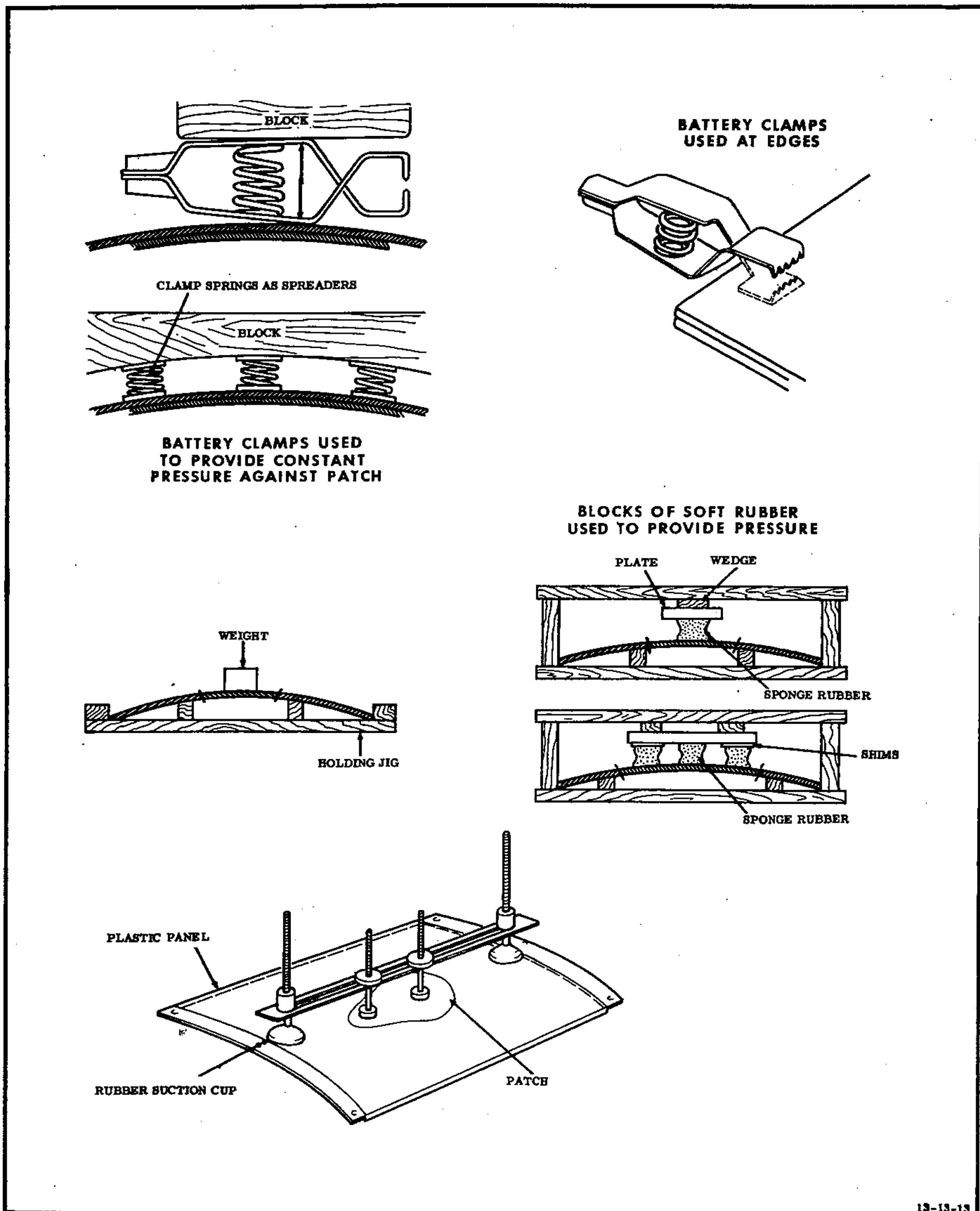


Figure 13-12 Typical Assembly Jigs

51 When placing the assembly in the jig and at intervals thereafter, it is advisable to examine the joint carefully. If slipping is noted before the joint has set, the pressure can be readjusted or the joint taken apart for reassembly. After the assembly has been locked in the jig, any excess cement and cushion which has extruded from the joint should be removed.

52 The assembly should be allowed to stand in the jig for at least four hours and an additional four hours should elapse before the assembly is subjected to handling or given heat treatment.

Curing and Heat Treatment

53 A solvent joint does not dry and will never become entirely free of solvent. If left at room temperature, the solvent in the cushion will penetrate to a certain depth and no further. In other words, an equilibrium of solvent and plastic is established that remains practically stable at any fixed temperature. If the temperature is raised, the cushion will slowly enlarge until a new equilibrium is reached. On cooling, the cushion will be larger and correspondingly harder if it contains less solvent per unit of volume. Heating a solvent joint long enough to expand its cushion to a new equilibrium will, therefore, produce a much stronger joint.

54 Heat treating of cemented joints must be undertaken with caution. Heat first activates the solvent which softens the cushion and the cushion then slowly expands as the solvent penetrates the material. If the plastic at that point is thin, or if the original cushion is too large, this expansion may cause serious weakening of the section. In heat treating, it is important that the temperature used should not approach the softening point of acrylic plastic nor too far exceed the boiling point of the cement. Suitable treatment would consist of 48 hours at 122° F. If this temperature causes undue dimensional changes in intricate assemblies, it may be desirable to heat treat at 113° F for 96 to 168 hours. Within these limitations, the strength of a solvent joint depends on the highest temperature to which it has been subjected. For example, if an untreated joint is heated by direct sunlight, the cushion is softened and the joint may be dangerously weakened. If, however, the joint has been heat treated, its strength will not fall below a safe limit when slightly reheated.

55 Heat treatment offers an additional advantage if the cement contains monomer. The same process (polymerization) by which this liquid becomes solid in the casting of acrylic plastic sheets takes place when the joint is heated. In other words, the monomer hardens into acrylic plastic, increasing the strength of the joint.

56 It is important that the joint be thoroughly hard before machining, sanding or polishing to remove the bead. The softened material in the joint continues to shrink until it has fully set. If the joint is trimmed or sanded too soon, a visible recessive scar will be left along the joint.

Cementing Procedure

57 Strict adherence to the following should result in strong and durable joints.

(a) Both pieces to be joined should fit accurately without forcing.

(b) The surfaces to be cemented should be polished or be sand or machine smoothed.

(c) The area around the joint should be masked against the etching action of the cement, using a tape impervious to the cement.

(d) Use only an approved cement (Item 26).

(e) Dip one of the two pieces of plastic in cement for approximately fifteen minutes until the surface has softened into a cushion.

(f) Assemble the two pieces quickly, so that the cement on the surface of the cushion will soften the dry surface of the other piece.

(g) Allow the two pieces to come in contact for a short interval (fifteen to thirty seconds) before applying pressure to allow the second cushion to form.

(h) Clamp the two pieces together, by means of spring clips, clothes pins or a jig incorporating springs, under just enough pressure to assure intermingling of the two cushions. This pressure need not be great and should be distributed evenly along the joints.

(j) Clean the joint promptly by scraping excess cement and extruded cushion onto the masking tape and removing the tape.

(k) Allow the assembly to stand in the jig for at least four hours.

(m) After an additional four hours, the assembly should be heat treated for 48 hours at 122° F.

(n) Remove excess cement. Clean and polish the joint.

58 For cementing cellulose acetate base plastic, a solution of base material filings and acetone (Item 6) may be prepared, the preparation depending upon climatic conditions. Thick adhesive is most suitable for hot climates. The use of acetone sometimes causes cloudy, unsightly joints of inferior strength. Acetone is highly inflammable.

TOOLS AND MACHINING METHODS

General

59 The fabrication of acrylic plastic parts may be generally compared to that of other materials, such as wood or soft metal. Light to medium woodworking equipment is satisfactory, but heavy duty machines, which are less apt to vibrate, are better. General rules for machining apply. Acrylic plastics are poor conductors of heat and being thermoplastic, tend to soften in excessive heat generated during machining. Water is the recommended coolant. Other coolants may contain chemicals harmful to the plastic.

Drilling

60 Standard drill presses are satisfactory. They can be of the single head, multiple head or radial type. Portable hand drills may also be used where convenient. Regular machine twist drills can be used successfully if ordinary care is observed. Standard drills, ground for hard metals, have a tendency to pull into the material and cause grabbing in much the same manner as with copper and aluminum. This may be overcome by using a modified drill, (see Figure 13-13).

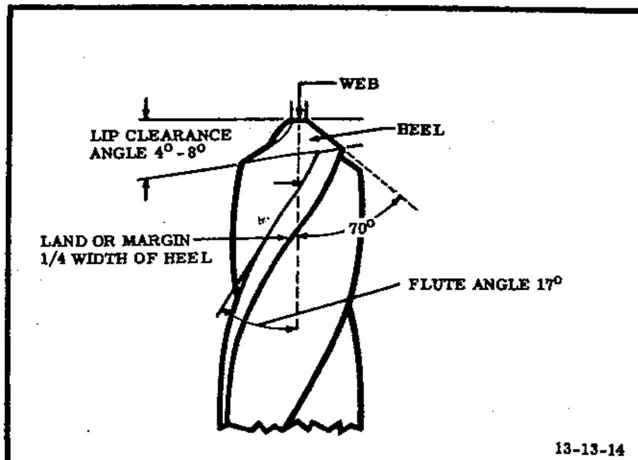


Figure 13-13 Plastic Drill Dimensions

NOTE

A thin web gives deep flutes and facilitates removal of chips. If the web is too thin, the drill will wobble and some compromise must be made between wobbling and convenient chip removal.

61 For drilling thin sheets, two other types of drills are satisfactory. One is a flat base drill such as has been used for many years to drill cellulose plastic. The other is a modified long lead twist drill with a sharp lip angle. Hollow end mills, mounted in a vertical drill press, can be used for drilling large diameter holes in thin stock. They produce clean, accurate holes and exhibit no tendency to chip on the break-through. Fly-cutters (or trepanning tools) are useful for cutting holes of more than one inch in diameter. Hole saws may be used for the same purpose. None of the tools should be run at high speed. Too fast a feed causes chipping and strain cracks. Proper feed is achieved when smooth, continuous, spiral chips or ribbons result. To avoid overheating, the rate of speed should be decreased as the depth of cut increases.

Drill Lubricants

62 Drill lubricants aid in chip removal, carry away heat and improve the surface finish of the hole. The best lubricant for drilling acrylic is a thin, mild, soap solution (Item 3). In drilling deep holes, the plastic should be immersed in the lubricant or provisions made to direct a steady stream of lubricant at the drill. In the latter case, the drill must be withdrawn every half inch to allow the chips to be cleared and the hole to be filled with lubricant.

Threading and Tapping

63 Taps and dies similar to those used in the metal working industry are used. If threading or tapping is necessary, observe the following precautions:

(a) Allow for the difference in thermal expansion between the different materials.

(b) Use special thread inserts when thread wear is expected. (Refer to Part 6, preceding.)

(c) Use standard taps and dies for cutting threads at 25% slower speed than for brass or cellulose plastic. High speed will cause excessive friction and gumming of the chips.

(d) Back the taps out frequently. Use the mild soap solution lubricant (Item 3) freely, especially when machine threading or tapping.

Sawing

64 Three general types of saw are used for cutting acrylic plastic: Circular saws, usually employed for cutting squares and rectangles; band saws, used for cutting irregular flat shapes and veneer saws, particularly suitable for trimming formed parts to shape while they are held in position on a jig.

65 Where extreme accuracy is not required, cutting lines may be pencilled directly onto the masking paper. For close tolerances, however, it is advisable to scribe layout lines directly on the surface of the plastic. If the masking paper is removed before scribing, it should be replaced again to within about one-quarter of an inch of the scribed markings before the piece is cut. A razor blade can be used to scribe and trim back the masking paper.

66 Jig saws for cutting curves with small radii and band saws for larger curves and straight cuts in thick material should have accurate blade guides in good adjustment. Circular saws are preferred for straight cutting of pieces which are not too large to be fed to the saw. Circular saws should be equipped with stiffener washers at the shaft to minimize blade vibration.

67 Because of the length of band saw blades, they dissipate heat more rapidly than do circular saws. Accordingly, they operate at lower temperatures and are better suited to cutting thick plastic sheets. Fine cutting may be done with hollow ground circular saws. Blades with from five to eight teeth per inch and no set give good results when running at a peripheral speed of about 10,000 feet per minute (4800 rpm for an eight inch diameter blade). As a general rule, the thicker the material being cut, the larger the diameter and the fewer number of teeth per inch needed.

68 The feed should not be forced, but will vary with the thickness of the stock being cut, the type of blade used, the speed and sharpness of the blade and the power available. Moderate smoking and smearing at the edge is an indication of too rapid speed. To obtain smooth edges at the exit end of the cut, slow the feed as the blade leaves the cut. The chipping of edges with circular saws can be minimized by adjusting the blade to the minimum height with relation to the table and thickness of stock. Keep saw blades sharp to obtain highest cutting efficiency. It is advisable to clean all types of blades periodically by soaking them in acetone (Item 6), toluene (Item 13), methylene dichloride (Item 14), ethylene dichloride (Item 15), trichlorethylene (Item 16) or some other suitable solvent to remove gummy deposit.

NOTE

Ensure that acrylic plastics do not come in contact with, or are not exposed to, the vapours of the above solvents.

Routing

69 Routers are used for a variety of operations, including machining flat sections to accurate contour, rabbetting edges to facilitate flush mounting, and machining rib sections to predetermined cross sections. For certain rabbetting operations, a jointer may be used. For rabbet or stepped routs, (see Figure 13-14), back off the teeth of the cutter on the underside to prevent drag and avoid burning. Radius the corners of routing cutters 1/16 inch to produce a fillet at the bottom of the rout. This prevents stress concentration and adds to the strength of the piece. Where an edge of the plastic bears on a router spindle collar as a guide during routing, oil the collar

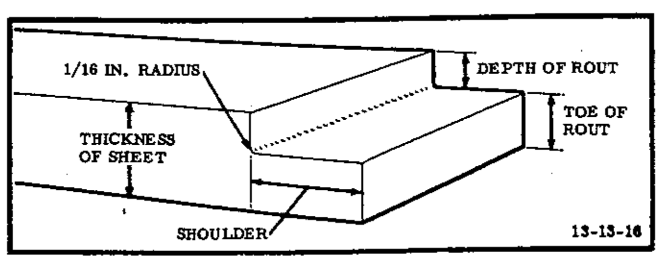


Figure 13-14 Step Rout or Rabbet

to reduce friction and excess heating. Special cross sections can be routed by using cutters ground to the desired shape. Rib shapes, for example, can be made by routing strips in much the same way that wood moulding is produced.

Routing to Shape

70 For high speed portable routers, standard two bladed wood cutters give satisfactory results. On vertical spindle shapers, multiple blade cutters may be used. Keep cutters sharp. Grind cutters with a back clearance of about 10°. Rake angle should be 20° to 30° for best results (see Figure 13-15).

71 Use high routing speeds to get smoother cuts, particularly on small diameter cutters under 1-1/2 inches. High speeds permit each cutter blade to take a very light cut as it passes the material and so reduces the tendency to chip. Acrylic sheets must be fed slowly and continuously to avoid any tendency to crack or overheat. Air blast or suction will remove chips and cool the cutter simultaneously. Hold work firmly by hand or in suitable fixtures which may be designed to serve as guides for the work.

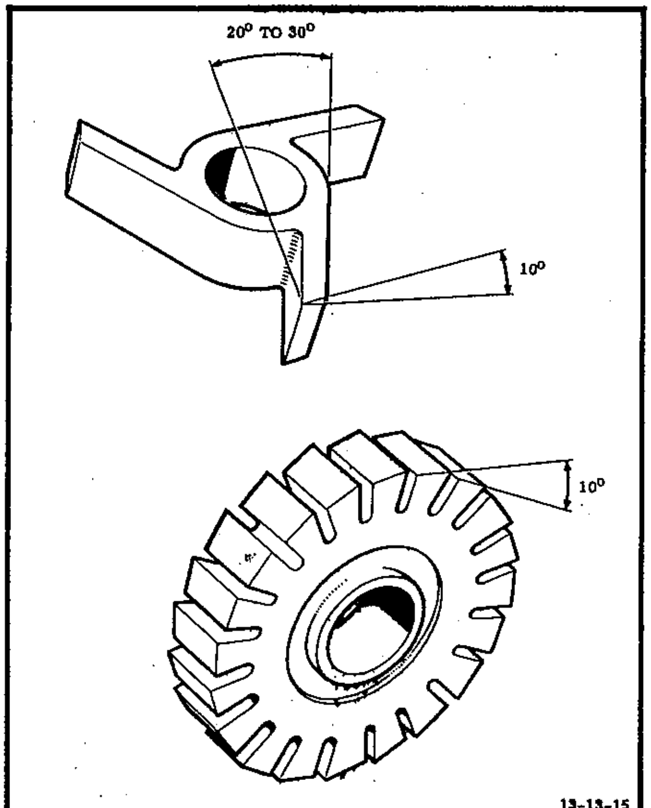


Figure 13-15 Typical Routing Cutters

72 Work in a clean room, and brush the forms free of dust and dirt before use. The acrylic plastic blanks should be slightly larger than the required finished size to provide an edge which can be handled freely without danger of scarring the surface of the material of the finished part. The pressures required to form acrylic plastics are extremely low and often the weight of the material itself is sufficient. The application of high, or even moderately high pressures, is neither necessary nor desirable, since it tends to increase the extent of mark-offs. After the material has been formed, allow it to cool slowly. Cooling can be accelerated by means of a fan or other device. Cool slowly and uniformly over the entire surface to reduce internal strain.

73 For complicated shapes, reinforced plaster forms are easy to make and are perfectly satisfactory. Forms should be free from waviness and other variations in contour which might cause optical distortions on the formed part. Smooth the surface and cover with a soft cloth, such as billiard felt, outing flannel, flannelette, imitation chamois or flocked or suede rubber sheeting. Where cloth is used, an application of petrolatum (Item 11) may be advisable. In an emergency, it is often possible to make forms from plaster using the broken panel itself as a mould. The broken panel is taped securely together and its inside surface well greased with petrolatum (Item 11) or soap (Item 3). Sand is packed around the outside surface to provide adequate support, while the plaster is poured and allowed to set.

74 The form should be provided with some means of holding the edges of the plastic sheet against the form. In some cases, flat rubber bands, fastened to the form block so that they can be snapped over the edges of the formed piece, will exert the necessary pressure.

Two Dimensional (Drape) Forming

75 Remove all masking paper from the plastic before heating. If the sheets become dusty or dirty after unmasking, rinse well with distilled water. If ordinary tap water is used, dry the sheet thoroughly by blotting with soft tissue paper. Any solvent in ordinary tap water will dig into the plastic surface if this precaution is not taken. After heating, and wearing soft cotton gloves, remove the hot plastic sheet from the oven and lay it carefully

over the form. Hold the edges of the sheet against the form, either by hand or by means of hold-down rings or yokes, until the sheet has thoroughly cooled.

Three Dimensional Forming

76 Parts with compound curves are formed from acrylic sheets by several different methods.

Stretch Forming (Manual and Mechanical)

77 Many compound shapes can be made by stretching the heated plastic sheet across the form. Heat the sheet slightly hotter than for drape forms. Fasten a number of wooden carpenter's clamps or anchor clamps to the edges, six to ten inches apart. Holding the sheet by these clamps, draw it down around the form. For some shapes, one edge of the sheet may be clamped to the form, and the sheet stretched over the form from the other edges. Since several men may be required for the stretching, depending on the size and thickness of the piece and the extent of the stretch, the form must be well built and firmly mounted. Stretch the sheet as uniformly as possible. Clamp a metal ring in position around the edges. This requires the use of a slightly oversized sheet, which not only simplifies handling but also compenstes for the slight tendency of the plastic to curl away from the form and flare at the edges.

Male and Female Forming

78 For compound shapes of irregular contour, stretch the hot sheet across the top of one form (usually the female), and hold in position with clamps while lowering the other form into place. Do not use high speeds and high pressures, since both tend to increase the extent of bolt marks or mark-off on the plastic sheet. The objection to this type of forming is that both surfaces of the plastic come in contact with the mould surfaces and the mark-off is doubled.

Trimming

79 Use a bandsaw to follow the correct outline which has been previously scribed on the surface. Where exact dimensional requirements are to be met on a large number of pieces, use a jig to hold the part in a rigid position. Trim, using a veneer saw or a hand router equipped with an end mill cutter.

80 Since they are thermoplastics, acrylic plastics become soft and pliable when heated over 220° F. They can then be bent to almost any shape and will retain the shape when cooled, except for a small contraction caused by the lowering of temperature. If the formed part shows excessive mark-offs or other imperfections, except scratches, on the surface, it can be placed back in the forming oven. It will resume its flat shape and original surface, except for scratches, and then can be formed again. It is usually easier and better to reform several times than to sand and polish mark-off and other mould imperfections.

Ovens

81 Ovens are used for softening acrylic plastic sheets prior to forming. A circulating air oven is preferable, heated by steam, electricity or gas. The oven should be capable of operating over a range of 220° to 350° F. Provide automatic control so that any desired temperature, within a few degrees, can be maintained throughout the oven. For uniform heating, hang the sheets of plastic vertically. Remove protective masking compound prior to heating. Wear white cotton gloves for handling the unmasked sheeting. In an emergency, any available oven, such as a kitchen baking oven, may be used. An alternative method employs a bath of mineral oil (Item 17) heated by immersion heaters or steam coils. This method is somewhat hazardous because of possible crazing and the danger in handling sheets covered with hot oil. It is also difficult to clean the plastic after such treatment. As a last resort, a heatgun or blowtorch may be used. Such equipment should be avoided whenever possible since it is almost certain to cause severe distortion. In general, any method other than oven heat is undesirable and should be used only when the latter is not available.

82 Thick heavy pieces are best supported by drilling a series of holes, spaced about six to twelve inches apart, along the edge of the sheet, and threading a heavy cord through the holes and around a supporting pole. For small pieces which are inconvenient to hang, and for pieces cut to finished dimensions which have no scrap edge to which the clips or channels can be clamped, shelves or drawers must be provided. Shelves, covered with soft felt or flannel, should be of open work construction to allow maximum circulation of air around the sheet to assure uniform heating. The oven should be so

designed that sheets which are hung vertically are heated by opposing streams of air which impinge directly upon opposite sides of the sheets. The air distribution should be uniform over the entire surface. Use filtered air and clean the oven frequently to prevent accumulation of dirt which may deposit on the sheet.

Heat Welding

83 It is possible to bond acrylic plastic sheets together by the use of heat and pressure. The process is quick and simple and produces joints that are transparent and fairly strong. The heating action may, however, set up internal stress that could reduce the strength of the plastic in the area of the joint. This method is not recommended where the joined panel will be subject to high stresses.

Heating Medium

84 A convenient heating medium consists of an electrical resistant strip of stainless steel, with a rheostat to control its temperature. It should be held in a frame designed to keep it hot when in use. The voltage and amperage necessary to obtain the required temperature will vary, depending on the size of the strip. With a 30 x 2 x .069 inch blade for example, a heavy duty transformer with a secondary output of 456 amperes and 3 volts is used.

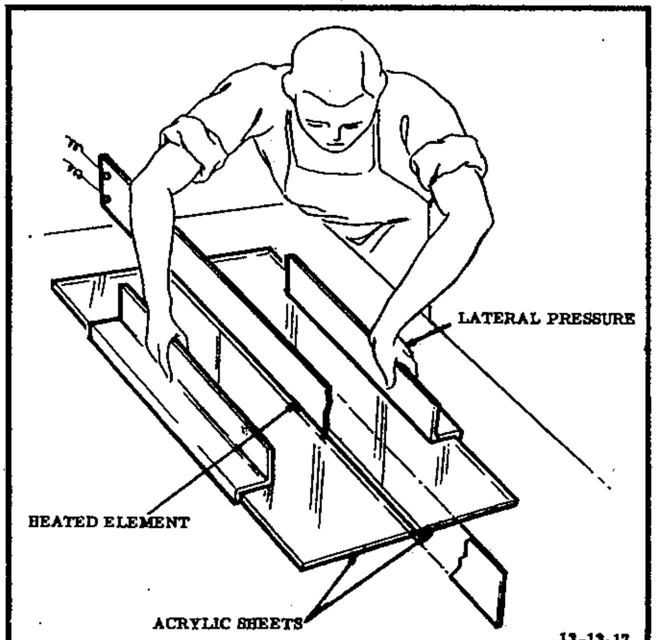


Figure 13-16 Pressure Application for Heat Welding

Butt Welding

85 Joints made at the blade temperature 662° F have a strength very nearly that of the material itself. If the blade is cooler than 572° F, the acrylic plastic does not decompose enough to form a liquid surface. If hotter than 752° F, the monomer vapourizes so rapidly that there is insufficient liquid left on the surface to form a bond. The temperature of the blade should be checked frequently with a pyrometer.

86 Hold the two acrylic plastic sheets to be joined rigidly in line by a jig set as close to the edges as possible. The heated material at the joint will become soft and will not remain accurately aligned under pressure unless properly supported by the jig. When the sheets are aligned, bring the hot blade between the two plastic edges and close the joint until, through this pressure and the softening of the material against the blade, a perfect contact between the two edges and the blade is established all along the blade. The pressure is then released so that the liquified surface is not extruded as it liquifies. At this point, edges of the material should be boiling and soaking slightly. In general, a joint should be heated only long enough to establish perfect contact and this bubbling condition (approximately thirty seconds). If it is heated any longer, the adjacent material is too deeply softened and will be deformed too easily under subsequent pressure.

87 Withdraw the heating blade and bring the edges immediately together under a spring or deadweight pressure of about two hundred and fifty pounds per square inch of joined area. Maintain pressure until the entire joint is cooled below forming temperature, (see Figure 13-16). The material immediately adjacent to the joint is soft and forms under this pressure, pushing outward as a rounded ridge, or as beads. If pressure is not maintained until the joint is cool, the distorted material will tend to return to its original shape, tearing or tending to tear apart. Experiments have shown that if pressure is released before the joint is cool, this shrinking of the material decreases the tensile strength of the joint by 10% to 15%. If a distorted joint is planed smooth, a groove is formed by the shrinking of the remaining material.

88 These disadvantages are overcome by confining the joint above and below the weld.

Two rigid non-heat-conducting surfaces, placed on either side of the joint and pressed against it after lateral pressure is applied, reduce distortion. This confining of the joint not only makes it possible to polish the joint immediately, but reduces loss of strength if the joint is heated for forming.

89 It is important to allow the joint to cool as slowly as practicable. The plastic expands when heated and if cooled too rapidly, the surface becomes rigid, forming a shell over the still hot interior. This uneven cooling sets up severe internal strains in the material. Thus, chilling not only tends to make the joint brittle but creates a tendency to crease. If cooled slowly, as in a confined joint, it is possible to obtain a joint with a minimum of stress.

90 Heat welded joints will contain dirt unless blade and plastic are kept clean. When proper precautions are taken, the resultant joint is very nearly invisible and has the advantage of immediate full strength without the delays, complicated jigs and hazards of the conventional solvent joints. Many variations of the welding technique are possible, depending on the type of joint and its strength requirements. Many different heating elements may be used and various jigs may be devised to apply the continuous low pressures required.

ACRYLIC PLASTIC REPAIR PROCEDURES

General

91 In general, repairs to acrylic plastic panels are at best only make-shift methods and usually result in serious impairment of clear vision characteristics. They should be considered for temporary use only and damaged sections replaced as soon as possible.

Patching

92 Repairs to damaged panels of acrylic plastic may be grouped into three categories: Patches secured by screws or rivets; inlay patches secured at the edges by an adhesive; and overlap or lap joints secured by an adhesive, (see Figure 13-17). Do not use cemented lap joints in any position where clarity of vision is essential, since the use of an adhesive on the surface of acrylic plastic tends to produce a minute greasing effect which cannot be removed. For emergency repair of cracks and holes, drill small holes at the end of each crack to relieve stress concentration and prevent further lengthening of the cracks. In the case of long cracks, drill a series of small holes along both sides and lace with soft wire (Item 18), (see Figure 13-18).

93 Acrylic plastic can be remoulded for making patches by the use of heat and light pressure. The temperature should be closely controlled. The correct temperature for remoulding material up to 1/8 inch thick is 212° F. Boiling water is used to apply the heat. The correct temperature for remoulding material over 1/8 inch thick is 230° F, immersed in oil or glycerine. Moulded repair patches should not be used in positions where clear vision is necessary, as instances have been recorded of transparent material becoming partially opaque after remoulding.

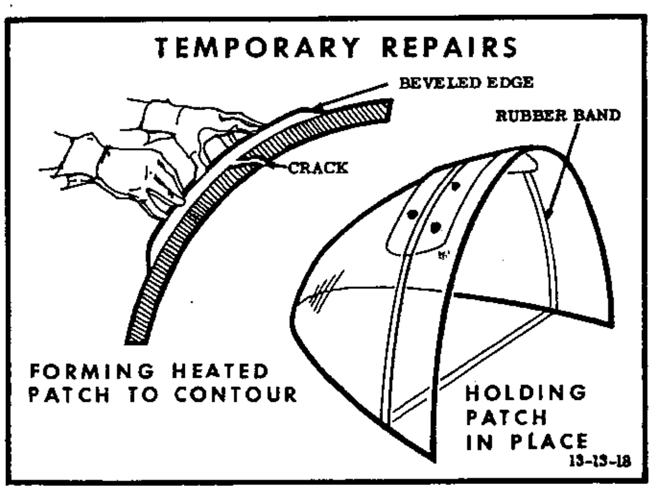


Figure 13-17 Overlay Patch to Reinforce Crack

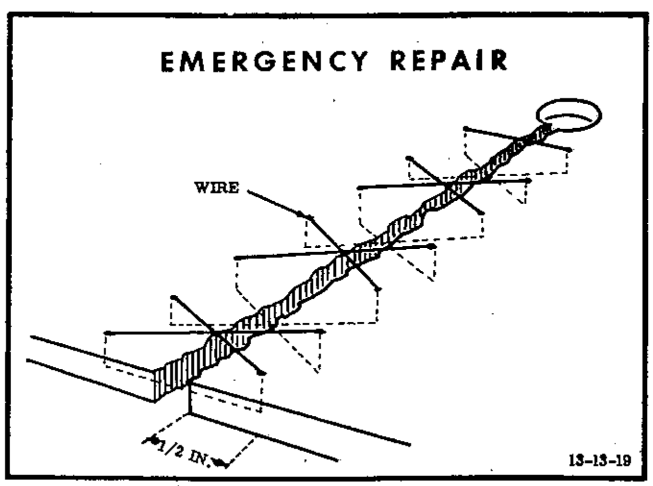


Figure 13-18 Lacing of Crack for Emergency Repair

Patches Secured by Screws or Rivets

94 Transparent patches secured to acrylic plastic panels by mechanical means may be of the same material or of a cellulose acetate base plastic. For panels up to 5/32 inch in thickness, a patch of 3/64 inch material may be used. For panels of greater thickness, the patch should be of 5/64 inch material. Always apply patches to the inside surface of the panel to minimize air resistance and erosion of the joint.

95 Drill holes for screws or rivets at intervals of one inch to two inches and not less than 1/4 inch from the edge of the patch. Use tubular or semi-tubular rivets and drill 1/64 inch oversize. Patches may be secured by bolts or screws. When bolts are used, drill fine clearance holes in both patch and panel. Screws require clearance holes in the patch and a tapping hole in the panel. Pass screw through the hole in the patch and screw tightly into panel, then cut off projection and file flush. Weatherproof by filling cracks and spaces with one of the approved cements.

Inlay Patches Secured by Cement

96 Trim small holes, up to two inches in diameter, to make them circular. Bevel the full thickness of the panel at an angle of 30°. Form bevel so that the patch is inserted from the side of the panel which receives air pressure during flight. The tendency will then be for the patch to be forced more securely against the panel. Another method of securing an inlay patch is to bevel the sides of the hole in the panel for half the thickness of the panel from each side. Two inlay patches are then fitted, each half the thickness of the panel, one from each side. Cement the patches together during fitting so that they become, in effect, a single plug, able to resist pressure from both sides. The material from which an inlay patch is to be made must always be the same as that of the panel and of the same thickness, except where a plug is made from two laminations, each half the thickness of the panel.

97 Before cementing a patch in a panel, remove all trace of oil or grease by cleaning with methylated spirits. Rub the surfaces to be joined with emery cloth (Item 20) using plenty of water. There is no need to polish these surfaces. Repairs by inlay patches requiring insertions larger than two inches in diameter should be effected by cutting a hole in the panel to a rectangular or square shape with rounded corners and shaping a piece of the same material as the panel to suit the hole.

Overlay Patches Secured by Cement

98 Use the following procedure to secure overlay patches by cement:

(a) Trim the damaged area.

(b) Cut a piece of plastic large enough to cover the area and bevel the edges. Form the patch, if necessary, by heating and pressing it over the area to be covered.

(c) Treat inner surface of patch with cement and apply to surface.

(d) Use regular cementing procedure, refer to Paragraph 57, preceding. Apply pressure using weights or clamps.

(e) When dry, the joint should be cleaned of all surplus cement by using emery cloth (Item 20) with plenty of water. Finally polish as previously detailed.

Butt Joints with Overlay

99 Mill edges of panels to be joined to ensure that mating surfaces are parallel. Bring panels together until a gap of only 1/16 inch remains between their edges. This gap can be maintained by laying the panels on a sheet of black paper coated with paste. Cut an overlap strip of similar composition and thickness to the panels and 3/4 to 1-1/2 inches in width and lay in position on the panels to be joined. Cover the surfaces of the panel on either side of the strip with masking tape (Item 12) to protect them from the cement. Remove the strips and pour an excessive amount of cement on the margins of the panels on which the strip is to be placed and in the 1/16 inch groove. Take care to prevent the formation of bubbles. Make joint by placing one end of the strip in position and gently lowering the remainder until contact is made along the entire length of the strip. Apply a light pressure with the fingers to remove air bubbles and excess cement, the latter being scraped away from the edges of the strip. After approximately one hour, the backing paper and masking tape may be removed and the joint baked for twenty-four hours at from 104° to 140° F.

Butt Joints without Overlay

100 Mill edges of panels to be joined in order to leave a groove 1/16 inch wide on each side of the assembly when the two panels are brought together. Cover the surfaces of the panel with masking tape as described in Paragraph 99, preceding. Backing paper, if used, will have to be removed and replaced by masking strips after the initial drying of the joints, in order to run the cement into the 1/16 inch groove on the underside of the panels. In other respects, the procedure is similar to that outlined in Paragraph 99, preceding. Butt joints without overlay should only be used where an increase in thickness is not permitted.

Repairs of Holes and Cracks

101 Acrylic plastic, up to 122° to 140° F, behaves as a glass-like, hard solid, and once a fracture has started in it, little extra energy is needed to propagate the fracture through the bulk. Its resistance to crack propagation is low and, in the failure of a structure, the critical stage in the process of the failure is the initial development of a surface crack in the structure. Prevent cracks from spreading by drilling or burning a hole at each end of the crack with a 1/16 inch diameter drill. Cover the crack by cementing a strip of acrylic plastic over it. This may be accomplished by either of two methods, as follows:

(a) Cut a strip of the transparent material 1/2 inch wide and long enough to cover the crack plus 1/4 inch overlap at each end of the crack. With the covering strip in position, use a No. 27 drill and drill a hole through one end of the crack and through the strip. Repeat at the other end of the crack. If the length of the crack is more than three inches, drill one or more intermediate holes of the same diameter through both the crack and the strip. Apply cement to the whole of one surface of the strip and to the area it covers surrounding the crack and clamp strip to panel by means of two or three small bolts and washers through the holes. When cement has set, remove bolts and washers, tap the holes and plug with shredded pieces of acrylic plastic which have been dipped in cement. Clean and polish the surface.

(b) Cut a strip of the transparent material two inches wide and long enough to cover the crack plus about one inch overlap at each end. Bolt or rivet strip to the panel as described in Paragraphs 94 to 97, preceding. Drill the holes

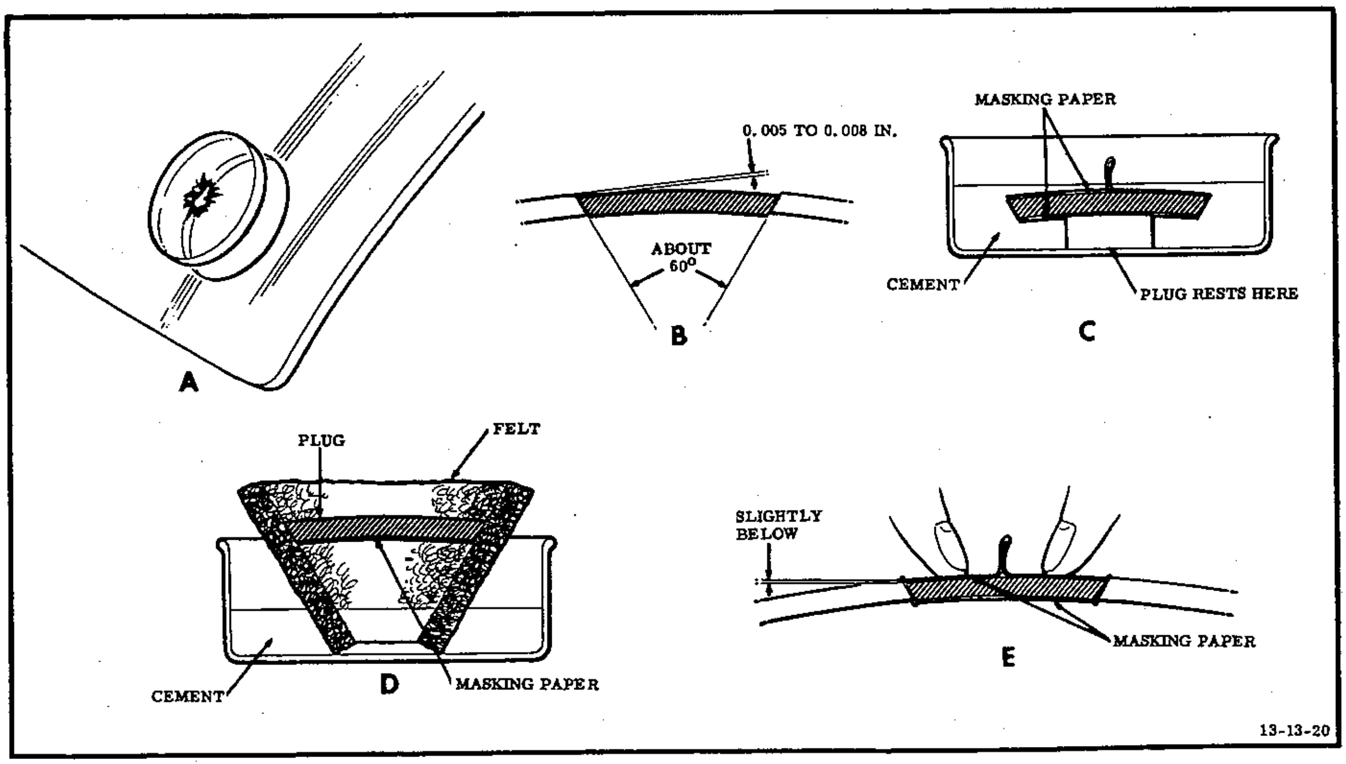


Figure 13-19 Plug Patch Installation

for the screws or rivets clear of the crack in the panel.

102 Where holes have radiating cracks, repair the holes with a circular inlay patch. At the extremity of each crack, drill and tap hole and plug with shredded acrylic plastic which has been dipped in the cement. Paint the crack with a solution of the cement and when set, clean and polish the surface. Owing to its brittle nature, acrylic plastic should only be drilled when the hole is to be plugged or filled with a cemented patch. Otherwise holes should be formed with a hot wire or needle.

Cemented Fabric Patch

103 Badly fractured areas may be reinforced in an emergency by cementing a layer of strong fabric over the damaged section. Rubber cement (Item 21), clear lacquer (Item 22) or acetate soap (Item 23) may be used as an adhesive. The use of acetate soap carries with it a risk of crazing.

Plug Patch

104 Another effective patch for temporary repairs is the plug patch shown in Figure 13-19. The damaged area should be removed by cutting a circular hole in the panel and bevelling the edges, as shown. A plug is cut and bevelled to fit. If the panel is curved, the material from which the plug is to be cut should be formed to the existing curvature and cemented.

CELLULOSE ACETATE PLASTIC REPAIRS

General

105 Do not attempt to remould distorted panels, since the application of heat necessary for the purpose causes severe shrinkage and the panel may become partially opaque after the repair has been effected. Replace distorted panels by new ones at the earliest opportunity. In general, the repair procedures used on cellulose acetate base plastic are similar to those for acrylic plastic. The chief difference between acrylics and acetate base plastics lies in the nature of the cements used. Because of the different chemical composition of the two materials, different solvents are required. In general these cements are two types, the solvent-type and dope-type.

Solvent-type Cement

106 The solvent-type cement (Item 26) is used where transparency must be maintained in the joint. It is relatively quick drying and hence is well adapted for use in making emergency repairs. The drying time will vary with the size of the joint and atmospheric conditions. Normally, from six to ten hours are allowed for thorough drying.

Dope-type Cement

107 The dope-type cement is preferred for use where the surfaces to be joined do not conform exactly. This cement softens the surfaces of a joint and creates a layer between the pieces being cemented. It does not yield a transparent joint and is slower drying than the solvent type. From twelve to twenty-four hours must be allowed for the joint to reach full strength.

FINISHING

General

108 Sanding or buffing carried out to remove a surface blemish may result in an ultimate finish poorer than that of untouched sheeting. For this reason, it is important that acrylic plastic be handled carefully during fabrication and servicing so that unnecessary finishing operations can be avoided.

CAUTION

> Under no circumstances should astrodomes, sighting panels or other critical optical parts be sanded or polished. Such sections should always be replaced when scratched.

Sanding

109 Never use sanding when ordinary buffing can be used to remove the blemish, nor should sanding be used unless some type of mechanical buffing equipment is available, since hand polishing is not sufficiently effective to restore polish to a sanded surface.

Hand Sanding

110 Where sanding is indicated, the finest sandpaper (Item 27) that will remove the scratch or other defect (no coarser than No.

320) must be used first. Wrap around a felt or felt covered wooden block and rub the defective area. Rub lightly, using water or a 2% soap solution as a lubricant. The use of soap will speed and improve the sanding operation. Use waterproof abrasive paper. Use light pressure and circular strokes. Sand an area having a diameter of about two to three times the length of the defect, (see Figure 13-20), to minimize optical distortion and excessive thinning. Follow the initial sanding by similar treatments using successively fine grades of sandpaper grits in the following sequence: 360A, 400A and 500A or 600A. Wash between each sanding.

Machine Sanding

111 The same general procedures apply to sanding with power-driven sanding machines as apply to hand sanding and the same succession of sandpaper grits is used. The generous use of water as a lubricant is especially necessary to dissipate frictional heat. Extremely light pressure is to be used.

CAUTION

Power sanders should only be used where the severity of the defect is such as to require excessive hand sanding. Only flat surfaces or surfaces with a radius of curvature greater than thirty-six inches should be so treated. Machine sanding tends to flatten curved surfaces of small radii, thereby producing excessive optical distortions and thinning out. After deep scratches have been removed, rinse thoroughly with clean water, rubbing with the hands to loosen any abrasive or foreign matter and wipe with a clean, damp, flannel cloth. The remaining scratches in the sanded area should be approximately 0.003 inch, when properly sanded.

Buffing

112 Machine buffing or hand buffing may be used to remove scratches remaining after the sanding operation or scratches that do not require sanding.

Machine Buffing

113 For machine buffing, use the following procedure:

(a) Buff the plastic with a wheel coated with tallow (Item 29) and Tripoli buffing compound (Item 28). When buffing wheels have been used before, remove any hardened tallow by running them against a metal edge. The abrasive coated wheel should operate at approximately 2000 fpm.

(b) Wash the plastic thoroughly with soap (Item 3) and water to remove all traces of abrasive. Dry and then buff with a soft cotton wheel to which only tallow has been applied. This wheel should operate at 3200 to 3600 fpm.

(c) Apply one coat of Anstac M plastic cleaner (Item 4) to the buffed area with a clean cloth and then wipe dry.

(d) A high gloss may be obtained by applying wax (Item 31) and polishing using a soft, clean, cotton cloth.

Hand Buffing

114 For hand buffing, use the following procedure:

(a) Remove scratches with a small amount of polish (Item 32) added to a damp flannel cloth which is wrapped around a wood or rubber block. Polish the entire area in a circular motion, as with the sandpaper.

(b) After the scratches have been removed, rinse thoroughly with clean water, rubbing with the hands to loosen any abrasive or foreign matter and wipe with a clean, damp flannel cloth.

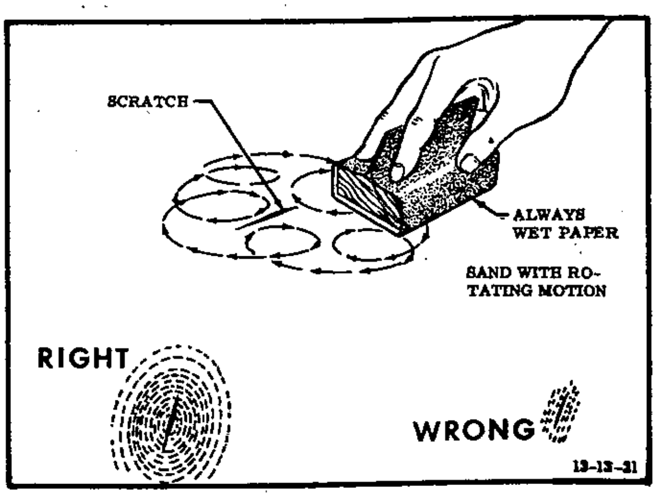


Figure 13-20 Sanding Methods

(c) As a final buffing agent, use fine abrasive (Item 33) and repeat procedure outlined in Sub-paragraph (a), preceding.

(d) Apply one coat of plastic cleaner (Item 4) to the buffed area with a clean cloth and then wipe dry.

(e) A high gloss may be obtained by applying wax (Item 31) and polishing the plastic using a soft, clean, cotton cloth.

NOTE

When sanding or buffing plastics, care should be taken to avoid overheating the material. While buffing, the plastic should be constantly moved so as not to buff the same area constantly. In critical areas of acrylic plastic parts, maximum allowable depth of scratches permissible for rework is .015 inch; in non-critical areas, .025 inch.

Ashing

115 Ashing is an alternative to sanding using a thick abrasive paste on a cloth wheel. Speed and pressure are critical. To prevent overheating, hold both within limits. Overheating will result in poor finish and, in extreme cases, formation of drag-marks on the surface. As a further precaution against over-heating, the plastic or the wheel should be kept in constant motion with relation to the other. For ashing, a wheel speed of approximately 900 surface feet per minute is recommended.

Hand Polishing

116 When buffing equipment is not available, a good cleaner or polish can be applied by hand to remove light scratches and other minor imperfections. Use a soft damp cloth, such as a soft fibre cloth, imitation chamois, glove lining, outing flannel or flannelette. Wash area to be polished to remove dirt and grit and rub vigorously with the polish. Do not rub too long in one place, but rub with a free circular motion over a fairly wide area. Several applications of cleaner may be necessary.

Waxing

117 To finish to a high polish and to protect the surface, use a good paste or water emulsion wax. This final application is done by hand. Most polishing waxes will effectively fill tiny hair scratches and make them less apparent. The wax also imparts a protective coating to the plastic. Wax should be applied with a soft cloth in the same manner as polish.

FORMING POLYTHENE PLASTIC TUBING

General

118 The following paragraphs give the procedures to be followed when forming polythene plastic tubing.

Bending

119 To bend a polythene plastic tube, proceed as follows:

(a) Fill the tubing with sand and plug both ends with wooden or rubber stoppers. Where a long tube is to be bent near one end only, the whole length of tubing should be filled with sand.

(b) Heat the tubing and the selected bend block in a hot water tank and bend the tubing by hand around the bend block, preferably while still in the tank.

(c) Remove from hot water, and with tube still bent around the block, immerse in a tank of cold water.

(d) Remove the sand from the tubing and blow out with compressed air. Ensure sand is completely removed.

Recommended Bend Radii

120 The following are the recommended minimum bend radii for polythene tubing with 1/16 inch walls:

(a) 1-inch OD, 8-inch radius.

(b) 3/4-inch OD, 6-inch radius.

(c) 1/2-inch OD, 4-inch radius.

Assembly of Beaded Connections

121 When assembling polythene tubing over beaded metal tubing, use either Aeroseal Type QS-200 or Wittek Type WWD clamps. Wrap tubing with two turns of black friction tape in those areas that are in contact with clamps.

Cleaning

122 Wash the tubing with soap (Item 3) and water. Use cold water on tubing that has been formed, flared, bent or assembled with hose clamps. Hot water may be used in other cases. Rinse with cold water or wipe with clean moist cloths after washing. The use of any solvent, such as thinners, trichlorethylene, gasoline, carbon tetrachloride etc., is prohibited.

Testing

123 Use compressed air for testing with the assembly immersed in water.

NOTE

In bending operations, make allowance for spring-back of the bend during cooling and subsequent pressure testing. If a final bend radius of 8 inches is required, the actual bending should be done on a radius of approximately 1 to 2 inches less. The dimensions shown in Paragraph 120, preceding, are the final radii.

NOTE

Reheating of the tubing above 120° F will tend to return the tubing to its original shape, and care must be taken to localize the heating, where more than one forming operation is required on a particular length of tubing.

NOTE

Wittek Type FBSS clamps are not suitable for use with polythene tubing.

FORMING THERMOPLASTIC TUBING

General

124 The procedure in the following paragraphs applies to all types of tubing fabricated from thermoplastics such as ethyl cellulose or cellulose acetate and cellulose acetate butyrate.

Softening

125 In order to permanently form thermoplastics without distortion, heat the material and place in jig for forming and cooling.

Heating

126 Heating may be performed as follows:

(a) Place in oven at 350° F. Length of heating process depends on wall thickness and tube diameter. Test, using scrap material, to determine time needed for heating.

(b) As an alternate method for small pieces, use boiling water.

CAUTION

Tube must not be heated to a temperature where it will collapse; only to a point where it will form with a minimum of distortion.

Bending

127 Immediately after heating, place the tube in a suitable jig and form. Allow the tube to cool sufficiently hard to handle without distortion. Force cool, passing air through the inside and over the outside of the tube. The forming jig must be of such design that a minimum distortion of the tube is achieved. Standard hand tube benders may be used. If distortion occurs during bending, insert a hard rubber tube in the plastic tube before heating, which will keep the tube from collapsing and aid in the bending.

GLASS FABRIC LAMINATE REPAIRS

General

128 The materials and procedures used in the repair of glass fabric laminate are described in the following paragraphs. The types of damage discussed are holes or cavities, ruptures, cracks, delamination, sections to be spliced, resin-starved areas, resin-excess areas, blisters and pulled inserts. In describing the repairs, reference is made to the methods of preparing, pressing and curing glass fabric laminate. These methods are described in separate paragraphs following the repair procedures. Use cellophane or approved parting agents, (refer to Paragraph 129, following), when pressurizing in contact with impregnated resin. Pressurizing and curing (application of heat)must be applied immediately after application of impregnated resin. The pressure required will be between 25 and 50 psi.

Parting Agents

129 The following approved types of parting agents may be used when necessary:

(a) Grease (Item 34).

(b) Grease (Item 35).

(c) Silicone (Item 36).

(d) Silicone Resin (Item 37).

Small Holes

130 Remove all foreign matter from the hole or cavity, fill with impregnated fibres, and cure, (refer to Paragraphs 142 and 147, following). After curing, refinish surface as necessary.

Large Holes

131 Sand area around edge of hole with coarse sandpaper. Coat with resin and place a piece of impregnated glass fabric cloth (Item 38), over the hole so that it overlaps the edge approximately 1/2 inch. Push the cloth into the hole to form a slight cavity and fill cavity with a quantity of impregnated glass fabric mat (Item 39), equal to the thickness of the laminate being repaired. Cover the patch with cellophane (Item 40) and cure, applying pressure during curing if strength and finish requirements are rigid, (refer to Paragraph 146, following). Refinish surface as necessary.

Minor Ruptures

132 In the case of a minor rupture, work a coating of resin (Item 41) into the ruptured area and cure, subsequently refinishing the surface.

Major Ruptures

133 In the case of a major rupture, sand area around rupture on reverse side. Laminate a prescribed number of resin-impregnated cloth layers over area, (refer to Paragraph 142, following). Tape cellophane (Item 40) over cloth and cure. Pressure must be applied during curing if requirements are rigid, and surface must be refinished after curing.

Cracks along Trailing Edge

134 To repair a crack along the trailing edge, sand the area for one inch on both sides of the crack. Insert a 1/2 inch strip of impregnated glass fabric mat (Item 39) in crack so that the edge of the mat is flush with the trailing edge of the part, (refer to Paragraph 142, following). The mat should extend the entire length of the crack. Cover the crack with one-ply glass fabric cloth (Item 38) so that the cloth overlaps the crack at least 1/2 inch. Cover patch with cellophane (Item 40), apply pressure if necessary, and cure.

Delamination

135 To repair delamination, work the resin in between the layers using a hypodermic needle. After working resin between the layers, apply pressure to force them together, and cure.

Sections to be Spliced

136 When a section is to be spliced, separate the layers in the laminate for a distance of approximately one inch from both edges. Work the resin between the layers and dovetail the edges together. Apply pressure, cure the rework, and refinish as necessary.

Resin-starved Areas

137 To repair a resin-starved area, coat the dry area with a 50-50 solution of resin and Zoluol (Item 42). Remove all excess resin and cure the rework.

Resin-excess Areas

138 When a resin-excess area is found, sand or chip off the excess resin to the bare glass fabric. Apply a coat of resin to seal the fibres and cure.

Blisters

139 To repair a blister, split with a knife and force resin inside using a hypodermic needle. Apply pressure and cure the rework.

Pulled Inserts in Moulded Glass Fabric

140 When repairing pulled inserts in moulded glass fabric, file the retaining grooves as deep as possible in the inserts in order to afford a good mechanical lock. Screw the insert on a bolt to keep resin out of the threads and clean the outside of the insert with Zoluol (Item 42). Clean out the hole in the glass fabric section with Zoluol and scrape grooves approximately 1/32 inch deep in the inside surfaces. Fill the hole with resin and then force in the insert. Remove all excess resin and cure the section for 10 minutes at 300° F.

Preparation of Resin

141 Weigh the desired amount of resin and to it add 2%, by weight, of benzoyl peroxide catalyst (Item 10). Stir the mixture until catalyst is dissolved. To prepare a 50-50 coating solution, add one part resin (Item 41) to one part Zoluol (Item 42) and stir until a uniform solution is obtained.

Preparation of Impregnated Fibres

142 Stir together 1 part milled glass fabric (Item 43) and approximately 3 parts, by weight, of prepared resin (Item 41) until a smooth, creamy mixture is obtained.

Preparation of Impregnated Mat and Cloth

143 Apply a thin coat of resin to the glass mat or cloth and scrape off the surplus. To thin the resin prior to the addition of catalyst, up to 5% by volume of Styrene N-99 (Item 44) may be added to the resin. Then add 2%, by weight, of catalyst and heat to approximately 100° F to facilitate catalysis.

General Pressurizing Methods

144 In most cases, sufficient pressure may be obtained by the use of small spring clamps or C-clamps. In other cases, the part may be replaced in the mould and pressure applied as in fabrication of the part. If an electric iron is used in curing, pressure may be applied through it to the laminate. Where these methods fail to produce satisfactory pressure, insert a vacuum valve in a sheet of polyvinyl alcohol (Item 45) and place it over the area to be pressed. Seal the edges of the polyvinyl alcohol sheet with sealing compound (Item 46). If it is not airtight, seal the reverse side of the area with a sheet of cellophane that is sealed around the edges with sealing compound. After the resin has jelled, the vacuum may be stopped.

General Curing Methods

145 Catalyzed resin requires a heat of approximately 300° F for two to ten minutes, varying with the thickness of the laminate, to ensure polymerization (curing). This temperature may be obtained by the use of a hot air gun, electric iron, electric pad, or an oven. Curing times and temperatures must be obtained by experiment, using scrap materials, prior to commencing the repair. The following alternate minimum time and temperatures may be used as a guide:

Temperature (Minimum)	Time in Minutes (Minimum)
190° F	90
200° F	45
225° F	20
240° F	10

146 The resin may also be cured by exposure to ultraviolet light or to sunlight. The time exposure necessary to effect a cure varies according to the thickness of the laminate, the temperature and the degree of the ultraviolet light or sunlight, but usually one hour is sufficient. When using heating equipment on installed parts, avoid damage to adjacent parts.

PHENOLIC PLASTICS

General

147 The following information may be used for the manufacture of materials required for the moulding of phenolic plastics.

Dyes

148 When it is required that the plastic be dyed red or black, use dye (Item 47 or 48).

Parting Agents

149 Parting agents must be applied to the mould prior to casting. Use zinc chromate primer, (Item 49), (refer to Part 23, following), paint (Item 50) or wax (Item 51).

Flexible Mould Materials

150 For flexible moulds, use Plastiflex (Item 52) or Superlastic P-1500 (Item 53).

Vinyl Resin Cement

151 Use vinyl resin cement (Item 54) or vinylseal (Item 55) with one coat of zinc chromate primer (Item 49) when casting in metal inserts in the mould.

Casting Resin and Catalyst

152 The casting resin (Item 56) is supplied as a liquid viscous resin which can be easily

poured at room temperature . The catalyst must be mixed as directed on the container.

Preparation of Non-flexible Moulds

153 Moulds are made similar to sand casting moulds, using plaster of paris, wood, steel, cement, etc. and using the same type of gates, risers, etc. Apply one coat of zinc chromate primer (Item 49) and three coats of paint (Item 50). Wax lightly before use.

Preparation of Flexible Moulds

154 Flexible moulds are cast over a master which is surrounded by a tin can or similar form. When using Plastiflex (Item 52), heat it to 320° to 340° F. Stir frequently.

CAUTION

Do not exceed 340° F.

155 Heat master form using infra-red lamp and pour liquid Plastiflex (Item 52) over master mould, keeping the liquid hot until evolution of bubbles from liquid ceases. Allow to cool and apply a light coating of wax or oil to the mould. Castor oil (Item 58) or mineral oil (Item 17) may be used. When using Superlastic P-1500, (Item 53) the master mould need not be heated. Stir material well just prior to use, pour over cold master mould and allow to stand for approximately one hour to eliminate bubbles. Then cure mould at 170° F until set up.

NOTE

Use Plastiflex moulds where extreme flexibility is desired and Superlastic P-1500 for slightly flexible moulds. Material for split moulds may be reinforced with plaster of paris. When pouring moulds, ensure that mould is properly tilted or agitated so that all small cavities or irregularities in the casting will be properly filled with mould material.

Phenolic Resin Castings

156 Use only resins based on phenol, melamine or resorcinol for the casting material. Heat the desired quantity of casting resin material to 110° F in oven or water bath.

NOTE

Never heat resin directly over hot plate.

157 Add red or black dye if required. Dye must be added to manufacturers directions. Allow to stand for three hours to disperse bubbles if dye was added. Then reheat to 110° to 125°F. Add catalyst according to manufacturers directions. Allow to stand at room temperature for two to eight hours.

Casting the Part

158 Treat mould with parting agent and preheat to approximately 160° F. Heat resin to pouring viscosity, 120° to 160° F. Pour resin carefully in order to trap as little air as possible. Vibrate or tilt mould as required to allow trapped air to escape while pouring and during next few minutes after pouring. Cure at 160° to 190° F as soon after pouring as possible. When part is sufficiently hard, remove from oven and cure at room temperature for one hour per inch of thickness.

Process Precautions

159 Metal inserts must have burr removed. Apply one coat of zinc chromate primer (Item 49) and approximately .010 inches of vinylseal cement (Item 55).

NOTE

When handling catalyst, observe safety precautions. (Refer to EO 00-25-25.)

160 Spilled liquid resin may be cleaned up by using denatured ethyl alcohol (Item 59). Recoat moulds with parting agent after each casting. Filter Plastiflex (Item 52) which becomes lumpy through a wire screen. When pouring Plastiflex over plaster of paris master mould, place pattern over the hole of a vacuum plate and apply vacuum continuously during the pouring and until Plastiflex has set up.

Postforming Phenolic Laminate

161 In the postforming process, a predetermined flat pattern blank is heated to plasticity by conventional means, and then, before cooling, is formed to the desired shape by the application of pressure in forming dies. The material is stretched and reformed by externally applied forces as in metal forming. Because of the low magnitude of forces needed to form the material, relatively inexpensive tooling of simple construction can be used. The recommended minimum and absolute minimum bend radii for 90° straight-line bends

are given in Figure 13-21. The absolute minimum radius can be held only for simple, straight bends. Bends, flanged holes and dimpled cutouts, such as are used for sheet metal, may also be produced in postforming phenolic laminates not exceeding 3/32 inch thickness. Deep drawing to a maximum of 15% is possible, depending upon the particular design. A deeper draw rips the fabric base.

EROSION-RESISTANT COATING OF LAMINATED GLASS FABRIC PARTS

General

162. All glass fabric laminated components, (except as noted in Paragraph 167, following), which are exposed to the airstream are to be maintained and repaired in accordance with the following instructions. The parts affected may be those of turbine or reciprocating engine type and include the following:

(a) Radome assemblies.

(b) Tip antennae housing assemblies of vertical stabilizers.

(c) Miscellaneous housings, covers and fillets.

163 Field repairs are to be made on coated parts when evidence of pitting, blistering, peeling or other visible damage is found on the coating during inspection. Visual inspection of coated parts should be made at least once every 100 flying hours if the speed of the aircraft is less than 350 knots, once every 50 flying hours if the speed of the aircraft is over 350 knots, and at all times when abnormal weather conditions have been encountered.

164 Some rain erosion occurs to a limited extent on glass fabric laminates installed on slow-speed aircraft as well as to those on high-speed aircraft. After a few minutes of flight through rain at the higher speeds, such extensive damage has resulted that in many cases external laminated plastic leading edge surfaces are eroded beyond hope of repair.

165 Rain erosion damage may be readily recognized, since it normally starts along the leading edges of the part and gives the part a characteristic pitted or delaminated appearance. These pits deepen and widen as erosion progresses. The process of erosion is slow in getting under way until after the first penetration takes place. As soon as the first ply of reinforcing cloth is penetrated, lateral spreading of the damage takes place between and under the layers, due to the hydraulic pressures exerted by rain drops.

166 Erosion is more prevalent along those edges having sharper curvature and where the rain strikes at 90° to the surface. Protection must be provided on at least the leading edges, and on all areas which present an angle impact in flight through rain of 15° or more. Head-on impact of a flat surface is considered as 90° angle of impact.

Extent of Repairable Damage of Laminates

167 Field repairs may be accomplished on laminated glass fabric plastic parts on which damage has not progressed to a point severe enough to impair their structural integrity. The repair of eroded surfaces will be governed by the following conditions:

(a) Repair may be accomplished over an unlimited area wherein only surface resin erosion has occurred, with no penetration through a reinforcing fabric layer.

Material Thickness	Recommended Min. Radius	Absolute Min. Radius
.03	.06	.03
.05	.09	.06
.06	.12	.09
.09	.25	.19
.12	.38	.31
.19	.75	.56
.25	1.50	1.00
.38	3.00	2.25

Figure 13-21 Bend Radii for Postforming Phenolic Laminate

(b) Eroded areas wherein the damage is not deeper than through the first layer of reinforcing fabric may be repaired, provided that the combined areas of damage do not exceed one square inch within an area enclosed in a six inch diameter circle.

(c) Pits extending through two or more layers of reinforcing fabric may be repaired, provided individual pits are not greater than 1/4 inch maximum diameter and the combined area of such pits does not exceed one square inch within an area enclosed in a six inch diameter circle.

(d) Long narrow eroded areas may be repaired if the maximum width of damage is not greater than 1/4 inch, and provided the depth of damage is not deeper than through the first layer of reinforcing fabric and the length of the eroded area is not greater than 25% of the overall dimension of the laminated plastic part, measured parallel to the length of the damaged area.

(e) If damage is found to be more extensive than outlined or is considered to be dangerous to flight, the part in question is to be replaced.

Coating of Radio Compass Loop Housings

168 The application of neoprene to radio compass loop housings reduces the efficiency of the radio compass under certain flying conditions. Therefore, no radio compass loop housing is to be coated with neoprene even though they are fabricated from glass fabric laminate. Any neoprene on radio compass loop housings should be removed as follows:

(a) Soften the neoprene by applying cloths saturated with toluol (Item 13) to the coated surface.

(b) Rub the coating, using a fibre bristle brush. Several applications of toluol may be necessary.

(c) To hasten removal of the neoprene, lay the saturated cloths on the coated surface for intervals of several minutes prior to scrubbing of the softened coating.

CAUTION

Precautions and careful supervision must be observed to avoid contact of the toluol with the glass fabric laminate underneath the coating since delamination of the part may occur. Steam or paint remover will also deteriorate the glass fabric laminate and must not be used.

(d) Following complete removal of the neoprene, radio compass loop housings (except LP-21-L and LP-21-LM) are to be coated with conductive paint (Item 60).

Repair Procedure of Laminates before Coating

169 Trim out loose or delaminated pieces and sand to a smooth surface, using abrasive paper (Item 27). In sanding the laminated glass, precautionary measures should be taken to keep the glass fibres from the skin. Protective cream (Item 30) is recommended for this purpose. Proceed as follows:

(a) Clean the sanded surface with solvent such as toluol (Item 13) to remove oil or grease.

(b) Apply adhesive filler (Item 25) to the depressions of the eroded area, using a spatula or knife to spread smoothly. Allow to dry for one hour. If sink marks show in the filled-in areas, this operation should be repeated.

(c) Sand the filled surfaces smooth and to the original contour of the surface laminate using abrasive paper (Item 27). Wipe free of dust.

Application of Neoprene Coating

170 The area to be covered will vary with the shape and proposed location of the part being coated. For maximum rain erosion protection, the material should be applied over the leading edge and extended to a point where the undisturbed air stream makes an angle less than 15° to the surface being covered. Apply the neoprene coating as follows:

(a) Process parts to be coated with air-drying neoprene coating (Item 57) in a sheltered area free from dust and protected from weather.

(b) Sand the surface to be coated with abrasive paper (Item 27) to remove paint or glossy finish of the laminate.

(c) Remove sanding dust by wiping with a clean, lint-free cloth and wipe surface lightly with a solvent such as toluol (Item 13).

(d) Some parts may have a hard brown phenolic paint covering the glass laminate, which is very difficult to remove. Do not remove but cover with neoprene coating.

Priming Surface with Adhesive Precoat

171 After cleaning the surface, apply a primer coat of adhesive precoat (Item 24). The thickness for the primer should be 0.001 to 0.002 inch. For brush application, two coats of the unthinned primer are applied by brushing with a well-wetted brush, from the wet to the dry surface, to prevent pinholing and blistering due to trapped air bubbles. For more ease in brushing, the primer may be thinned by using methyl ethyl ketone (Item 9). The thinned primer requires additional coats in order to build up to the specified thickness. For spray application, use one part of primer to a maximum of three parts, by volume, of methyl ethyl ketone. Allow a five minute drying period between coatings.

Preparation of Neoprene Topcoat

172 Neoprene topcoat (Item 57) is packaged unaccelerated to provide good shelf-life. The neoprene is ready to use only after the accelerator has been added. Shelf-life of the unaccelerated components, when stored at room temperature, is eight months. The accelerator is supplied with the topcoating material and the containers are marked with the mixing directions. Thin the topcoat to the desired consistency with toluol (Item 13) for either brush or spray application before adding the accelerator. Add the accelerator and mix thoroughly. The prepared topcoat mixture should be lightly stirred again prior to each successive coat. Only the amount of material to be used within the following eight hours should be accelerated at one time. Material that has been mixed and allowed to stand beyond this period of time, or is hardened, must be discarded. Do not attempt to thin any coating material which has jelled beyond brushable use. Keep containers tightly covered when not in use.

Brush Application of Topcoat

173 Allow sufficient time for the final primer coat to dry (30 to 60 minutes) before brushing on the first neoprene topcoat. Use short, even strokes, brushing from wet to dry surface, to prevent pinholing and blistering due to trapped air bubbles. Do not disturb the surface after a smooth coating has been applied. Brushing over an area that has partially dried will result in drag. This can be minimized by keeping the brush well wetted with the coating material and by thinning with a small amount of toluol (Item 13). Any trapped air can be released by spraying the surface gently with a mist of thinner mixture consisting of one part by volume of methyl ethyl ketone (Item 9) and one part by volume of toluol (Item 13). Allow sufficient time between layers of neoprene top coating for the shiny wet appearance to disappear. Under normal drying conditions, 20 to 30 minutes drying time between coats should be satisfactory. Keep accelerated material container tightly closed when not in use.

Spray Application of Topcoat

174 Allow sufficient time for the final primer coat to dry (30 to 40 minutes) before spraying on the first neoprene topcoat. Use long even passes, spraying from wet to dry surface. Two or three fast passes per coat are preferable to one slow pass since they give a slightly greater coat thickness with less danger of running or sagging. Pinholes are caused by water or oil entering the spray gun, or by improper atomization. Any trapped air can be released by spraying the surface gently with a mist of thinner mixture consisting of one part, by volume, toluol (Item 13) and one part, by volume, methyl ethyl ketone (Item 9). Allow only enough time between coats for the shiny wet appearance to disappear. Under normal drying conditions, 10 to 15 minutes drying time between coats should be satisfactory. Keep accelerated material container tightly closed when not in use.

Thickness of Coating

175 The number of layers of primer and topcoat vary with the viscosity of the material. However, the number of coats is not as important as obtaining the correct thickness. Use the number of coats required to obtain a total thickness of 0.007 to 0.009 inch, exclusive of primer. The complete coat (topcoat plus primer) should be 0.008 to 0.011 inch and should air-dry tack-free to the touch in not more than a total time of six hours, including time between coats. Check coating thickness at edge of the part or on a separate piece of sheet

metal which has been given an identical coating to that on the part.

CAUTION

Since the materials used in the foregoing procedure are inflammable and toxic in sufficient concentration, the standard precautions used with such materials, such as fire prevention and adequate ventilation, must be exercised.

Edge Finishing

176 The parts of the metal mounting rim are not to be coated. Where a coating is to extend to a mounting rim, the coating should be terminated under the rim, see Figure 13-22. If that part of the laminate fitting under the mounting rim is offset to make a smooth outer surface, the laminate at the edge of the rim should be rounded off to a radius of curvature of at least 1/8 inch. Sharper outside radius of plastic parts should be avoided, since erosion resistance falls off rapidly with a decrease in radius of curvature. Where a coating is to be terminated elsewhere than at a mounting rim, the edge of the coating should be feathered to a smooth tapered junction following the curve, by use of abrasive paper (Item 27).

Curing Cycle and Colour of Finished Coating

177 The finished part should cure for at least 72 hours at room temperature. In an emergency, the coated article may be put into service as soon as the neoprene coating is past the tacky stage, or forced drying may be employed. In this case, two or three hours at 150° F will cure the material sufficiently to permit installation. Air-drying neoprene materials are light sensitive and may be expected to darken to nearly black with age. No significance is to be attached to the fact that some batches or areas will darken before others. Subsequent application of paint over the neoprene coating is not to be made.

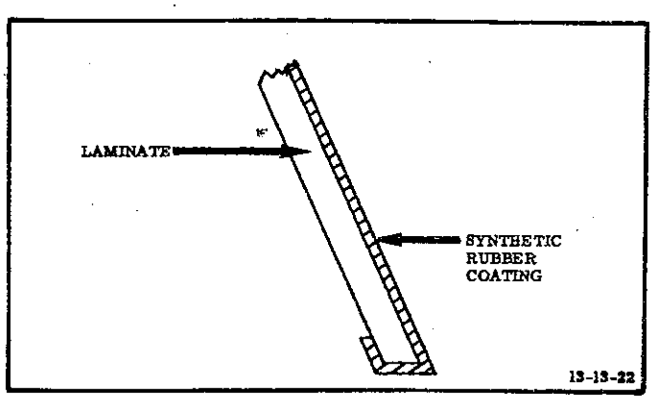


Figure 13-22 Rubber Coating Methods

Repair of Neoprene Coating

178 When the cured coating is blistered or a localized failure of the coating occurs in service, repair may be made as follows:

(a) Trim loose coating, sand open area of laminate to a smooth surface using abrasive paper (Item 27), and wipe free of dust.

(b) Apply primer (Item 24) and catalyzed neoprene topcoat (Item 57). Cure as described in Paragraph 177, preceding.

NOTE

Avoid applying coating beyond edge of area being repaired since adhesion to existing coating is only fair. Avoid build-up beyond that specified in Paragraph 175, preceding, particularly on radomes, since the electrical properties may be affected. Should complete replacement of the neoprene coat be necessary, the old coat can be removed by following instructions in Paragraph 168, preceding.

Use of Other Neoprene Compounds

179 Do not use neoprene coatings other than that specified (Item 57) without prior approval of engineering authority. Use of coating and catalyst is described in the manufacturer's instructions provided with each container.

APPROVED MATERIALS

General

180 For table showing item numbers, materials, specifications and manufacturers, see Figure 13-23.

Approved Materials

181 Materials listed in Figure 13-24 are approved materials but are not specifically mentioned in the text. The supplier's instructions with regards to temperature, mixing, shelf life and application must be complied with.

Item No	Material	RCAF Ref	Specification	Manufacturer
1	Compound, Coating	33G/52	MIL-C-6799A	
2	Kerosene	34A/217	3-GP-3	
3	Soap, Detergent powder	33C/667	2-GP-103	
4	Cleaner, Anti-static, Anstac M, Soap and liquid	33C/675		Chemical Development Corp., Montreal.
5	Hexane			Technical Grade
6	Acetone	33C/417	O-A-51B	
7	Talc	33C/11	MAT-2-1	
8	Polish, Liquid	33C/652	C-71A	
9	Methyl Ethyl Ketone	33C/520	TT-M-261	
10	Benzoyl Peroxide (50-50 solution with Tricresyl phosphate)			Lucidol Corp., Buffalo, N.Y.
11	Petrolatum	34A/165	3-GP-665	
12	Tape, Adhesive, Pressure sensitive	33G/5 or 6	43-GP-3 Grade B Type 2	
13	Toluene (Toluol)	33A/467	TT-T-548A	
14	Methylene Dichloride			Technical Grade
15	Ethylene Dichloride	33C/282	C28-23A	
16	Trichlorethylene	33C/163	MIL-T-7003	
17	Oil, General purpose	34A/124	3-GP-335a	
18	Wire, Soft		AN995	
19	Glycerine	14B/43		
20	Cloth, Emery, Durex	29/1833-1840		
21	Adhesive Resin Alkyd	33G/11		
22	Lacquer, Clear		MIL-L-7178	

Figure 13-23 (Sheet 1 of 4) Table of Material Specifications

Item No.	Material	RCAF Ref.	Specification	Manufacturer
23	Soap, Acetate			Technical Grade
24	Adhesive, Precoat	33G/23		
25	Adhesive, Filler	33G/112		
26	Adhesive, Cement, Acrylic resin	33G/10	MIL-C-8576	
27	Paper, Abrasive, Waterproof	29/1869 etc.	Fed. PP 101-1 (US)	
28	Compound, Buffing, Tripoli, Grade 17 (cake), Acrylic plastic	29/1843		Can. Hanson and Van Winkle, Toronto.
29	Tallow, Buffing (rouge)	29/1879		McAlear Manufacturing Co., Chicago.
30	Cream, Hand	33C/399		
31	C.I.L. No. 7			Canadian Industries Ltd., Montreal.
32	Paste, Pre-buff, M37			O'Cedar of Canada Ltd., Stratford, Ontario.
33	Abrasive, Fine, Type A5175			Linde Air Products Co., New York City, N.Y. U.S.A.
34	Parting Agent, Grease type, Soyab No. 300 Lecithin, Bleached and Refined			Glidden Paint Co., Toronto.
35	Parting Agent, Grease type, Aquarex L			E.I. Du Pont de Nemours Inc., Wilmington, Del. U.S.A.
36	Parting Agent, Silicone type, DC-7			Dow-Corning Corp., Midland, Mich. U.S.A.
37	Parting Agent, Silicone Resin type, Pan-Glaze			Dow-Corning Corp., Midland, Mich. U.S.A.

Figure 13-23 (Sheet 2 of 4) Table of Material Specifications

Item No.	Material	RCAF Ref.	Specification	Manufacturer
38	Cloth, Fiberglas, Impregnated	32E/		Owens-Corning Fiberglas Corp., Toledo, Ohio. U.S.A.
39	Mat, Fiberglas, T-34 .050 inch thickness			Owens-Corning Fiberglas Corp.,Toledo,Ohio.U.S.A.
40	Cellophane			Commercial Grade
41	Resin, Styrene Polyester, Selectron No. 5041		MIL-R-7575	Pittsburgh Plate Glass Co., Pittsburg, Pa. U.S.A.
42	Zoluol S-9400X			W.P. Fuller & Co., Los Angeles. U.S.A.
43	Fibres, Milled, Fiberglas, 1/8 in. length			Owens-Corning Fiberglas Corp.,Toledo,Ohio.U.S.A.
44	Styrene N-99			Dow Chemical Co., West Toronto.
45	Polyvinyl alcohol, Sheet .003 inch			Resistoflex Corp., Belleville 9, N.J. U.S.A.
46	Compound, Sealing, RL-3700			W.P. Fuller & Co., Los Angeles, U.S.A.
47	Dye, Reichold No. 9403, Black			Reichold Chemicals Co., White Plains, N.Y. U.S.A.
48	Dye, Reichold No. 9406, Red			Reichold Chemicals Co., White Plains, N.Y. U.S.A.
49	Primer, Zinc Chromate, Toluene thinner	33A/462	MIL-P-6889A	
50	Paint, Tygon, TP-21			U.S. Stoneware Corp., Akron 9, Ohio, U.S.A.
51	Wax, Emulsion			S.C. Johnson & Son Inc., Brantford, Ontario.
52	Plastiflex			Cal Resin Corp., Los Angeles. U.S.A.

Figure 13-23 (Sheet 3 of 4) Table of Material Specifications

Item No.	Material	RCAF Ref.	Specification	Manufacturer
53	Superlastic P-1500			P.R.Sales Co.
54	Cement, Vinyl Resin			Bakelite Co., Belleville, Ontario.
55	Vinylseal			Bakelite Co., Belleville, Ontario.
56	Resin and Catalyst, Casting, Phenolic plastics			Bakelite Co., Belleville, Ontario.
57	Coating, Adhesive, Neoprene	33G/110		
58	Oil, Castor		AN-JJ-O-316	
59	Alcohol, Ethyl. Denatured	34A/213	MIL-A-6091A	
60	Paint, Conductive, 3053	33A/381		Canadian General Electric, Toronto, Ontario.
61	Paper, Abrasive	29/1872		
62	Deleted			
63	Deleted			
64	Deleted			
65	Lucite			E. I. Du Pont de Nemours Co. Inc., Wilmington, Del.
66	Plexiglass			Rohm & Haas Co.
67	Perspex			Imperial Chemicals Ltd., England.
68	Fibestos			Monsanto Chemical Co.
69	Lumarith			Celanese Celluloid Corp.
70	Plastacele			E. I. Du Pont de Nemours Co. Inc., Wilmington, Del.
71	Nixonite			St. Nixon Nitration Works, Nixon, N. J. U.S.A.

Figure 13-23 (Sheet 4 of 4) Table of Material Specifications

BUFFING COMPOUNDS	MANUFACTURER
Compound No.771	Matchless Metal Polish Company, Glen Ridge, N.J., U.S.A.
Learock No. 832	Lea Manufacturing Company, Waterbury, Conn., U.S.A.
Compound 4M-30 (Grey) Compound 6M-157 (White)	Hanson-Van Winkle-Munning Co., Matawan, N.J., U.S.A.
Triple A Buffing Compound	McAleer Manufacturing Company, Rochester, Mich., U.S.A.
Plascor No.705 (White) Plascor No.1403 (White)	United Laboratories, Linden, N.J., U.S.A.
Newcomb No.7	Newcomb Products Company, Cleveland, Ohio, U.S.A.
ASHING COMPOUNDS	**MANUFACTURER**
Pumice, Grade FF or FFF	James H. Rhodes, Chicago, Illinois, U.S.A.
Du Pont Rubbing Compound No. 45 (rough) Du Pont Rubbing Compound No. 12 (fine)	E.I. Du Pont de Nemours Co.Inc., Wilmington, Del., U.S.A.
Learock No. 765	Lea Manufacturing Company, Waterbury, Conn., U.S.A.
POLISHES	**MANUFACTURER**
O'Cedar of Canada M37 Plastic	O'Cedar of Canada Limited, Toronto 3, Ontario.
Parko Gloss Polish and Cleaner No. 4B-L	Park Chemical Company, Detroit, Mich., U.S.A.
PL-464-A2	Minnesota Mining & Manufacturing Company, Detroit, Mich., U.S.A.
Ken-Glo	Ken-nite Company, Detroit, Mich., U.S.A.
Lincoln M-3828 Liquid Cleaner	Lincoln Motor Car Division, Ford Motor Company, Dearborn, Mich., U.S.A.
Turco L-567 Cleaner	Turco Products Inc., Los Angeles, Cal., U.S.A.

Figure 13-24 (Sheet 1 of 3) Table of Approved Materials

POLISHES	MANUFACTURER
WILCO Scratch Removing Compound Nos.55 & 35	WILCO Company, Los Angeles, Cal., U.S.A.
Simoniz Liquid Cleaner	Simoniz Company, Chicago, Illinois, U.S.A.
McAleer Plexi-Glo Cleaner and Polish	McAleer Manufacturing Company, Rochester, Mich., U.S.A.
Aerogroom Cleaner	The Autogroom Company, Inc., Woodside, Long Island, N.Y., U.S.A.
Crystal X Cleaner and Glaze	Crosdale & deAngelis Upper Derby, Pa., U.S.A.
Triple Life Cleaner and Glaze	Franklin Research Company, Philadelphia, Pa., U.S.A.
Noxon Cleaner Polish	Noxon Inc., Ozone Park, N.Y., U.S.A.
Puritan's Plasti-Kleen	Puritan Chemical Company, Atlanta, Ga., U.S.A.
CLEANERS	**MANUFACTURER**
Sinec. No.2 Mark 2 Cleaner	O'Cedar Limited, Slough, England.
Sno-Flake No.223 Cleaner	Snow Flake Products Company, Detroit, Mich., U.S.A.
Franklin High Gloss Cleaner	Franklin Research Company, Philadelphia, Pa., U.S.A.
WAXES	**MANUFACTURER**
Johnson's Industrial Wax No. 102-C	S.C.Johson & Son Inc., Racine, Wisc., U.S.A.
Parko Eze-Wax	Park Chemical Company, Detroit, Mich., U.S.A.
Franklin Plexiglas Wax	Franklin Research Company Philadelphia, Pa., U.S.A.
Simoniz Wax	Simoniz Company, Chicago, Illinois, U.S.A.
3M Auto Wax	Minnesota Mining & Mfg.Co., St.Paul, Minn.U.S.A.

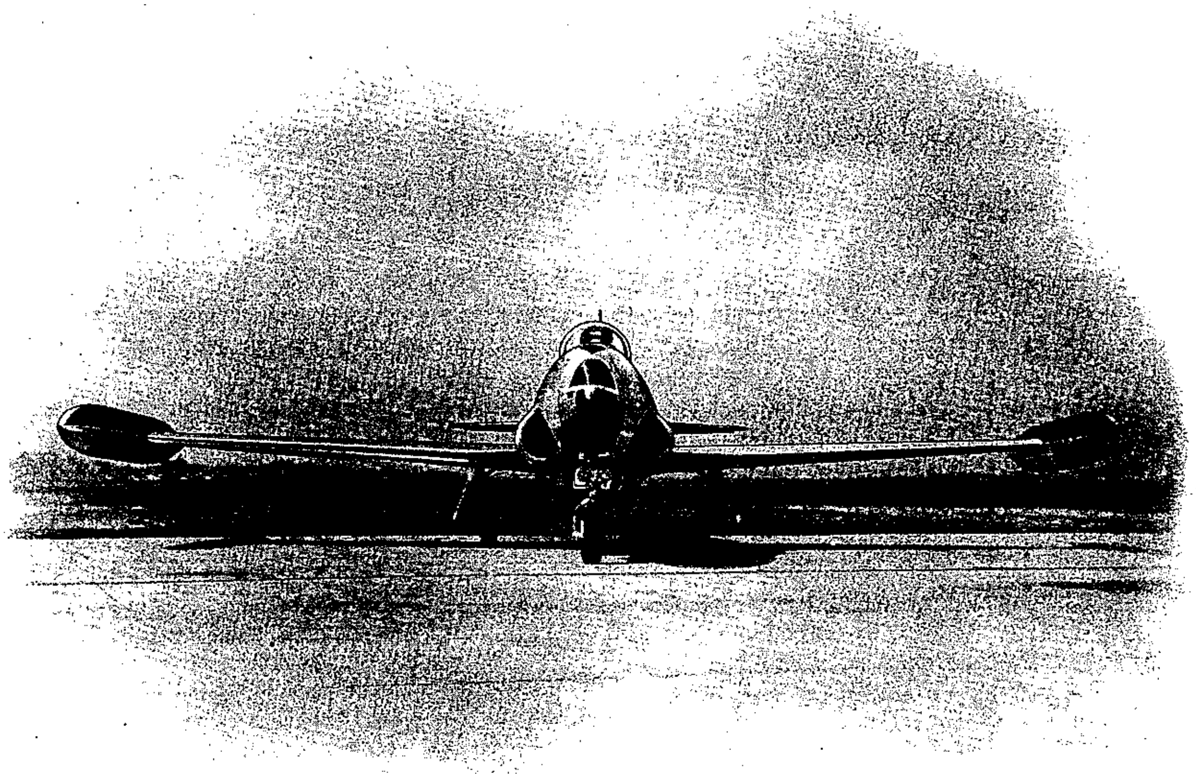
Figure 13-24 (Sheet 2 of 3) Table of Approved Materials

WAXES	MANUFACTURER
Permaseal	Commercial Chemical Company, Charlestown, Boston, Mass., U.S.A.
MASKING TAPES	**MANUFACTURER**
Scotch MFA (Flat Back Paper) or (Crepe Paper)	Minnesota Mining & Mfg. Co., St. Paul, Minn., U.S.A.
Permacel XB-95	Industrial Tape Corporation, New Brunswick, N.J., U.S.A.
GASKET MATERIALS	**MANUFACTURER**
Neoprene M-8831	U. S. Rubber Company, Detroit, Mich., U.S.A.
Neoprene Dome Gaskets	Vulcanized Rubber Company, Morrisville, Pa., U.S.A.
Fairprene No. 5545	E.I. Du Pont de Nemours & Co., Fairfield, Conn., U.S.A.
Grade GR-1 Synthetic No. 624 GN Synthetic A-086	B. F. Goodrich Company, Akron, Ohio, U.S.A.
Anchorite Buna S No. 200	Anchor Packing Company, Philadelphia, Pa., U.S.A.
Paraplex X-100, Stock JK-160 Paraplex X-100, Stock JK-161	Resinous Products & Chemical Co., Philadelphia, Pa., U.S.A.
Freeze-resisting Neoprene	Peerless-Key Imperial Company, Newark, NY., U.S.A.
Synthetic Glass Sealer No. 23212	Presstite Engineering Company, St. Louis, Mo., U.S.A.
MASTIC MATERIALS	**MANUFACTURER**
3-M Mastic Compound EC-612 3-M Elastic Cement EC-373	Minnesota Mining & Mfg. Company, St. Paul, Minn., U.S.A.
Synthetic Glass Sealer No. 23212	Presstite Engineering Company, St. Louis, Mo., U.S.A.
RL-3774 Cockpit Enclosure Compound	W. P. Fuller & Company, Los Angeles, Cal., U.S.A.
Matiseal	Pittsburgh Plate Glass Company, Pittsburgh, Pa., U.S.A.
GREASES	**MANUFACTURER**
Cazar No. 2 Light Grade No. 3886 Die Lubricant	Esso Marketers and Associates New York 4, N.Y., U.S.A.
Gulf Precision Grease No. 1	Gulf Refining Company, Pittsburgh, Pa., U.S.A.

Figure 13-24 (Sheet 3 of 3) Table of Approved Materials

PART 14

FUEL CELL REPAIR



PART 14

FUEL CELL REPAIR

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PART 14

FUEL CELL REPAIR

SELF-SEALING CELLS

General

1 A self-sealing cell is a fuel or oil container which automatically seals holes or injuries incurred during operations. A self-sealing cell is not bullet-proof, but merely bullet or puncture sealing. This sealing action reduces the fire hazard brought about by leaking fuel or oil and keeps the aircraft fuel or oil supply intact so that it may continue the operation and reach its base.

2 The purpose of cell repair is to restore a cell to its original condition, to restore its ability to carry fuel or oil, and to renew its ability to seal future injuries.

Construction

3 There are three primary layers of material in a self-sealing fuel cell; the inner liner, the sealant and the retainer. Most cells now in service contain more than the three basic component parts, but each ply may be classified as being related to one of the three primary groups.

4 The purpose of the inner-liner is to contain the fuel and to keep it away from the sealant layers so that it will not bring about premature swelling or deterioration of the sealant.

5 The sealant material remains dormant in the fuel cell until the cell is ruptured or penetrated. When this occurs, it is the function of the sealant to seal the ruptured area so that no gasoline is allowed to flow through to the exterior of the fuel cell.

6 The purpose of the retainer material is to lend strength to the fuel cell and to protect the sealant and inner liner. The retainer also increases the efficiency of sealing action after the cell is penetrated.

7 In this construction, (see Figure 14-1), the Buna-N synthetic rubber acts as the inner liner. Nylon is used as a barrier to prevent the diffusion of aromatic fuels into the sealant material. The sealant is placed on the cell in two layers, a layer of cord fabric, the retainer material, being placed between the two layers of sealant, and the final layer or layers of cord fabric retainer material being placed on the exterior of the fuel cell.

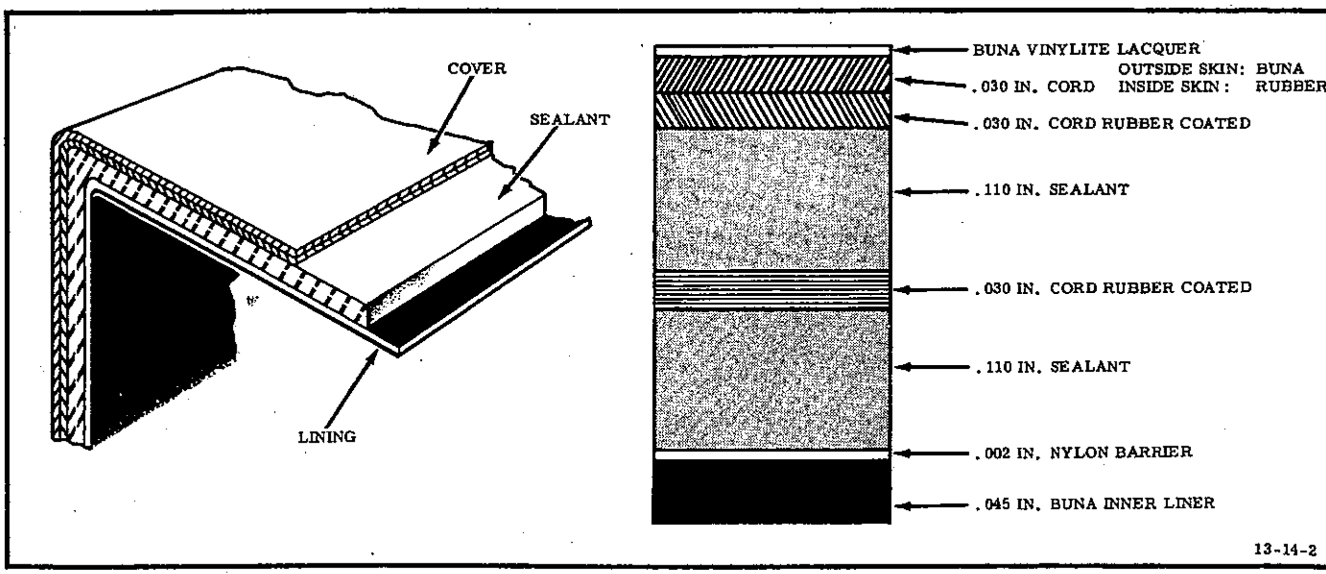


Figure 14-1 Fuel Cell Section

Function of the Self-sealing Fuel Cell

8 The sealing function is brought about by the mechanical and chemical reactions which take place upon penetration of the fuel cell. The mechanical reaction results from the fact that rubber, both natural and synthetic, will give under the shock of impact, limiting damage to a small hole in the fuel cell. The fuel cell materials will allow the projectile to enter or leave the cell and then will closely approximate their original position. This mechanical reaction is almost instantaneous. The chemical reaction of the sealant takes place as soon as gasoline or gasoline vapours penetrate through the inner liner material and reach the sealant. The sealant, upon contact with gasoline or gasoline vapours, will extend or swell to several times its normal size, thus effectively closing the rupture and preventing the gasoline from escaping.

9 A fuel cell is self-sealing but not self-healing. Any fuel cell which has been ruptured so that gasoline is in contact with the sealant material must be repaired as soon as possible, with 72 hours as a maximum time limit.

Storage

10 Provide adequate protected storage for non-metallic fuel cells, observing the following precautions:

(a) Cells are of rubber and must be stored where the cell will not be exposed to direct sunlight.

(b) Cells are shipped in special containers. Do not remove from these containers except as required for inspection and installation.

(c) Stacking of containers is permissible, but do not allow partial or complete collapse of the lower containers or cells.

(d) Do not place cells, whether in or out of containers, near heaters or hot pipes.

(e) Whenever a self-sealing cell has been in service and filled with fuel, spray, paint or slush the interior surfaces of the cell with engine oil (Item 1) prior to storage and within ten days of the removal of fuel from the cell. Do not permit excessive amounts of oil to remain in the cell. Where repairs are required on a cell, carry out prior to oiling. After the initial oiling, re-oil interior surfaces of cells at intervals of two months. When cells are to be put back into service, flush the oil out with cleaner (Item 2). After the first and each subsequent oiling, mark cells with a tag containing the following information: "Interior sprayed (or painted or slushed) with oil. Date."

(f) Treat interior surfaces of non self-sealing cells in accordance with all the requirements of Sub-paragraph (e), except that engine oil (Item 3), should be used in place of engine oil (Item 1). Tag cell accordingly.

(g) When removing cells from storage for installation, use the oldest cells first.

Handling

11 Take particular care when removing cells from their containers, handling and installing. Observe the following precautions:

(a) Do not allow cells to rest on protruding fittings or stack them unsupported one upon another.

(b) Seal all cell openings, not sealed during assembly, with covers, closed fittings or other equipment.

(c) Where installed cells, which have been filled with fuel, are to stand empty of fuel for more than ten days, oil, tag and re-oil at intervals of two months as required. (Refer to Paragraph 10 (e) or (f), preceding, whichever is applicable.) Tagging may be replaced by other suitable methods of marking.

(d) Carry rubber parts; do not drag or scuff along the floor. Take care to avoid knocks, distortion and damage to fittings.

(e) Do not paint rubber parts except where required for camouflage purposes. Small parts need not be masked to prevent overspray from spray painting of adjacent components. Do not paint fittings having rubber portions or inserts.

Folding of Cells

12 Fold self-sealing cells for installation only when necessary, observing the following precautions:

(a) If the self-sealing cell is folded and/or strapped to aid installation, fold and/or strap just before the cell is to be installed. Do not keep cells folded any longer than is absolutely necessary.

(b) Ensure that fittings are not damaged or torn loose from the cell during folding.

Connecting Fittings

13 In connecting fittings, proceed as follows:

(a) Bring the parts into the best possible alignment so that the screws or bolts can be started with minimum torque.

(b) Inspect fittings and threaded parts prior to installation to ensure freedom from foreign matter, damaged threads or other defects.

(c) Tighten a sufficient percentage of the bolts, distributed uniformly about the fittings, to a value close to but below the specified final torque value, in such a manner that the fitting is evenly seated.

(d) Install the remainder of the bolts and torque all bolts to the specified value. After the bolts have been torqued, a drop in torque value may occur. Do not retighten. If retorquing is necessary, loosen all bolts and completely retorque the fitting.

14 If a fitting is found to be leaking after the application of correct torque, remove and examine the mating surfaces carefully. Examine the bolts and bolt holes for damaged threads or foreign matter. If no defects are found install the fitting again. Repeated tightening of bolts will only distort the metal insert, tear the rubber and contribute to further leakage.

15 Torque requirements for installation must be as specified on the applicable assembly drawing or Engineering Order. Disregard any torquing instructions stencilled on the fuel cell or cell door.

16 Upon installation of fuel cell fittings, maximum specified bolt or screw torque is sometimes attained before fitting is securely sealed to the cell. This may be caused by misalignment of matching holes or foreign matter on the bolts, screws or in tapped inserts. To obtain the same compression achieved by direct torque measurement, the following alternate method of installing cell fittings may be used:

(a) Align fitting on cell in proper position.

(b) Insert and tighten bolts or screws diametrically opposite each other until all bolts or screws have drawn fitting down just flush with cell.

(c) From this position, tighten each bolt or screw, in the same order, an additional one-third (120°) turn. This should securely seal fitting to the cell.

Installation

CAUTION

The use of sharp edged tools such as screwdrivers, punches, drift pins, etc., to align fitting is strictly prohibited. Use only round wooden bars.

NOTE

For further information regarding inspection and maintenance cycles, packing, storage and salvage, refer to EO 05-1-2L.

17 Apply talc (Item 4) to the outside of all cells before installation. Treat cells, which are to be installed in bays which are finished with only zinc chromate primer or interior green tinted primer, with talc by any convenient method. Treat cells, which are to be installed in bays which are finished with other than zinc chromate primer or interior green tinted primer (e.g. purged bays), with an aqueous suspension of talc to aid in installation and to prevent sticking to the painted surfaces of the bay during service.

18 Brush or spray two coats of the talc suspension on the exterior surface of the cells. Make the talc suspension as follows:

1.5 pounds talc (Item 4).
3.5 quarts water.
1.5 ounce Bentonite Clay (Item 5).

NOTE

Before using, stir material thoroughly. Continue agitation if the material is to be sprayed

19 Apply the talc uniformly to the outside of the cell and if the suspension is used, allow the film to dry completely before the cell is installed. Take care to ensure that no talc gets on the interior surface of the cell. After application of the talc, keep handling of the tank at a minimum to prevent rubbing off the coating before installation. Dust accessible surfaces of fuel bays which contact the cells with talc.

REPAIR OF SELF-SEALING CELLS

General

20 The time and effort required for making temporary repairs is as great as that necessary for permanent repairs, and the results are not satisfactory. Therefore, all repairs made are to be of the permanent type.

Repair Precautions

21 When repairing self-sealing cells, observe the following:

(a) If leakage from access door or fittings is suspected, torque access door and fitting bolts in accordance with applicable Engineering Orders of affected aircraft.

(b) Inspect cells thoroughly before repairs are begun. Much time is wasted making one repair at a time when several could be made concurrently.

(c) The limit to the number of repairs and fitting replacements is left to the discretion of engineering authority. Obviously, a cell could have several small injuries and be repaired safely, while the same number or fewer large injuries would be impractical and unsafe to repair. Reparability of a cell can be determined only by the number and location of the injuries. Do not repair large injuries located where the cell is folded sharply during installation.

(d) Inspection of repaired cells, except nylon Pliocel, must not be performed until 24 hours have elapsed after draining.

(e) Clean fuel and oil cells, except nylon Pliocel, inside and outside to remove any oil or foreign substance by the use of aircraft cleaning equipment with soap paste (Item 6) and hot water not to exceed 200°F. After cleaning, remove all soap residue with clean hot water not to exceed 200°F. If this equipment is not available, clean by hand using detergent (Item 30) mixed with warm water. Apply with lintless cloth and rinse with warm water.

NOTE

Pay strict attention to the choice of materials and methods.

Repair Materials

22 The outside repair material is a fabric, coated on both sides with Buna-N synthetic rubber (Item 7), obtained in gauges .038 to .062 inch. The .020 inch gauge material (Item 8) is used for corner repair chafing strips, fitting wraps and in other instances where a lighter gauge material is suitable.

23 The inside repair material is sheet Buna-N synthetic rubber, cured on both sides, of .045 inch gauge (Item 9).

24 Apply cement (Item 10) evenly and thinly, and allow to dry between coats. When two surfaces are to be joined, apply at least two coats to each. Use 40 to 80 grit emery cloth (Item 11) when hand buffing Buna materials.

25 Use solvents (Item 12) for washing buffed surfaces and for freshening or reactivating cemented surfaces of the type specified for the cement being used. Use of incorrect solvent can be detrimental to the adhesion of surfaces to be cemented.

Preparation of Cell for Repair Work

26 Carry out repair work on fuel cells in a dry place. High humidity, especially in combination with low temperature, will cause condensation to form on cemented surfaces and will make adhesion of repair patches impossible.

27 Drain cells and dry thoroughly as soon as possible after injury. Drying may be speeded up by keeping the cell in a warm place and by using an air hose on the inside. Do not keep the cell warm for long periods of time and never at a temperature over 120°F. Higher temperatures will dry out the gasoline-soaked sealant next to the injury, but will trap gasoline in the sealant farther away from the injury. If gasoline is trapped in this way, it will cause separation and breakdown in the sealant material. To prevent

this, spread the edge of the injury slightly with a small stick or pencil long enough to allow all gasoline to escape from the sealant material. Drying may require several days. Begin repair work as soon as the sealing gum has resumed its normal appearance and no longer is swollen.

28 Make repairs on the inside of the cell before repairs on the outside. Inside injuries may be reached through the cell access doors or filler openings. In some cases it is necessary to use a mirror and a safety light inside the cell to see the injury.

CAUTION

Do not lay unguarded light bulb on cell inner liner.

WARNING

The vapours from aircraft fuel, rubber and solvent are dangerously toxic, even if inhaled for only a short period. Before work is begun, drain all fuel from the cell and dry thoroughly. Attach a flexible hose to a blower and place inside the cell to displace the fuel vapour by circulating air at low pressure. When it is necessary to work on the inside of cells, two persons should be assigned to the work. The person entering the cell must wear a respirator equipped with a remote breathing line for fresh air, (see Figure 14-2), or a respirator designed for organic vapours and a safety line. (Refer to EO 00-25-7.) The second person must remain outside the cell in such a position that he can observe any sign of distress shown by the person inside the cell.

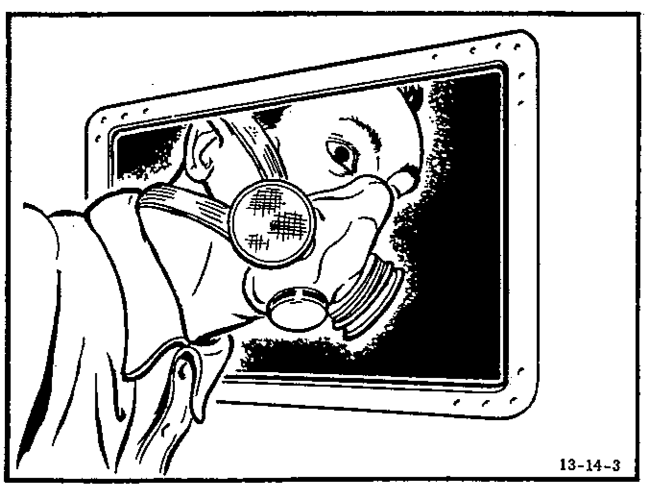


Figure 14-2 Use of Respirator

Repair of Closed Hole or Slit-type Injuries

29 A closed hole or slit-type injury is an injury extending through one or more layers of the cell but with no displacement of material. If the slit does not extend through the cell wall, the undamaged side need not be repaired. If the slit extends through the cell, patches on both sides are necessary.

Inside Repairs under Two Inches

30 When the cell is ready for repair, proceed as follows:

(a) Buff the inside of the cell for 2-1/2 inches in all directions from the edge of the injury with clean emery cloth (Item 11) or buffing tool. Buffing must be heavy enough to remove all gloss, leaving the surface covered with closely spaced fine scratches. An air drill may be used as a buffer by inserting a sand or emery wheel in the chuck. When buffing with air drill, do not use excessive pressure. To avoid burning the surface of the material, do not buff in one spot too long. When using power buffer for the first time, practice on a condemned fuel cell before attempting to buff the repair. Occasionally it has been found that buffing by the ordinary power buffer produces a surface that is too smooth for best adhesion. When this condition is found, roughen the buffed surface of the cell or patch with a piece of coarse emery cloth (Item 11).

(b) After buffing, clean the surface lightly with a clean cloth moistened with solvent. Do not soak buffed area but wash lightly until all grit and buffing dust are removed.

(c) Measure the injury and cut a patch of inside repair material (Item 9) large enough to extend two inches in all directions from the edge of the injury. The patch must have a smoothly rounded outline, and the edges must be skived or cut at an angle by tilting the shears instead of cutting at right angles.

(d) Apply the patch with the flat side next to the cell lining and the skived side away from it.

(e) Support the outside of the cell around the injury so that the edges will be lined up properly in their natural position, (see Figure 14-3).

(f) Clean the buffed area on the inside of the cell with solvent (Item 12) immediately before cementing.

(g) When the inner liner is dry, apply a thin coat of cement (Item 10) to this area and to the inside of the patch. After the first coat is dry, apply another coat of cement to both the cell and the patch. To determine if the cement is dry enough for application of the second coat, test by pressing a knuckle gently against the cemented surface and withdrawing it. If no cement sticks to the knuckle, the surface is ready for the second coat.

(h) Before the patch is applied, the second coat of cement on both the patch and the cell must be slightly tacky. A few threads of cement should stick to the knuckle when it is tested. If the last coat of cement has become dry, tackiness may be increased by wiping it gently with a solvent (Item 12) dampened cloth or by applying another thin coat of cement.

(j) When the last coat of cement has sufficient tackiness, centre the patch over the injury and roll down firmly with a 1/4 inch hand roller. Take care not to apply the patch before the cement has reached the proper stage of tackiness, as air bubbles or blisters may form under the patch in the drying process. If the cement has reached the proper stage before the patch is applied, there will be no skidding or sliding of the patch immediately after application. This can be checked by trying to slide the patch across the surface with the thumb. Sliding should not be evident in any area of the patch.

(k) If blisters or poor adhesion are found in the patch, remove and start the repair over again. A cloth moistened with solvent and rubbed briskly over the cement, before the cement is too dry, will remove it satisfactorily.

Outside Repairs

31 Support the cell around the injury so that the edges of the injury will be lined up properly in their natural position, (see Figure 14-3). Place trestle or other support inside the cell to be repaired. Pad wooden blocks or boards used inside of the cells or cover with cloth to protect liner from damage. Proceed as follows:

(a) Buff an area on the outside of the cell extending three inches in all directions from the edge of the injury.

(b) Cut a round or oval patch of outside repair fabric (Item 7) large enough to extend 2-1/2 inches beyond the edges of the injury on all sides. Buff one side of this patch.

(c) Clean the buffed surfaces of the cell and the patch with a clean cloth moistened with outside solvent (Item 12).

(d) Apply two coats of cement to each surface, allowing the first coat to dry before applying the second.

(e) While the second coat is still slightly tacky, centre the patch over the injury and roll down, being careful to remove all trapped air.

(f) Apply two coats of Buna Vinylite lacquer (Item 13) on the patch and buffed area, allowing proper drying time between each coat. If Vinylite lacquer is not available, cement (Item 10) may be used.

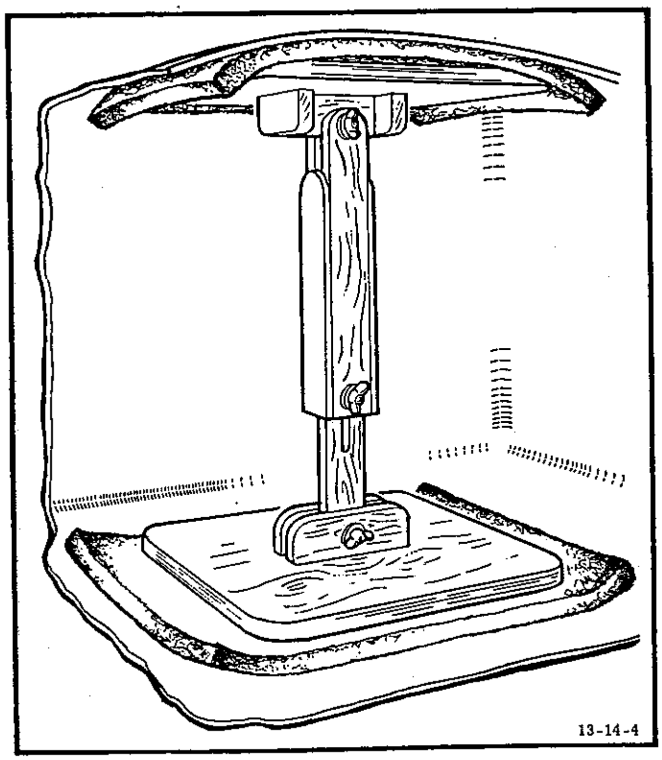


Figure 14-3 Pedestal for Supporting Cells

Injuries over Two Inches and Less than Ten Inches

32 If the injury is two inches or longer in size, use two patches both inside and outside the cell. Proceed as follows:

(a) Buff an area of the cell one inch larger all around than the size of the first patch. Buff both sides of the first patch. Make a feather edge on the first patch to facilitate sticking down the second patch.

NOTE

Feathering is the process of tapering the edge of the patch by buffing, to a considerable greater degree, than can be obtained by merely skiving or bevelling with shears. Extend the taper at least 1/2 inch in from the edge of patch. Failure to feather edge of the first patch will produce an undesirable channel under the second patch. Such channels trap fuel and cause eventual failure of cell.

(b) The second patch must overlap the first by one inch in all directions. Complete all necessary buffing before the cement is applied. Buff an area on the cell 1/2 inch larger in all directions than the second patch.

(c) Apply first patch, (refer to Paragraph 30 or 31, preceding).

(d) Before applying the second patch, ensure that cement (Item 10) under the first is thoroughly dried, otherwise the solvent in the cement may cause the edges of the first patch to become loose.

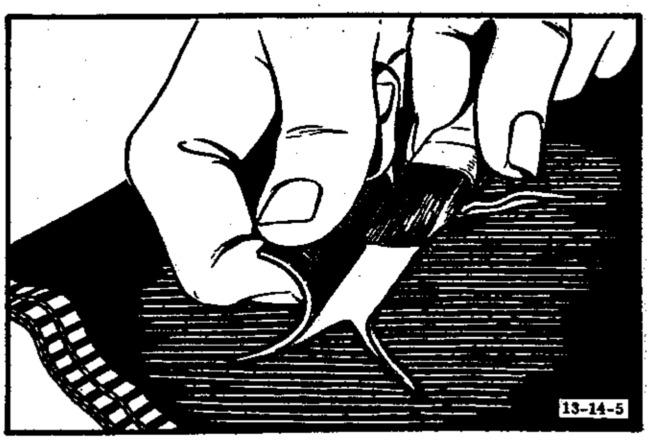


Figure 14-4 Cementing Blister

(e) Apply two coats of cement on patch and buffed area. Allow proper drying time between each coat. Apply second patch. Check repair for loose edges and trapped air.

NOTE

Some injuries, especially on flat surfaces, are simple to repair. Injuries in corners or other awkward places may prove very difficult if not impossible. Where the contour of the cell prevents good adhesion of the patch, it is better to abandon the repair and condemn the cell rather than to make a doubtful repair.

CAUTION

Air-cure repaired fuel cells a minimum of 72 hours prior to installation. Do not, under any circumstances, put a cell in a Vitacap chamber, pot heater, Plexiglas oven or any similar heating chamber. Such action would cause the cell to deteriorate and shrink beyond safe dimensions.

Repairing very Large Injuries

33 The repair of large hole injuries or long tears exceeding 10 inches is not advisable. In extreme emergencies, however, they may be repaired using the methods outlined in preceding paragraphs but the cells must be replaced as soon as possible.

Repairing Blisters

34 An inner liner blister is caused by trapped air between the liner and the sealant, and is often mistaken for separation of plies. Ply separation is the loss of adhesion between successive layers. Blisters under one inch in diameter are not injurious and need not be repaired. To repair a blister, proceed as follows:

(a) Buff the surface of a blister and an area extending 2-1/2 inches in all directions from its edges.

(b) Slit the blister from end to end with a knife and buff under side of loose edges, (see Figure 14-4).

(c) Apply two coats of cement (Item 19) to the inside surfaces. Allow proper drying time between coats, (refer to Paragraph 30, preceding).

(d) Roll down the blister carefully to remove all trapped air.

(e) After the blister has dried thoroughly, apply a patch extending two inches in all directions from its edges, and complete the repair in the same manner as an inside injury, (refer to Paragraph 30, preceding).

Repairing Loose Seams and Patches

35 Repair loose lap seams on the inside of the cell as soon as they are noticed to prevent the separation from spreading to the sealant. Proceed as follows:

(a) Buff both surfaces inside the separation. Buff an area on top of the loose seam extending 2-1/2 inches in all directions from the edges of the separation, continuing the measurement on the next cell wall when the end of the cell is reached.

(b) Clean the buffed surfaces inside the separation with a cloth moistened with solvent (Item 12). Allow to dry.

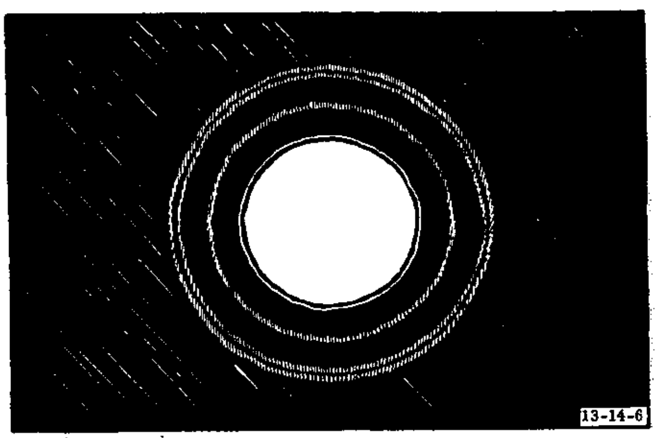


Figure 14-5 Featheredge Opening

(c) Apply two coats of cement (Item 10), allowing proper drying time between coats.

(d) Roll the separation down firmly to remove trapped air and allow to dry.

(e) Cut a patch of inside repair material (Item 9) extending two inches in all directions from the edges of the separation. Round the corners slightly and buff one side. Bevel the edges of the patch with bevelled edge on the outside.

(f) Cleanse the buffed surface of the patch and cell with solvent (Item 12), apply the patch, and complete the repair in the same manner as an inside injury, (refer to Paragraph 30, preceding).

(g) Repair loose lap seams on the outside of the cell by the same method as that described in the preceding paragraph except that outside repair material (Item 7) is used.

(h) Repair loose patches by buffing, washing, cementing the separation and rolling it down, unless it is obviously better to replace the patch with a new one.

Built-up Repairs

36 If the injury consists of a hole in the cell with a section of material blown out rather than a slit or cut, it is necessary to replace the material that is missing. This repair is made as follows:

(a) Mark two circles around injury on outside of cell wall. Draw the inside circle large enough to include all damaged sealant and ragged edges, but not smaller than 3 inches in diameter, and the outer circle on a one inch larger radius. Buff area on retainer extending from outside circle outward for 2-1/2 inches

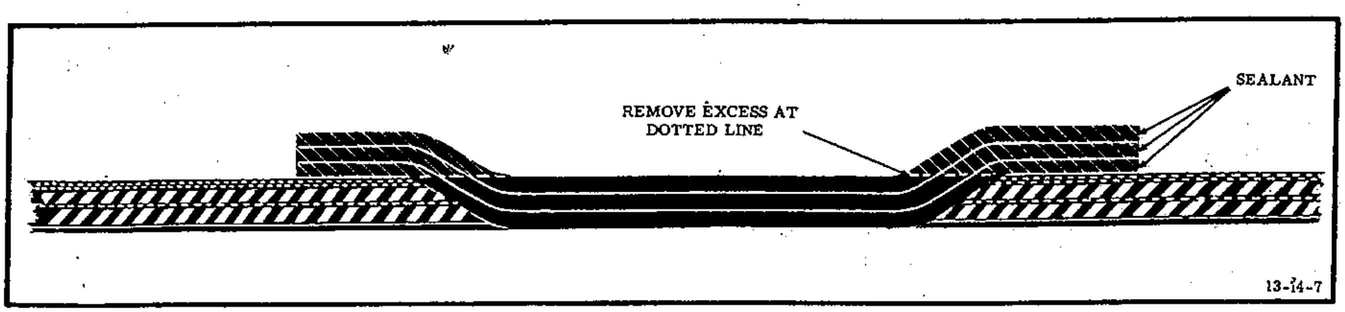


Figure 14-6 Built-up Cell

larger radius. Re-mark outside circle. Using the inside circle as a guide, cut away the cell material with a knife blade held at right angles to cell wall. Bevel the edge of hole, using the larger circle as one guide, and edge of line in hole as other. This results in a bevel of 30° and provides efficient adhesion surface. Cut liner to featheredge. (See Figure 14-5.)

(b) Support cell, (refer to Paragraph 31).

(c) Cut three patches of sealant (Item 14) one inch larger in diameter than top of the cutout in cell so that they will overlap about 1/2 inch all around when applied. Use cement (Item 15) as layers are applied. Apply each layer of sealant separately, sticking each down thoroughly. (See Figure 14-6.)

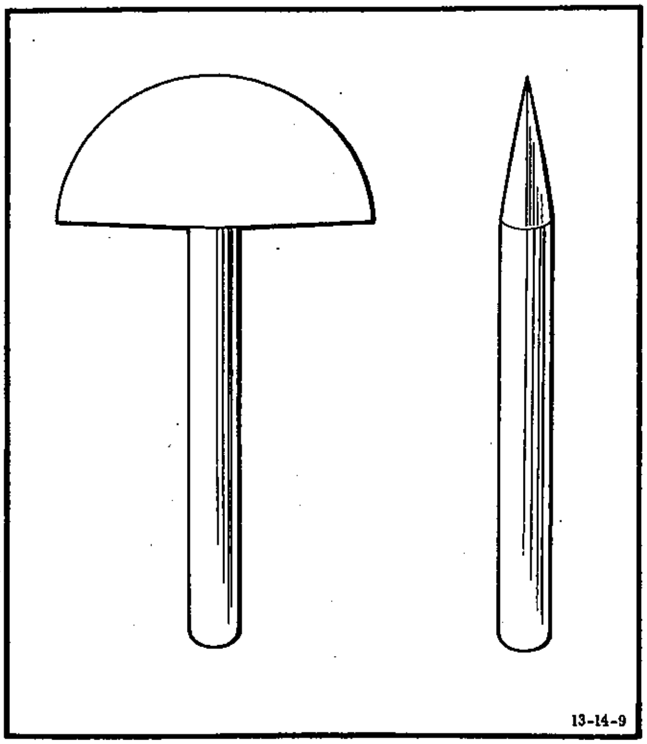


Figure 14-7 Model of Hot Knife Blade

(d) After repair has dried, carefully trim excess sealant (Item 14) to a line flush with outside of cell. A handy tool for fuel cell work can be made from an ordinary soldering iron. A semi-circular piece of copper, 3/8 inch thick cut on a 1 inch radius, is welded or brazed onto a 3-1/2 inch length of 3/8 inch round copper stock. The head is tapered down so that the tool resembles a rod cutter, (see Figure 14-7). The finished part then is inserted in the soldering iron in place of the regular copper tip. This is known as a hot knife and is adaptable to removing fittings, trimming sealant, etc. When hot, it cuts very readily and care should be taken not to cut too deep. It is advisable to practice on a condemned cell before using the knife for actual repair.

(e) Apply outside patches as outlined in Paragraph 31, preceding. (See Figure 14-8.)

(f) Before proceeding with inside patch, permit this much of the repair to cure for several hours to avoid its loosening during the remainder of the operation. Carefully remove inner support from cell and place a support against the outside over the repair area. Apply inside patches (refer to Paragraph 30, preceding). If injury is in an awkward location making it impossible to stick the inner patches the repair should be abandoned and the cell condemned.

Inside Corner Repairs

37 All inside corner repairs require a double (two-layer) patch. To prevent wrinkling or stretching of the repair material, these patches must be cone-shaped and must fit accurately into the corner. Proceed as follows:

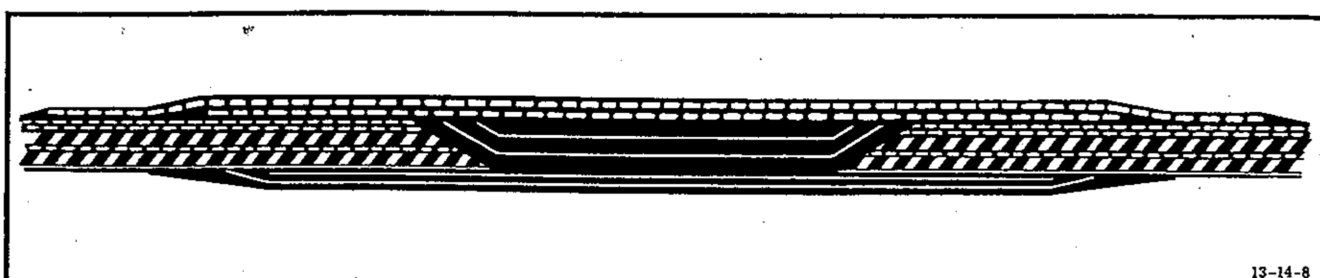


Figure 14-8 Finished Repair

(a) Buff the area around the injury, in the same manner as used in repairing a flat surface, for a distance of 2-1/2 inches in all directions from the edge of the injury.

(b) Cut a patch of inside repair material (Item 9) large enough to extend one inch in all directions from the edge of the injury. Cut a single slit in the patch running from the outside edge to the apex of the corner. At the end of the slit, in the centre of the patch, make a second slit 1/8 inch long at right angles to the first.

(c) Before any cement is applied, fit the patch carefully into the corner. Trim to size and place the slit so that the lap formed will be on a flat side as far away from the injury as possible. Scratch the outline of the patch lightly on the cell while the patch is still in the correct position, indicating the location of the slit so that the patch can be returned to the same position after cementing.

(d) Buff patching material on both sides and feather the edge before cementing. In addition, buff, wash and cement (Item 10) the portion of the top side that will be overlapped at the slit.

(e) Apply two coats of cement to the cell and the inside of the patch, with proper drying time allowed between coats. While the second coat is still slightly tacky, line up the patch with the outline previously drawn on the cell and press down a narrow strip, running from the outer edge of the inner end of the slit with the fingers. Place the patch so that it matches its outline accurately and the inner end of the slit falls in the apex of the corner.

(f) Work down the patch with a hand roller. Start rolling from the edge of the slit which has already been stuck down and work around the patch to the outer edge of the slit. Avoid any wrinkles or trapped air. If the roller or sticker proves to be too awkward, the patch may be applied with a rolling motion of the finger. (See Figure 14-9.)

(g) After the patch has been rolled down, apply cement (Item 10) to the surfaces that will form the lap. Be careful to coat the inner end of the slit well and roll down the lap.

(h) Be sure that all edges are rolled down securely. If some of the edges do not stick well, wipe the loose places with a clean, lintless cloth moistened with solvent (Item 12). After they have dried for a short time, re-roll. If they still fail to stick apply one more thin coat of cement (Item 10) and roll again after it has dried. If the patch is still loose at any point it should be torn off and scrapped, the cell cleaned of cement, and the repair procedure repeated.

(j) After the first patch has been carefully examined and found to be absolutely smooth and tight, apply a second patch of inside repair material (Item 9), large enough to overlap the first patch at least one inch. Apply the second patch in the same manner as the first, after it has been fitted to the corner by making a slit and overlapping. The location of the overlap on the second patch, however, must be opposite that of the first patch. Be sure to buff both surfaces that form the overlap before cementing.

(k) Roll the second patch in the same way as the first. Take extreme care to remove all trapped air. If there are any wrinkles or air bubbles that cannot be removed, the second patch must be pulled off and started over.

NOTE

Due to the awkwardness of sticking down patches, injuries in a corner of the cell will be found difficult to repair. Often the irregularity of the inner surface will prevent a patch from adhering. In cases where a reasonable effort has been made on a corner repair and the patch refuses to adhere, the repair may be abandoned and the cell condemned at the discretion of engineering authority.

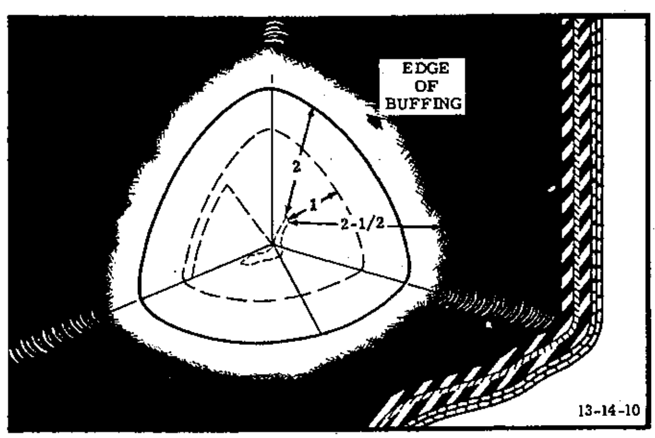


Figure 14-9 Complete Inside Corner Repair

Outside Corner Repairs

38 Outside corner repairs are made in the same manner as inside corner repairs (see Paragraph 37, preceding) with a slit cut in each patch so that it will fit the corner. Cut patches from outside repair material (Item 7) and apply by the same method as outside patches for slit injuries on a flat surface. (Refer to Paragraph 31, preceding.) Cover the lap on an outside corner patch by an extra strip of repair fabric extending one inch on each side of the outside edge of the lap from the apex of the corner to the outer edge of the patch.

Reinforcing Wrap for Tubular Fittings

39 The normal procedure for wrapping fittings is as follows:

(a) Determine the extent to which fitting surface is to be wrapped. Include as much as the tubular portion as possible and, in one-piece fitting, extend the fingers two inches onto the flat surface of the cell proper. (See Figure 14-10.)

(b) Wrap the fitting with paper to make an exact template of the stock required. Allow enough stock to overlap 1/4 inch.

(c) Cut a wrap of outside repair stock (Item 7) according to the above template. The template may be saved and used on other fittings of the same manufacturer and stock number.

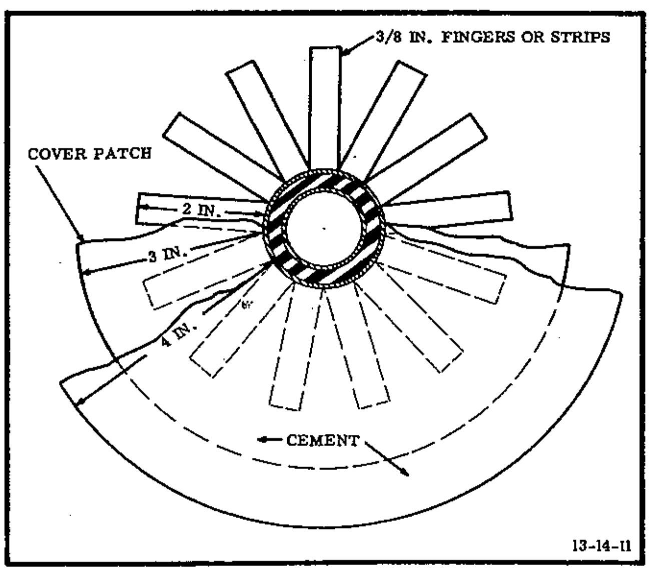


Figure 14-10 Application of Wrap

(d) Remove any partial fabric wrapping which may have been applied previously to the fittings.

(e) Buff the surface of the fitting to be wrapped. This should be done carefully with 40 or 80 grit sandpaper (Item 11). Do not use a power buffer, as fittings are easily damaged and difficult to procure and replace.

(f) Apply two coats of cement (Item 10) to the surface, allowing proper drying time between coats

(g) Buff and cement fabric wrap in the same manner as in preparing an outside patch, (refer to Paragraph 31, preceding).

(h) Apply fabric wrap carefully to the fitting, sticking securely and overlapping 1/4 inch at adjoining surfaces. A mandrel the same size as the inside diameter of the tubular fitting may be inserted in some cases to facilitate sticking.

(j) After one-piece fittings have been wrapped, cover the fingered area with a reinforcing patch (Item 8). Cut this cover patch so that its inside diameter is the same as the outside diameter of the base of the fitting and the outside diameter extends 1/2 inch beyond the fingers of the wrap.

CAUTION

Do not wrap a fitting if the weather-cracks penetrate beyond 50 percent of the depth of the stock. Fittings that are weather-cracked to this extent must be replaced. When wrapping a fitting that is weather-cracked less than 50 percent of the depth of the stock, work the cement into the cracks and allow to dry thoroughly.

Replacing Fittings

40 When cell fittings are damaged or deteriorated, remove the cell from the aircraft as soon as possible and replace the fitting or install another cell. Fitting replacement is not a difficult operation although it is a lengthy one. Take infinite care to achieve accuracy. The materials and tools used are the same as those used for other repairs. To replace the fitting, proceed as follows:

(a) Locate the old fitting accurately by measuring from selected points of the cell, so that the new fitting can be centred in exactly the same position. If this is not done, the new fitting may not align properly when the cell is re-installed. Use a fine marking pencil when locating fittings as above. Marks from crayon or chalk are generally too wide for the required accuracy.

(b) When replacing one-piece fittings with those of the two-piece type, it may be necessary to relocate the fitting opening in the cell, due to the fact that the tubular part of the two-piece fittings is sometimes different to that of one-piece fittings. Whenever possible, use replacement fittings of the same type as the fitting that is removed from the cell. Relocation of fitting openings should not be attempted unless no alternate is possible.

(c) If there is a finishing collar covering the fitting flange on the outside of the cell, strip off the collar with a pair of pliers, (see Figure 14-11). Loosen the cement under the collar by the use of solvent (Item 12).

(d) Strip the outside flange from its edge back to the centre of the fitting, taking care to avoid injury to the outside ply of the cell material.

(e) After the outside flange has been stripped back, cut off the fitting and flange flush with the outside surface of the cell. Cut out the core of the fitting to the edge of the cell wall. Be careful to avoid cutting the cell or enlarging the original opening. (See Figure 14-12.)

Installing New Fittings

41 To install new fittings proceed as follows:

(a) Using a sand wheel or emery buffer, remove enough of the inside flange of the old fitting and the covering ply to reduce the thickness of the cell wall so that it will fit between the flanges of the new fitting.

(b) Buff the inside and outside surfaces of the cell where flanges of the new fitting are to be placed. This buffing must cover an area extending 2-1/2 inches beyond the edge of the flanges when the new fitting is set in place.

(c) If the new fitting has not been buffed, buff the surfaces inside and outside both flanges with 80 grit emery cloth or wire buffer. Avoid deep cuts in the material with the wire wheel, especially if an old wheel is being used.

(d) If the cell wall does not have sufficient thickness to fill the space between the flanges of the new fitting, apply a patch of inside repair material to the inside of the cell in the same manner as in applying an inside patch, (refer to Paragraph 30, preceding). This patch must be large enough to extend 1/2 inch beyond the area to be covered by the fitting flange, and the centre must be cut out to match the throat of the fitting. Before the patch is applied, buff the outside surface and feather the edge. Before inserting the fitting through the opening, check the size and shape carefully, using a pair of calipers. Make cutout opening to conform exactly with the size and shape of the throat of the fitting. When making replacement of the same fitting, a plug or template can be used to advantage.

(e) Moisten the surfaces of the fitting with solvent and force the fitting through the opening of the cell, pulling the top flange through from the inside of the cell. Check the fit of the new fitting in the cell opening. If the opening is too small, buff until the new fitting fits satisfactorily. If the opening is too large, fill the excess area with sufficient sealant (Item 15) to assure a perfect fit. After making sure the fit is satisfactory, remove the fitting from the cell.

(f) Apply two coats of cement (Item 10) to the inside of the fitting flanges and the buffed area of the cell wall, allowing each coat to dry thoroughly.

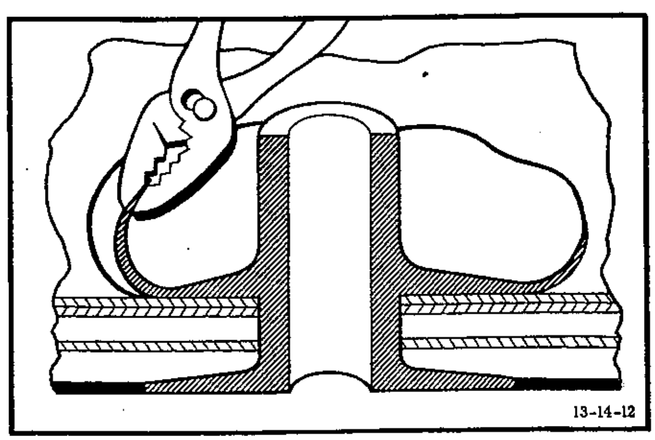


Figure 14-11 Removing Injured Fitting Flange

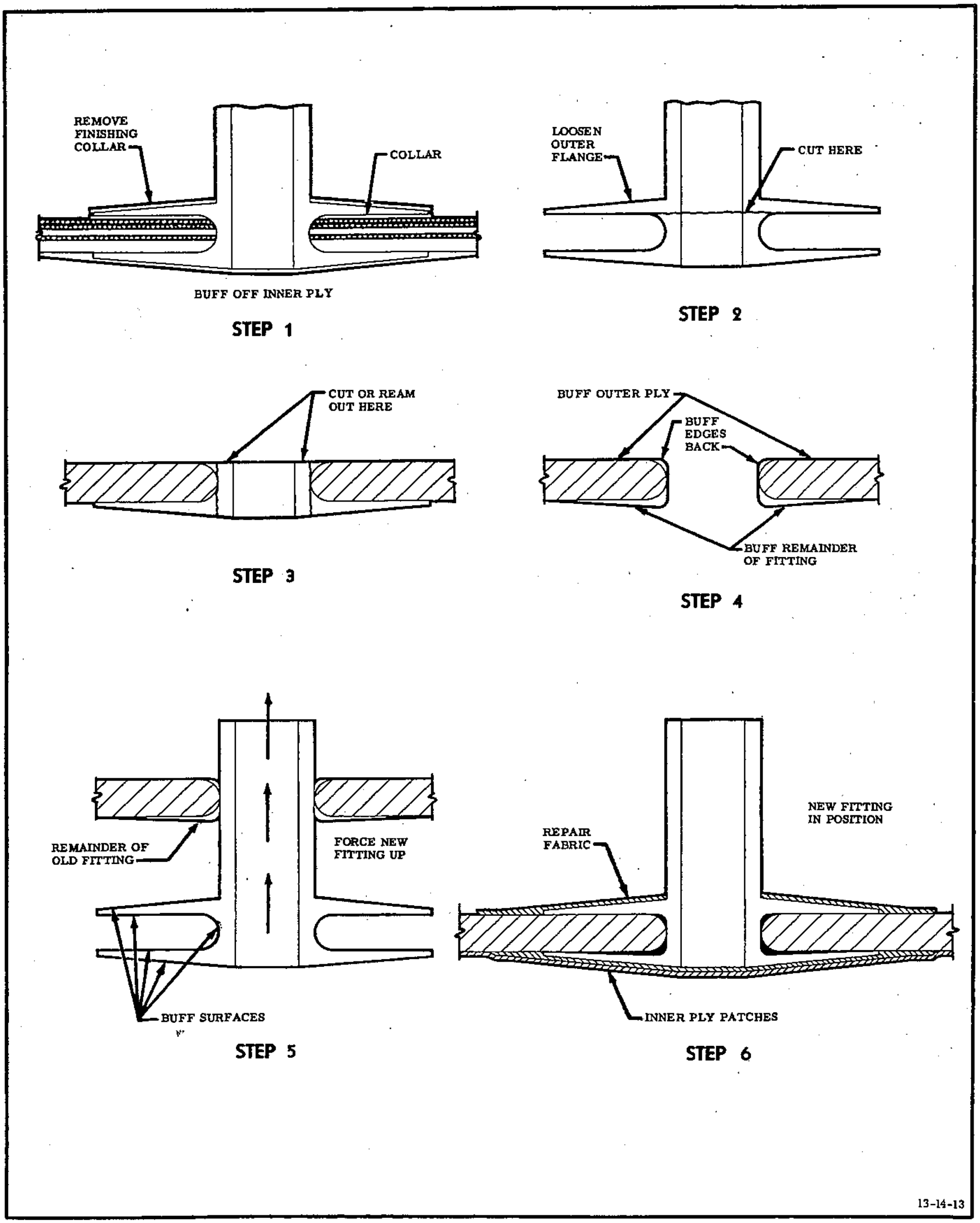


Figure 14-12 Fuel Cell Fitting Replacement

(g) Insert the fitting in the opening of the fuel cell, pulling the top flange through hole from inside the cell. Line up the fitting carefully so that its location is exactly the same as that of the old fitting. (Refer to Paragraph 40, preceding.) Reactivate the cement on the inside fitting flange with solvent (Item 12), using a lintless piece of material, preferably sponge. Stick the flange to the cell wall. Let inside flange dry approximately thirty minutes before working the outside flange. Use the same procedure on the outside flange as outlined above for the inside flange, ensuring that the cement on the throat of the fitting is reactivated.

Application of Cover Patches

42 Apply cover patches over fitting flanges as follows:

(a) Apply two patches over each inside flange after the cement holding the fitting has dried thoroughly, (approximately 45 minutes). Cut the first patch one inch larger in all directions than the fitting flange, buff the cured surface, and feather the edge. Cut an opening in the centre of the same shape as the opening in the fitting but 1/8 inch larger in all directions.

(b) Cut the second patch one inch larger in all directions than the first patch. The opening in this patch is cut 1/4 inch larger than the opening in the fitting. Cut and buff all patches at one time.

(c) Cement and apply patches, (refer to Paragraph 30, preceding). Centre the opening carefully so that two steps of equal width are formed. After the patches have cured approximately two hours, use a power buffer to blend the edge of the patches so there will be no irregularity of surface which would be attacked by fuel.

(d) Use only one patch on the outside of the fitting. Cut this patch two inches larger in all directions than the fitting flange. Cut the centre to the proper size and shape to accommodate the fitting. A patch applied to a protruding or barrel-type fitting must fit snugly around the base of the fitting barrel. A patch applied to a metal insert fitting may have an opening 1/2 inch larger in all directions than the gasket or compression surface of the fitting.

(e) The fitting replacement procedure described above may not be practical with all replacements. In some cases it may be more convenient to insert the fitting from the outside of the cell. Some installations can be made easier if the patches are cemented to one flange before the fitting is inserted. The following points must be observed:

(1) Cement must have proper tackiness by knuckle test. (Knuckle will tend to stick to cemented surface, but will not raise any strings when withdrawn.)

(2) Use at least two cover patches on the inside and one on the outside flange.

(3) Outside patch on metal insert fittings must not interfere with gasket or compression surface.

(4) Feather the edge of first patch on inside.

(5) Fill in any void between cutout opening of cell and fitting throat with strips of sealant.

(6) Make sure fitting is in proper position before sticking and applying patches.

(f) Wrap fittings, (refer to Paragraph 39, preceding).

Repairing Non-metallic Cells

43 A non-metallic tank is a combination fuel cell and rigid tank in one single unit. Whereas most fuel cells are enclosed in a metal shell when placed in the aircraft, non-metallic tanks are complete in themselves.

44 Damage to the non-metallic portion of the tank under 10 square inches in area need not be repaired if the strength of the unit is not impaired, but the inner liner of the self-sealing fuel cell must be repaired and a patch placed over the damaged portion of the non-metallic tanks to prevent gasoline from attacking the injury.

45 If the damaged area is over 10 square inches but under 25 square inches, repair as in Paragraph 32, preceding. If some of the material has been blown away or otherwise displaced, pack the opening with sealant before the patches are applied. Because of the hardness of the non-metallic portion of the cell, do not try cutting the hole to a smooth contour. The sealant material can be applied in small

sections if necessary. Fill the entire opening, making sure there are no air pockets which would expand at high altitudes. The hot knife will be found very useful to remove and smooth the sealant. Apply cover patches inside and out as described in Paragraph 32, preceding.

46 Fittings for the different non-metallic cells are interchangeable to a limited extent. Fittings may be interchanged in cells having similar construction and equipped with fittings have the same distance between flanges.

Repair of Self-sealing Oil Cells

47 Self-sealing oil cells are repaired in the same manner as fuel cells but greater care must be taken in cleaning the cells in preparation for repair work. Repair as follows:

(a) Allow the oil cell to drain. Remove oil from the inside and outside by washing, (refer to Paragraph 21, preceding). Take special care to remove all oil in and around injuries. Hold edge of injuries apart and wash all surfaces with a clean petroleum solvent until all oil is removed. Wash lightly, as the injury must not be soaked with solvent.

(b) Dry the oil cell thoroughly before beginning repair work.

(c) When repairing oil cells, use cement (Item 15).

Test Procedure

48 Test self-sealing cells in the following manner:

(a) Seal all openings except one.

(b) Apply bubble soap compound (Item 18) on the exterior surfaces to be tested.

(c) Use dried, filtered air and apply 0.5 psi air pressure to the interior of the cell.

Repair of Fully Moulded Fittings

49 Repair of checked, cracked or broken places in the rubber coating of the metal attachment fittings on self-sealing fuel and oil cells are made as follows:

(a) Carefully buff or sand the surface of the damaged fitting with aloxite cloth (Item 19) and clean so that the damage is removed and only sound material is exposed in the area to be repaired. This would include cleaning and sanding of the metal fitting plate, if exposed. Final step in cleaning should include washing with naphtha (Item 20). Repairs are limited to 15% of surface area for each repair.

(b) Insert special short screw pins or shortened bolts of an appropriate size into the screw holes to keep stock from flowing into them.

(c) If any metal has been exposed in the preparation of the area for vulcanization, apply one coat of metal primer (Item 17) and allow to dry for 30 minutes before proceeding.

(d) Apply two or more coats of Buna-N fast curing cement (Item 15) as necessary, allowing sufficient time for each coat to dry before applying the next coat. When the last coat is dry, add sufficient uncured Buna-N stock (Item 14) to the injured area to bring the thickness of this area up to that of the rest of the fitting area after curing has been accomplished.

(e) Place a special heat transfer and pressure fixture on the fitting undergoing repair. The fixture consists of an internal and an external pressure plate, which conform to the contours of the fitting, and a bolt which applies pressure between the plates. Torque to 15 inch-pounds.

(f) Apply a flat type heater to the outer face of the pressure plate fixture and heat the whole assembly to a temperature of 280°F by conduction for a period recommended by the supplier of the uncured Buna-N material (Item 14).

(g) Remove the heater and allow the plate fixture to cool. If necessary, buff, clean and smooth the new surface of the fitting. Apply a coat of Buna-Vinylite lacquer (Item 13) to the fitting area.

REPAIR OF BLADDER TYPE CELLS (NON SELF-SEALING).

General

50 Repairs to bladder type, non self-sealing cells are similar to repairs to self-sealing cells.

Fuel Cells

51 These cells are of lightweight construction, composed of one or two layers of square woven rubberized fabric outside, nylon film barrier and one layer of Buna-N synthetic rubber inside. Repairs of the inner liner and outside fabric will be the same as for self-sealing fuel cells, disregarding sealant layers and with the exception of buffing. When buffing, exercise care due to the lightweight construction of this type of cell.

Oil Cells

52 These cells are of lightweight construction, composed of one layer of rubberized fabric outside and one layer of Buna-N synthetic rubber inside, with no nylon barriers. Repairs are the same as for self-sealing oil cells.

Water-alcohol Cells

53 Make repairs to water-alcohol cells in the same manner as fuel cells, since the construction of the cell is the same.

Replacement of Fittings

54 Replacement of fittings on bladder type cells is not satisfactory and will not normally be attempted.

Inspection

55 Inspect visually to determine extent of repairs needed after removal from the container or aircraft cavity. Inspect for leaks by the use of air pressure, not to exceed 1/4 psi. Apply soap suds on the outside of cell with a small paint brush. Use a manometer to determine any loss of pressure. Air pressure must be used with caution to prevent damage to cell.

Handling and Packaging

56 Bladder-type cells are more delicate than self-sealing fuel cells and require more careful handling. They will abrade easily if dragged over a rough surface and will rip if snagged on a protruding sharp point. Bladder-type cells exposed to cold temperatures should be warmed to room temperature before being unfolded or handled excessively.

57 Prior to packaging, treat cell interior with a light oil (Item 3), (refer to Paragraph 10, preceding). Cover all openings with masking tape or similar adhesive material. Fold as smoothly and lightly as possible, with the least number of folds. Do not compress excessively. Wrap in moisture-proof paper and wadding before packaging. Select a box that will fit the folded cell and not permit shifting. If it is necessary to use a larger box in emergency, fill the unused space with crumpled or shredded paper. Packaging is unnecessary if cell is to be installed immediately.

REPAIR OF GOODYEAR NYLON (PLIOCEL) FUEL CELLS

General

58 Pliocel fuel cells differ in construction and material from Buna rubber fuel cells. This type cell can be identified by the trade name Pliocel stencilled on the cell. Their repair must be accomplished by entirely different methods and with different material. Pliocel construction consists of two layers of nylon woven fabric laminated with three layers of transparent nylon film. Cement (Item 10) and Buna rubber must not be used for this repair.

Repairs

59 Repair tears, holes and cuts of less than two inches by the application of a patch on the interior of the cell as follows:

(a) Clean the repair area with a cloth moistened with methyl ethyl ketone (Item 12) or acetone (Item 22). Either of these solvents will remove any residual matter left by the fuel.

(b) Using scissors or knife, trim the damaged area to remove rough edges or irregularities. Round the corners.

(c) Cut a patch of repair material (Item 23) to sufficient size and shape to cover the damaged area and extend 3/4 inch beyond in all directions.

(d) To prepare the surface, use a cloth moistened in ethyl alcohol (Item 24) and wipe the mating surfaces of the patch and damaged area. Squeeze all excess alcohol from the cloth before wiping the material.

(e) Place the damaged area on a suitably shaped smooth maple block.

(f) Position the patch on the damaged area and cover temporarily with cellophane (Item 25). The cellophane protects the nylon construction from sticking to the iron and, at the same time, permits visibility.

(g) Check temperature of sealing iron as described in Paragraph 64 following. Apply heat to approximately two square inches of the repair patch until the cellophane is slightly browned. Heavy browning is unnecessary and may cause excessive porosity of the repair area. Do not press down on the sealing iron. Hold gently and apply a guiding movement rather than pressure. Do not permit the sealing iron to roll beyond the edge of the patch. Heat applied to the single layer of material will induce porosity. Small blisters will probably appear as the material heats, but these blisters are not harmful. When the area is properly heated, roll down immediately with cold roller and repeat operation until entire patch is completed. Do not attempt to heat more than two square inches at a time, as a greater area would cool before it could be rolled down properly with the cold roller. Finished patch must be bonded securely around its entire edge. (See Figures 14-13 and 14-14.)

(h) Wet cellophane with a lintless cloth moistened in clear water. Permit the wet cloth to remain on cellophane for several minutes and the cellophane will peel off easily. Wipe repaired area with a dry, clean cloth.

(j) Wipe again with a cloth moistened in ethyl alcohol (Item 24). Prepare nylon paint as explained in Paragraph 65, following. Paint three coats of liquid nylon on the entire repaired area. The first and third coats are to be blue nylon (Item 26) and the second coat of yellow nylon (Item 27). Allow twenty minutes drying time between coats.

60 Repair injuries of two inches or over in the same manner and, in addition, apply a patch on the outside of the cell. The outside patch follows the same pattern as the inside patch but is 1/2 inch larger in all directions and is applied after the inside patch. Before beginning outside repair remove the black outer lacquer with solvent (Items 12 or 22). Paint the finished patch with one coat of synthetic rubber cement (Item 28) over the normal three coats of nylon. Mix the cement (Item 28) at a ratio of one fluid ounce of 1408C to 32 fluid ounces of 5070C to make 5071C. Mix only the amount which can be used in one day. Do not use any paint which has been left over from the day before.

61 Make fitting repairs basically the same as any other repair. Replacement fitting assemblies as found on self-sealing cells are not required. Occasionally it will be simpler to replace a small section of cell rather than attempt repair. A good illustration of this is a tunnel end or corner. The replacement section could be cut from a condemned cell if new part is not available.

62 Fabric fitting collars which are damaged by installation must be torn out to the fitting opening. To repair, remove the fabric collars by working a small amount of ethyl alcohol (Item 24) under the edge, lifting the collar until it is removed. Repair tear in cell ply

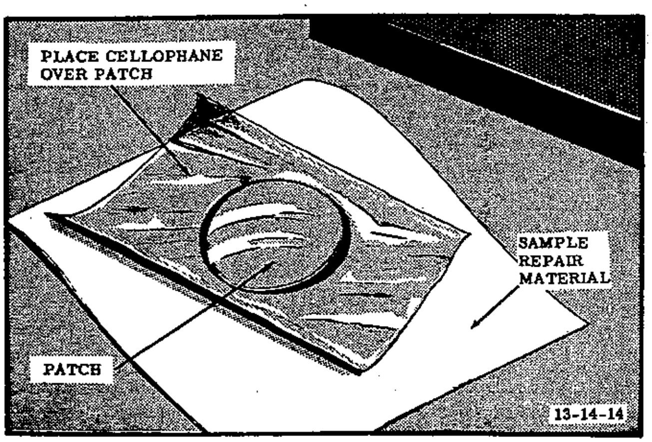


Figure 14-13 Simulated Repair

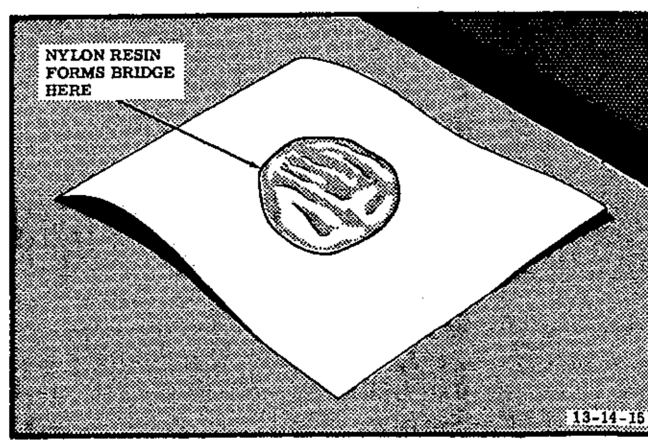


Figure 14-14 After Removal of Cellophane

Item No.	Material	RCAF Ref	Specification	Manufacturer
1	Oil, Engine, Grade 1100	34A/17	3-GP-100A	
2.	Cleaner	33C/182	3-GP-8	
3	Oil, Engine SAE 10	34A/182	3-GP-45	
4	Talc	33C/11	MAT-2-1	
5	Clay, Bentonite			
6	Soap, Paste	33C/683	2-GP-4	
7	Rubber, Synthetic, Buna-N .038"-.062"	32C/		
8	Rubber, Synthetic, Buna-N .020"	32C/		
9	Rubber, Synthetic, Buna-N .045"	32C/		
10	Cement, Synthetic Base, Aromatic Fuel Resistant	33G/116	MIL-P-9117	
11	Cloth, Emery, 40 to 80 grit	29/1833 to 1840		
12	Solvent, Cement, Methyl Ethyl Ketone	33C/520	TT-M-261	
13	Lacquer, Buna Vinylite	33A/	MIL-L-7178	
14	Sheet, Sealant, Fuel cell, Self-sealing .110 gauge	32C/		
15	Cement, Sealing, Synthetic Rubber No. 4006	33G/116	MIL-C-9117	B.B. Chemical Co. of Canada Box 1447 Montreal
16				
17	Primer, Ty-Ply, BN.	33A/462	MIL-P-6889A	
18	Compound, Bubble-soap (dilute 1 to 10)			B.W. Deane & Co. 3620 Namur Montreal
19	Cloth, Aloxite			
20	Naphtha	33C/653	TT-N-95	

Figure 14-15 (Sheet 1 of 2) Table of Material Specifications

by overlapping and heat sealing a narrow strip of nylon fabric (Item 23). Apply collars to cell and cut holes, using holes in cell fabric as a guide.

63 If a Pliocel cell is to remain without fuel for a period exceeding seven days, fog the inside of the cell with a solution of equal parts of water and glycerine (Item 29). If spray equipment is not convenient, make the application with a lintless cloth moistened in the solution. Prior to installation of the Pliocel cell in the airplane or before any repair, remove the residual solution with a cloth well moistened with water.

Method of Checking Temperature of Sealing Iron

64 To check temperature of sealing iron, proceed as follows:

(a) Simulate the repair with pieces of scrap repair fabric (Item 23) and cellophane (Item 25).

(b) Apply heat to approximately two square inches until cellophane is slightly browned.

(c) Roll down with cold roller.

(d) Dampen and remove cellophane.

(e) Pull the sealed pieces apart and note their appearance. If all the nylon film has adhered to one piece of material and the remaining piece has bared fabric, the iron temperature is correct and the seal is satisfactory. If, when applying the iron to fabric, it blisters immediately or turns dark brown, the iron is too hot. Pull plug and cool for a few minutes before applying the iron again.

Preparation of Nylon Paint

65 To prepare nylon paint, heat liquid nylon (Items 26 and 27) in a small double boiler or glue pot to 150° to 160°F. (Minimum temperature 130°F.) Maintain this temperature range during the working period. Heat only the amount of nylon to be used each day.

66 Between applications keep the brush either in the liquid nylon or in a container of ethyl alcohol (Item 24). Do not allow nylon to

Item No.	Material	RCAF Ref	Specification	Manufacturer
21	Methyl Isobutyl Ketone			Technical Grade
22	Acetone	33C/417	0-A-51	
23	Fabric, Pliocel Repair Material, FT 45			
24	Alcohol, Ethyl	34A/214	3-GP-525	
25	Cellophane, Water-permeable, 6" wide			Commercial Grade
26	Nylon, Liquid blue 5073C			
27	Nylon, Liquid yellow 5074C			
28	Cement, Chemigum coating 5071C (consists of 5070C and 1408C)			
29	Glycerine	14B/43		
30	Detergent	33C/667		

Figure 14-15 (Sheet 2 of 2) Table of Material Specifications

dry on the brush. Clean thoroughly at the end of each working period in ethyl alcohol (Item 24). Use brushes on one material only unless cleaned thoroughly with the proper solvent.

Handling and Packaging

67 Prior to packaging, treat cell interior with water-glycerine solution. For further instructions, refer to Paragraphs 56 and 57, preceding.

Testing

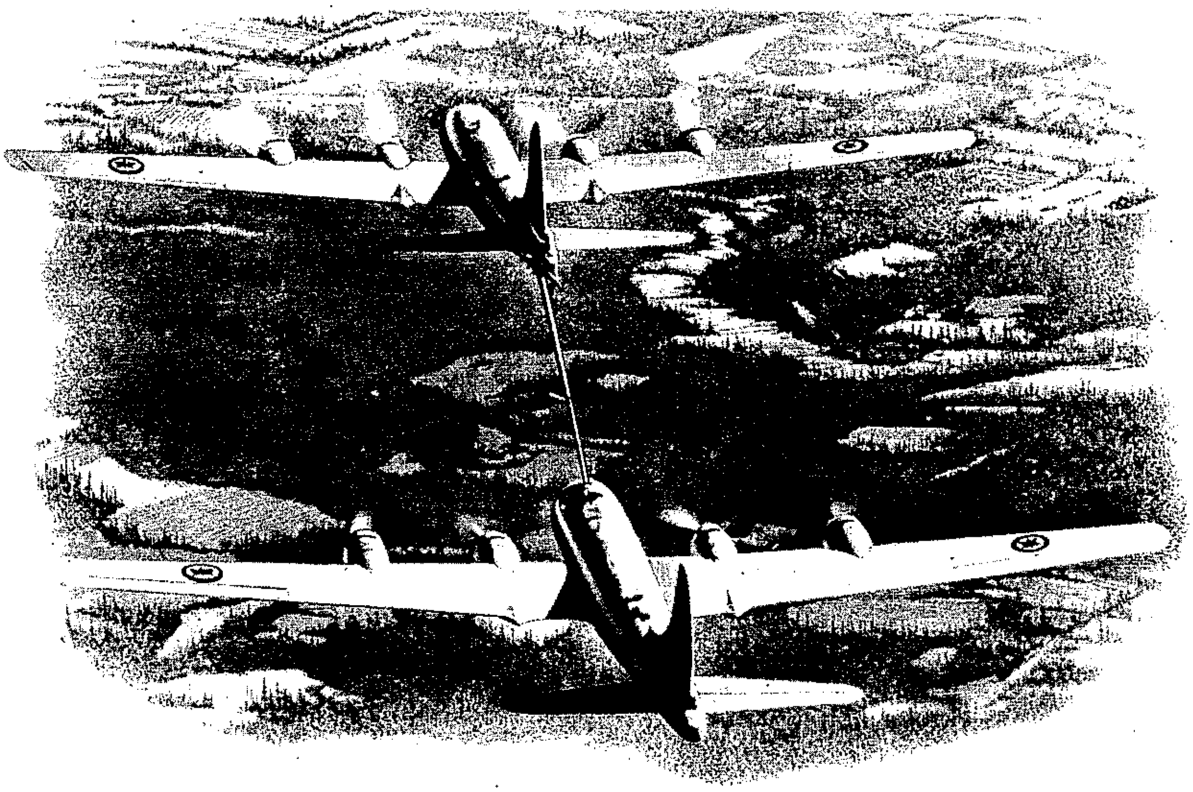
68 Air testing of Pliocel fuel cells can only be accomplished in a strong metal tailored jig. Since the large number of shapes and sizes makes this impractical, soak testing is recommended. Place cells in a cheaply built cage which conforms approximately to the size and shape of the cell and prohibits strain on the various contours. Use wire mesh to make the walls of the cage, exposing the largest cell area possible to view. Place cells in the cage, fill with jet engine fuel and permit to remain overnight. Leaks will be apparent by moist areas on the outside. Comply with the local fire prevention rules during soak test.

Material Specifications

69 For table showing item numbers, materials, specifications and manufacturer, see Figure 14-15.

PART 15

FUEL AND OIL TANK REPAIR



PART 15

FUEL AND OIL TANK REPAIR

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PART 15

FUEL AND OIL TANK REPAIR

FUEL AND OIL TANK REPAIR

General

1 Most causes for fuel and oil tanks becoming unserviceable are sealant failures. Some of the types of sealant failures and their causes common to both original and repair sealant are as described in the following paragraphs.

Blisters

2 Blisters are caused by air bubbles or cleaning solvents entrapped in the sealant. Expansion of the air in the blister at altitude and flexing of the structure or an extreme increase in temperature can rupture the blister and thus open the sealant.

Flexing of Wing Structure

3 Continual excessive flexing of the wing structure in flight, rough landings, or taxiing too rapidly over rough terrain with a heavy fuel load, can cause ruptures in sealant.

Voids or Omissions in Sealant

4 Leaks will result if sealant is omitted from hard-to-get-at places or is not thoroughly worked into all voids along all seams and joints.

Poor Adhesion

5 Sealant will not adhere to structure if applied over dirt, grease, soap film, oil film or moisture trapped in seams and joints.

Pinholes in Sealant

6 Brush sealant, if not worked thoroughly around each rivet or fastener, may break unnoticed as the sealant cures. Fuel will extract unmixed accelerator material from the sealant if the accelerator and base compound are not completely blended. This will occur sooner if the sealant is not cover coated adequately. Too rapid mixing of accelerator and base compounds can introduce small air bubbles into the sealant. The bubbles may break and cause pinhole leaks.

Deterioration of Sealant

7 Improper proportions of base compound and accelerator can affect the quality of the sealant. Too much accelerator for the amount of base compound used results in loss of sealant flexibility at low temperatures. If too little accelerator is used, the sealant will not have the required fuel resistance. If an adequate protective coating has not been applied, the fuel will attack the sealant, resulting in pinholes and causing the sealant to appear chalky and powdery and to crack on flexing, even at room temperature.

Dry Fuel Tanks

8 If fuel tanks are left dry for extended periods, the sealant and the mechanical gaskets and seals dry out and fuel leaks result. If an aircraft is to be parked outside for a few days or if it is to be out of service for a prolonged period, each tank should contain at least 50 gallons of fuel. The fuel vapour will help to preserve the sealant that is not actually in contact with fuel.

Inspecting and Recording Leaks

9 Careful inspection in a well-lighted area is of prime importance. It is particularly important to inspect carefully for seeps and leaks in confined areas and make the necessary repairs. Care and judgement will ensure that old stains and leaks that have been fixed are not recorded. If there is doubt as to whether a stain actually indicates the presence of a leak, the stain should be wiped off and the area observed for a time to see if fuel reappears.

Types of Leaks

10 The most common types of leaks encountered are:

(a) Stain, which is the mildest kind of leak. This is a discolouration around fasteners or seams caused by very slow fuel seepage which dries as it meets the open air. A stain should be wiped off and, if it does not reappear within one hour, it should be merely recorded and periodically inspected.

(b) Seep, which is a heavy stain and when wiped off with a rag, reappears within one hour. This type of leak should be inspected frequently for increased activity.

(c) Heavy seep, which is seepage that increases to the point where it reappears immediately after being wiped off. Repair if the aircraft is at a maintenance base.

(d) Dripping leak, which is a continuous fuel leak wetting a limited area and then drips off. Repair before the aircraft is released for flight.

(e) Running leak, which is a continuous running of fuel is caused by a definite break in the sealant and the source is usually easy to locate. Repair before the aircraft is released for flight.

Sealing Compound

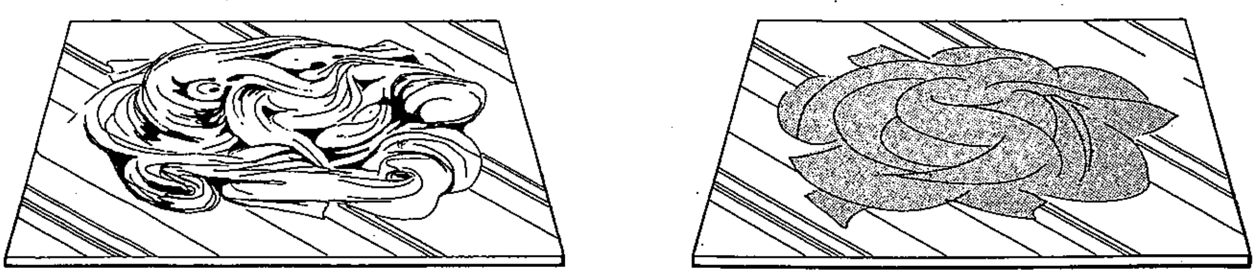
11 This material is essentially a long-chain polymer thiokol-type synthetic liquid rubber that cures chemically to solid rubber when mixed with an accelerator in the correct proportion. Refer to Paragraph 67, following, for the list of materials and the protective coatings and cleaners used. When correctly mixed and applied to a properly cleaned area, these sealants may be depended upon for a good seal. They may be used to repair any sealant previously installed, providing that the deteriorated portion of the old sealant is completely removed. Sealants have an application life of 1/2 hour to 8 hours after mixing. Sealant (Item 1) is a heavy viscosity sealant used for injection and fillet sealing in voids, holes, and along structure seams and joints. Sealant (Item 2) is a brushable material used for sealing fasteners, such as rivets and bolts.

12 The protective coating material is a phenolic resin coating which protects the sealing materials from deterioration in service. This type is used in the field for cover coating repairs and is applied by brush.

Mixing

13 The different brands of base sealing compounds range from black to white. The accelerator is dark brown. The white basic compound shows definite streaks of colour until it is thoroughly blended with the brown accelerator, (see Figure 15-1). Where large quantities of sealant are used, the base and accelerator are mixed on a flat glass plate so that the two can be thoroughly blended.

14 For service repairs, vendors provide the correct proportions of base compound-to-accelerator in a kit consisting of an accelerator container attached to the lid of the base compound container. It is suggested that the 1/2 pint kit be used, as this amount suffices for average repairs. The proper and complete mixing of these materials is vital for good results.



THE REPAIR WILL FAIL UNLESS THE ACCELERATOR IS THOROUGHLY MIXED INTO THE SEALANT

13-15-2

Figure 15-1 Mixing Sealant Materials

Application Life

15 The period during which the mixture of the accelerator and base compound retains a consistency suitable to its particular use (for example, brushing, filletting, or injection sealing) is called application life. The brush material is usable until brush marks no longer flow out when it is applied to rivets and bolts. The fillet and injection materials are usable until the sealant becomes rubbery and sticks to the application gun instead of to the surface of the tank.

16 The application life of sealant varies with the relative humidity, the ambient temperature and the temperature of the mixture. Assuming the mixture is at ambient temperature, above 77° F and 50% relative humidity, the application life of the sealant is less than three hours. Below 77° F and 50% relative humidity, the application life is longer. The relative humidity has a distinct effect on the application life of the mixed sealant, but only within the range of 70° to 120° F.

17 For approximately each 15% increase in relative humidity over 50% at any temperature between 70° F and 120° F, the application life of the mixed sealant is reduced by approximately one-half, and for each decrease of 15% in relative humidity under 50%, the application life is about doubled. The relationship of temperature, relative humidity and application life is easier to understand if it is kept in mind that the sealant cures by chemical action and does not harden through evaporation.

Cure Time

18 The time the sealant takes to set up after application is the cure time. This depends on the initial application life, the ambient temperature, the temperature of the material and the relative humidity. The time of cure is about 10 times the application life if the air temperature and relative humidity do not vary. If, during the cure time, the air temperature is increased by 12° F over the 77° F, the sealant will cure in approximately one-half the time. Below 65° F the sealant will not cure, but will become tacky and remain so until exposed to higher temperatures, when it will cure properly.

19 To reduce cure time, air may be circulated through the tank at 120° to 140° F until the sealant has cured.

Storage Limitations for Kits

20 Follow the manufacturer's recommendations with regard to storage limitations. Most manufacturers specify one year of shelf life at temperatures under 90° F.

Protective Coatings

21 One of the problems encountered in sealant maintenance is due to inadequate protective coating over the sealant. Any of the accelerated sealants presently available which are not completely cover coated will deteriorate upon contact with fuel. This applies to both original and repair sealant.

Instructions for Mixing of Sealants

22 Follow the manufacturers instructions carefully. Proceed as follows:

(a) Mix all the accelerator and the base compound in the kit, regardless of how much sealant will be required.

(b) Scrape all the accelerator into the base compound can.

(c) Scrape all the base compound from the lid and from under the rim of the can into the mixture, otherwise the proportion of the accelerator to the base compound will not be correct. Unless all the accelerator is added, the sealant probably will not cure properly and will not have adequate fuel resistance. If more than the recommended accelerator is added, the sealant will cure, but its flexibility and elongation properties will be seriously impaired.

(d) Stir the mixture slowly by hand, using a flat mixing paddle, for three to six minutes. Stirring the mixture rapidly will introduce air bubbles which might later burst and result in pinhole leaks.

(e) Stir thoroughly until the accelerator and base compound are completely blended and free from a marbled appearance. All the mixture must be completely uniform in colour, (see Figure 15-1).

CAUTION

Do not mix only part of the accelerator and part of the base compound that comes with the kit. This would result only in an ineffective repair. Do not intermix different brands of sealing materials. Do not intermix different types of the same brand of sealing materials.

EXTERIOR SEALING-INTEGRAL FUEL TANKS

Preparation of Sealer

23 Sealer (Item 7) must be in a free-flowing, fluid condition when applied. Since it becomes jelled in temperatures below 90° F, place the container in a water bath and bring the sealer within the range of 120° to 160° F, using electrical heating units only. Stir occasionally while heating. When the temperature is constant and the blend is clear, it is ready for application. Heat the sealer (Item 7) as quickly as possible by preheating the bath. Evaporation of the volatile and inflammable solvent will produce a concentration of the materials. Loosen caps, lids or corks before heating to prevent excessive container pressures.

NOTE

Solvent evaporation from open containers and from the above heating cycle may result in undesirable brushing consistency of the sealer. Reduce the sealer, when necessary, by adding denatured alcohol (Item 8). Reduction must not be accomplished if the sealer is cooler than 120° F.

Procedure

24 For exterior sealing, proceed as follows:

(a) Remove all compound, camouflage paint and zinc chromate primer from surfaces to be sealed, with stripper (Item 9). Remove excessive sealing compound from crevices and slots in the screw heads. Do not use metal scrapers.

(b) Make a final clean up of the metal surfaces with clean cloths dampened with stripper. Wipe dry with absolutely clean, dry cloths. Areas cleaned must be at least 12 inches greater than the surfaces to be coated.

(c) Fill any crevices with sealing compound (Item 2) applied with a putty knife. Apply carefully to completely fill the depressions and level the sealant flush with the adjacent surface. Remove all surplus material from the adjacent surfaces, using a clean cloth wetted with stripper. Allow the sealant to cure before applying subsequent coatings. Cure can be expedited by applying heat.

(d) With a clean stiff bristle brush, apply one even medium coat of cement (Item 5) and allow to dry until the film is dry to touch. The cement must be applied over a greater area than the subsequent sealing coats.

NOTE

The surface of the cement must be free from foreign matter, such as oily fingerprints, grease, etc., immediately prior to the application of sealer (Item 7). Remove all contamination with a clean cloth dampened with denatured alcohol (Item 8).

(e) With a clean, stiff bristle brush apply three normal coats of sealer (Item 7) allowing a minimum of 30 minutes drying time between coats. Best results are obtained by applying the sealer as rapidly as possible. Each application of sealer should cover a slightly smaller area than the preceding coat. Do not apply the sealer over bare metal, as inferior adhesion will result, with subsequent loosening of the coat along the edges.

(f) Allow the final coat of sealer (Item 7) to dry thoroughly. Apply two spray coats of aluminized lacquer (Item 12), allowing 30 minutes drying time between coats. Overlap the primed and sealed surfaces at least six inches with the lacquer, where practical.

NOTE

Brushes must be kept clean. Brushes used to apply the cement (Item 5) must be kept in cement in a closed container. Brushes used to apply sealer (Item 7) may be cleaned with denatured alcohol (Item 8), or stripper (Item 9).

Safety Precautions

25 Improper use of materials and equipment in the tanks can result in injury to personnel and damage to the aircraft. Conscientious observation of the following safety rules while investigating leaks and making repairs is necessary:

(a) Be certain that the aircraft is electrically grounded and that the pumping rig is grounded to the aircraft.

(b) Use air motors for all drilling operations. If a vacuum cleaner is used to clean tank interiors, it must be air-driven. Wear wing socks or gym shoes when working inside tanks.

(c) Use only explosion-proof electrical equipment in the area.

(d) Use only explosion-proof lights and flashlights inside the tank.

(e) Have fire extinguishing equipment readily available.

(f) Before entering a tank, circulate fresh, filtered air through the tanks for at least 30 minutes. A venturi type air remover at the filler well and filtered air forced through the access panel in the lower wing surface will serve the purpose. The purging will be more effective if the residue in the low spots in the tank is mopped up or removed with an air-driven vacuum cleaner after the preliminary purging. Supply fresh filtered air continuously while personnel are working in the tank.

NOTE

Use filtered, dry, compressed air only, otherwise impurities will be deposited in the tank and will prevent satisfactory adhesion of the sealant.

Rivet Size	Hole Diameter	Pre-drill No.	Finish Drill No.
1/8	.1285 +.003 -.000	32	30
5/32	.160 +.003 -.000	26	21
3/16	.191 +.003 -.000	16	11
1/4	.254 +.003 -.000	D	F

Figure 15-2 Table of Drill Sizes

(g) If only one section of the tank is to be repaired, plug the interconnecting tube. This will prevent the fumes in the unpurged section from entering the purged section. Place a flat or a streamer on the plug as a reminder to remove the plug before closing the tank.

(h) Station a man outside the tank to be responsible for the safety of the man working inside.

(j) Wear an air-fed respirator at all times.

(k) Use clean cotton cloths and wear proper explosion-proof clothing, free from exposed steel buttons or belt buckles.

(m) Remove all loose items from pockets, especially the breast pocket, before entering the tank.

(n) For further safety precautions, refer to EO 00-25-7

SEALING, BOLTING, RIVETTING - INTEGRAL FUEL TANKS

Drilling Holes

26 When drilling holes through more than one thickness of metal, fasten the parts securely together throughout all drilling operations. When drilling skins, ensure correct alignment and tolerances of holes. The axis of each hole must be held as nearly as possible at right angles to the surface of the skin. For temporary holding, use Cherry Tack Rivets, or Cleco Fasteners.

27 Use a drill jig for drilling holes, wherever possible. Make finished hole sizes for plain (not sleeved, or jacketed) rivets as in Paragraph 28, following. For sleeved or jacketed rivets use the following finished hole sizes:

Rivet Size	Hole Diameter
5/32	.169 (+.003, -.000)
3/16	.201 (+.003, -.000)

28 Unless a bushing is used for drilling, predrill all holes with a drill of suitable size and clean all holes with a short fluted drill so that the finished hole sizes will be as in Figure 15-2. When a bushing is used and the original hole

drilled is to be a finished size hole, use a fast spiral drill.

29 When authorized by engineering authority to use 7/32 inch or 9/32 inch oversize rivets for salvage or rework, use the following holes sizes:

Rivet Size	Hole Diameter
7/32	.222 (+.003, -.000)
9/32	.285 (+.003, -.000)

30 Use only sharp drills so that burring is minimized. If a countersink is used for burring, use a 110° countersink and do not countersink any deeper than is absolutely necessary to remove the burr.

Countersinking

31 For countersinking procedure, refer to Part 5, preceding.

Preparation for Assembly

32 Before assembly, prepare the surfaces as follows:

NOTE

Avoid the use of oil-type coolants and lubricants as much as possible. When any lubricant is used in drilling, reaming, countersinking, dimpling or any other operation, thoroughly clean the areas involved with cleaner (Item 13) upon completion of the operation.

(a) Complete all drilling, burring, fitting and reaming operations before applying any sealing compounds.

(b) Metal surfaces under sealing compounds must be absolutely free from solvent or moisture and free from any foreign material such as metal chips, filings, oil or grease at the time the joints are assembled. Clean all metal faying surfaces before application of sealing compounds as follows:

(1) Thoroughly clean all faying surfaces, using a clean cloth wet with ethyl acetate (Item 14). Pour the ethyl acetate onto the cloth and discard the excess wrung from the cloth. After cleaning about six linear feet or about two square feet of surface, wipe the area with a dry, clean cloth before proceeding with additional cleaning.

(2) Clean all surfaces at such stages in the process that there will be no subsequent handling. Should such handling be necessary, however, use only clean gloves or cloths to touch the cleaned surfaces.

(c) Clean the interior of the tank before applying filletting compounds, as follows:

(1) Brush fresh ethyl acetate (Item 14) over the surfaces. Thoroughly scrub all areas that appear oily or dirty with a brush and ethyl acetate. Follow with a brush wash of fresh ethyl acetate. Use a stiff brush, such as a stencil brush, to assist in cleaning around the upset ends or rivets, around castings, angles, etc., and around all surrounding areas.

(2) After cleaning with ethyl acetate, it is advisable to remove any remaining traces of the fluid with a clean, dry cloth. When it is necess-

Bolt	Thread	Torque (Inch-Pounds)	
		Minimum	Maximum
10	32	45	50
1/4	28	80	90
5/16	24	140	155
3/8	24	240	265
7/16	20	500	550
1/2	20	660	725
9/16	18	960	1060
5/8	18	1400	1540
1/4 (Access cover plates)			60

These torques apply to tension bolts only.

These torques will be used in integral fuel tanks in the absence of specified instructions from Engineering Orders for torques values in particular locations.

Figure 15-3 Table of Installation Torques ary to speed evaporation of the ethyl acetate from crevices which cannot be reached with a cloth, air blown by fans into the crevices may be used. If compressed air is used, it must be filtered to remove any oil or water. A water-trap should not be used for this filtering.

Bolting

33 When installing bolts, either permanent or temporary, use calibrated torque wrenches. Whenever possible, insert all bolts passing through tank boundaries from the in-tank side of the boundary. Coat final bolts and drive pins on the shanks with compound (Item 2) before insertion. Clean heads of bolts before coating and installing.

34 When bolts are specified in an assembly and no sealing material is to be used between the faying surfaces, insert final installation bolts and torque them to the values given in Figure 15-3.

35 When bolts are specified in an assembly and a sealant is to be used between the faying surfaces, install as follows:

(a) Install permanent or temporary bolts in all holes in light attachments and in every other hole in castings and heavy fittings. Starting from the centre bolt and working outward, tighten every bolt to the torque values shown in Figure 15-3.

(b) Torque inspection of bolts must be made within 2-1/2 hours after application of sealant.

(c) After any temporary bolts have been torqued as above, remove the centre bolt and replace with a final bolt. Tighten this bolt to the installation torque value. Repeat this procedure on all surrounding bolts until all final bolts are in place.

36 When gaskets are used between faying surfaces, proceed as follows:

(a) Do not use temporary bolts. Insert final installation bolts to the installation torque values.

(b) Fifteen minutes after the installation of the last bolt in the installation involved, check and retighten.

(c) Complete all final torque inspections for a given area before fillets of sealant are applied to the area.

37 Where sealant (Item 2) is used between faying surfaces, pull members together and torque bolts within 2-1/2 hours after the sealant has been applied. Set up card items for all faying surface applications. There will be an item for the time when sealant is applied and another for the time that assembly is accomplished.

Rivetting

38 Where sealing material is used between rivetted faying surfaces and drawing the rivet before upsetting is not sufficient to give metal-to-metal contact, draw up with temporary bolts.

39 When bolts and rivets are specified for the same part and sealing material is used between faying surfaces, completely install final installation bolts whenever possible before any rivetting is done. After the rivetting has been completed, recheck and, if necessary, retighten all bolts to the installation torque. If no sealing material is used between faying surfaces bolts may be installed after rivets are upset.

40 Keep rivet sets, bucking bars and draw sets clean. A roughened bar set may be used to buck rivets if sealing compound is causing clinched rivets. Use a pressure pad set wherever possible.

41 Install parts on assemblies with Cherry Tack Rivets or permanent rivets at no greater than six inch intervals to prevent any shifting during rivetting, since shifting of parts causes misalignment and undesirable displacement of sealing material (if used) from between faying surfaces during rivetting. Use only rivets, either temporary or permanent, as fasteners in holes that have been drilled to final size. Spot rivet the assemblies securely in place at approximately six inch intervals. On spars, alternate rivets from inside to outside rows. Draw and buck each rivet before proceeding to the next. All hand driven rivets must be drawn with standard draw sets before bucking.

42 When rivets are installed by squeezing, use pressure feet, employing the maximum pressure that can be used without distortion, quilting or marring of members being rivetted.

43 Perform final trimming of flush rivet heads. (Refer to Part 5, preceding.)

Orientation of Rivets

44 Orient rivets in tanks as follows: (See Figure 15-4.)

(a) For attachments involving one or more members inside the tank as well as the skin or web, but involving no seams leading to the outside of the tank or no members attached outside the tank, upset the rivet outside the tank. (See Detail A, Figure 15-4.)

(b) For attachments involving one or more members inside and one or more members outside the tank, as well as the skin or web, but involving no seam leading to the outside of the tank, upset the rivet inside the tank. (See Detail B.)

(c) For attachments involving one or more members outside the tank as well as the skin or web, but involving no seam leading to the outside of the tank, upset the rivet inside the tank. (See Detail C.)

(d) For seams leading to the outside of the tank, upset the rivet inside the tank. (See Detail D.)

NOTE

Whenever there is an out-tank attachment involved at any point coinciding with an in-tank attachment such as in Subparagraph (b), all the rivets passing through the tank boundary and through the in-tank attachment must have the upsets on the in-tank side.

(e) In dimpling, use only tooling that is in perfect condition. Check punch and die for damage at least every 15 minutes while machine is in operation by visual inspection with the aid of an inspection mirror.

(f) Use a brazier head rivet set or flat rivet set on round head rivets whenever possible.

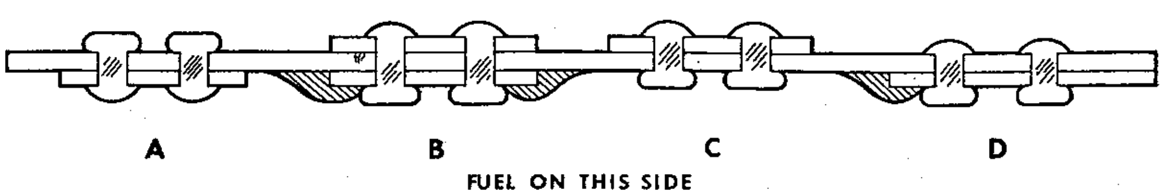
Sealing between Faying Surfaces with Nylon Thread

45 To seal between faying surfaces with nylon thread, proceed as follows:

(a) Carefully check members and see that all drilling, removing of burrs, fitting, reaming and cleaning has been completed before application of thread. Be certain that all burrs are removed from areas where thread is to be applied.

(b) Apply a uniformly thin layer of rubber cement (Item 15), that has been thinned with an equal amount of methyl ethyl ketone (Item 6), to one of the faying surfaces. This layer of rubber cement must not be over .001 inch thick. Allow to dry for one to two minutes.

(c) Using special applicator, lay nylon thread (Item 16) along inside and outside of rivet pattern and between each row of rivets. Plan thread pattern so as to lay the thread continuously and avoid splicing of the thread as much as possible. Keep thread at least 1/64 inch away from rivet holes, but do not allow it to lie over 3/16 inch away from the holes.



FILLETING REQUIRED FOR VARIOUS JOINTS. SHADED PORTION OF RIVET SHANK SHOWS AREA OF MAXIMUM SHANK SWELLING UNDER UPSET.

13-15-3

Figure 15-4 Rivetted Joint Filletting

(d) After thread (Item 16) has been applied, handle and assemble parts carefully to avoid dislocating the thread.

Filletting with Sealant

46 To fillet with sealant proceed as follows:

(a) Apply all sealant (Item 2) by means of the applicator gun. (Refer to Paragraph 54, following.) Pack designated cracks, crevices and joggles solidly with sealant (Item 2) at that stage of assembly during which the work can best be accomplished. These applications must be approved by engineering authority before being covered.

(b) Apply a 3/16 to 1/4 inch wide base fillet of sealant (Item 2) to all seams, stiffeners, doublers, castings and fittings in the tank.

(c) The base fillet must be approved by engineering authority before further filletting is done.

(d) Build the base fillets up, wherever possible, to a width of at least 1/2 inch. In all cases, carry the fillet up and over the edges of doublers, stiffeners and similar attachments.

(e) Filletting and the cleaning of tanks must be completed before tanks are filled and drained.

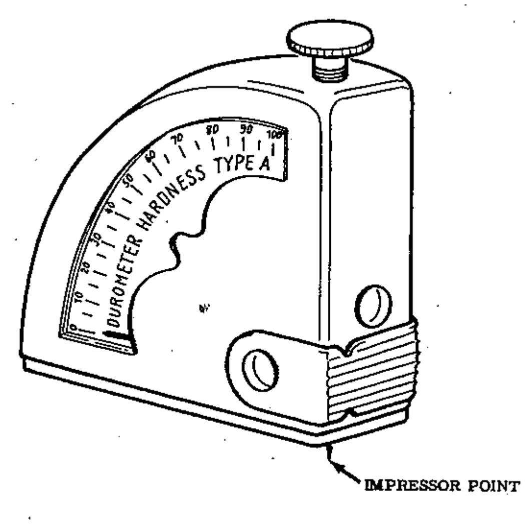


Figure 15-5 Shore Durometer

Filling and Draining

47 To fill and drain tanks proceed as follows:

(a) Dry tanks by circulating 120° F air through them for 30 minutes. Allow tanks to return to room temperature before proceeding

(b) Fill tank approximately 75% full of Sealant (Item 5)

(c) Rotate tank through 360° at a rate of 30° per minute.

(d) Apply and maintain two psi of air pressure on the sealant while rotating the tank 360° in the opposite direction to the first rotation.

(e) Remove pressure and again rotate the tank 360° in the same direction as the first rotation.

(f) Drain sealant from the tank.

(g) Allow tank to complete draining in normal flight position, at room temperature, for two hours. Carefully check for any tendency toward collection of puddles of sealant at the end of first hour and again at the end of the second hour. Check drain holes every 10 minutes to see that they are kept open. If any puddles are found at these inspections, remove them by mopping with a cloth or by brushing excess material to the drain.

(h) Allow tank to stand for one additional hour and then check for any puddling.

(j) Introduce 110° F air through inboard door and attach air mover to filler neck to circulate the air through the tank for three hours or until the material has lost all tackiness.

Testing after Completion of Sealing

48 After completion of filletting with sealant (Item 2), filling and draining with sealant (Item 5), installation of access doors, liquidometers, booster pump, drain valves etc., test tank. (Refer to Paragraph 54, following.)

Shore Durometer

49 The Shore Durometer is used to measure the hardness of rubber and similar materials. The impressor point is pressed into the material being tested, and the hardness is read on the scale, (see Figure 15-5). The hardness numbers are arbitrary, with no relation to any other scale of hardness numbers.

Miscellaneous Instructions

50 The following miscellaneous instructions should be followed, where applicable:

(a) Install all hard-type gaskets (Johns-Manville No.76 and similar) with sealer (Item 2) on the faying surfaces.

(b) For sealing tooling holes and similar holes in the tank, install rivets oriented according to Figure 15-4.

(c) No repair of any kind is to be performed in a tank after it has been sealed, except with engineering authority.

(d) When retorquing 10-32 screws, it is advisable to back the screw off approximately 1/8 turn before tightening.

(e) Personnel using cleaning solvents and sealing compounds must conform to safety precautions detailed in EO 00-25-7 and EO 00-25-24.

(f) Do not peen or centre punch rivets to stop air test leaks.

(g) Do not pressure test or fill and drain tanks until the sealant is completely cured. Cured sealant (Item 2) should have a minimum Shore Durometer hardness of 40 - 45, (see Figure 15-5).

(h) Sealant (Item 2) has a working life of about 2-1/2 hours. Sealant must be discarded when it becomes too stiff to work readily. The mixed sealant may be stored on dry ice for 3 days or at +10° F for 24 hours after mixing before it is used. It is recommended that the material be mixed, as required to the manufacturers specifications.

(j) Maintain the accelerator (Item 19) at the consistency of a heavy syrup. If it dries out excessively, restore consistency by the addition of Toluol (Item 18) and stirring.

(k) Mix the sealant (Item 2) and accelerator (Item 19) thoroughly and completely to obtain an even and complete cure of the sealant.

(m) Because ethyl acetate (Item 14) dries very rapidly, wipe only a small area of surface with solvent at a time. Wipe area immediately with a clean, dry cloth before the solvent dries and before applying solvent to another area. Change both solvent and dry cloths frequently, or residues will merely be transferred from one portion of the tank to another. Cured sealer (Item 2) may be wiped once only with a cloth dampened with ethyl acetate. Excessive use of ethyl acetate on sealant, however, will spoil the adhesion of the sealant to the metal.

(n) Before installing flush rivets, install several rivets in scrap material of the same thicknesses as the parts to be rivetted and trim the ends flush. By this method rivetting machine settings can be checked so that the countersinks are filled after the rivets are trimmed off.

(p) Sealant (Item 5) may be thinned by adding methyl ethyl ketone (Item 6) in the amount recommended by the workshop laboratory.

REPAIR OF EC-801 SEALANT LEAKS IN INTEGRAL FUEL TANKS

Determination of Source of Leak

51 Sources of leaks may be determined as follows:

(a) Cover a small area around the suspected leak on the outside of the tank with bubble solution (Item 4).

(b) Apply the plain open end of the filtered compressed air line to the inside of the tank, pressing it against the sealant in the area of the suspected leak. Open the air pressure up to a maximum of 100 psi and move the open end of the air line until a positive indication is given on the bubble solution outside the tank.

(c) Mark the position determined on the inside of the tank as accurately as possible.

(d) Remove bubble solution thoroughly by wiping with a clean dry cloth.

Stripping Sealants with Stripper

52 Sealants may be stripped as follows:

(a) If the sealant (Item 2) has a cover coating (Item 5), remove the latter around the repair area by scrubbing with a clean cloth dampened with butyl acetate (Item 3). Apply the cloth to only a small area at a time and wipe off with a clean dry cloth before the butyl acetate (Item 3) dries. Change cloths frequently.

NOTE

In reworking to correct leakage, existing sealant should not be removed nor fresh sealant applied until the source of the leak has been definitely determined. Reworking of sealant to repair leakage should be performed only by authorized personnel.

CAUTION

Rubber gloves must be worn at all times, and a heavy pair is mandatory when using stripper (Item 17). Keep stripper in an air-tight container and store in a cool dry place when not in use.

(b) Cut away as much of the sealant (Item 2) as possible locally around the repair area, using a sharp micarta scraper, (see Figure 15-6). Sealant remover tools may be used in a slow hitting rivet gun or corner hammer to facilitate initial removal of the sealant. Do not use a tool made of metal. Take care not to scratch the surrounding metal surfaces.

(c) Mask off the area surrounding the scraped sealant with fabric-backed masking tape. Similarly mask any other areas where the ensuing application of stripper may splash or drip.

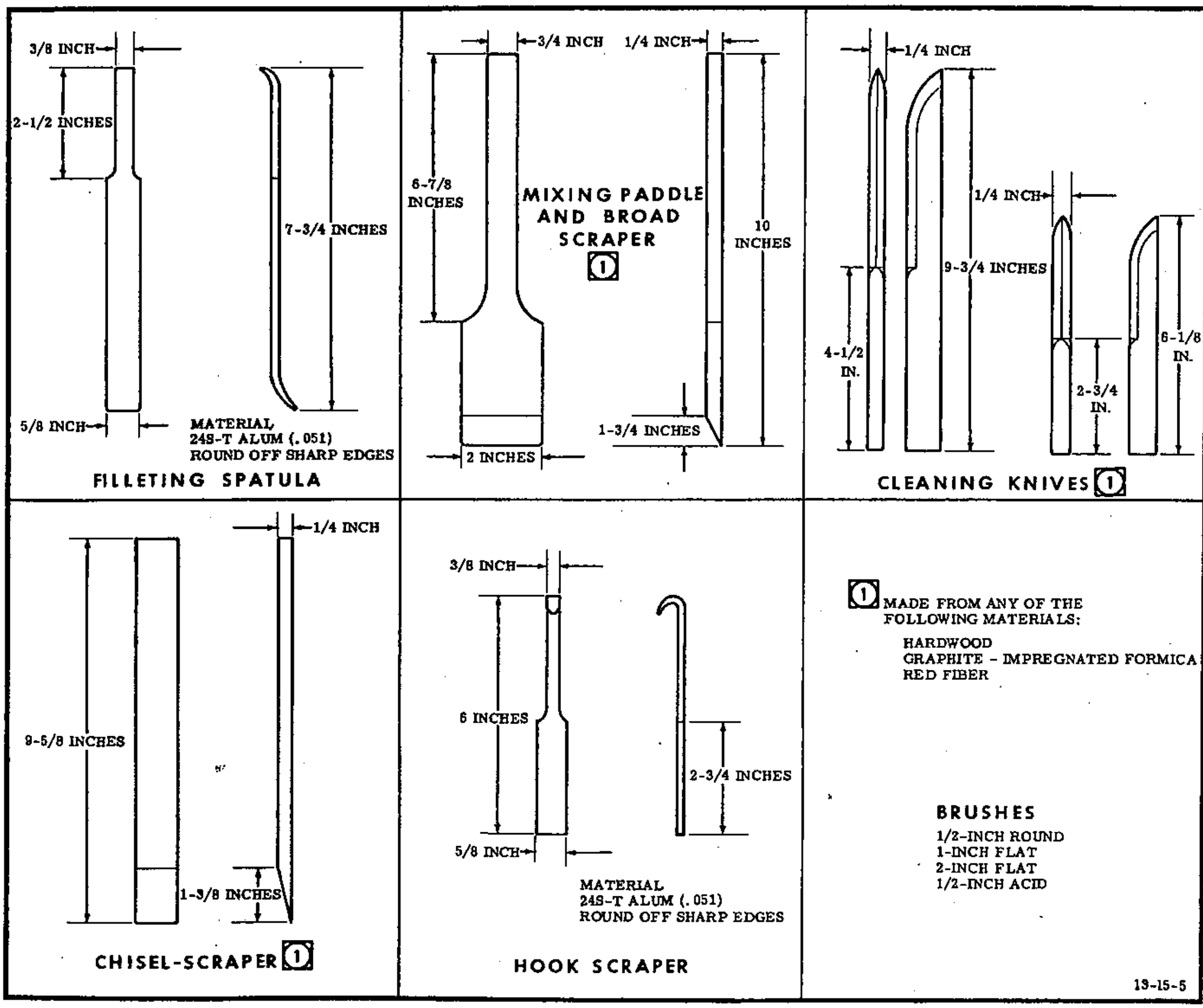


Figure 15-6 Recommended Hand Tools

(d) Apply stripper (Item 17) to the scraped sealant as heavily as possible without running or dripping. A micarta scraper pushed under the sealant will accelerate the action of the stripper. Wipe off immediately any stripper which falls accidentally on unmasked surrounding areas using a clean, dry cloth, and mark its position for cleaning later. Refer to Paragraph 53, following. For an alternative method of applying stripper, refer to Paragraph 59, following.

(e) At 10 minute intervals, remove the stripper and any loosened sealant with a micarta scraper, and apply a fresh quantity of stripper. Do not allow the stripper to dry on the solvent at any time. Repeat this cycle of operations until all the sealant has been removed. If there is any finish such as primer or lacquer under the sealant, continue stripping to bare metal.

(f) Remove all masking tape.

(g) Roughen all surfaces of the original sealant adjacent to the stripped area over at least 1 inch of their length, using a micarta scraper or clean hardwood stick. Take care not to scratch the surrounding metal surfaces.

(h) If there are structural or other repairs besides the sealant repairs to be made, incorporate them at this juncture.

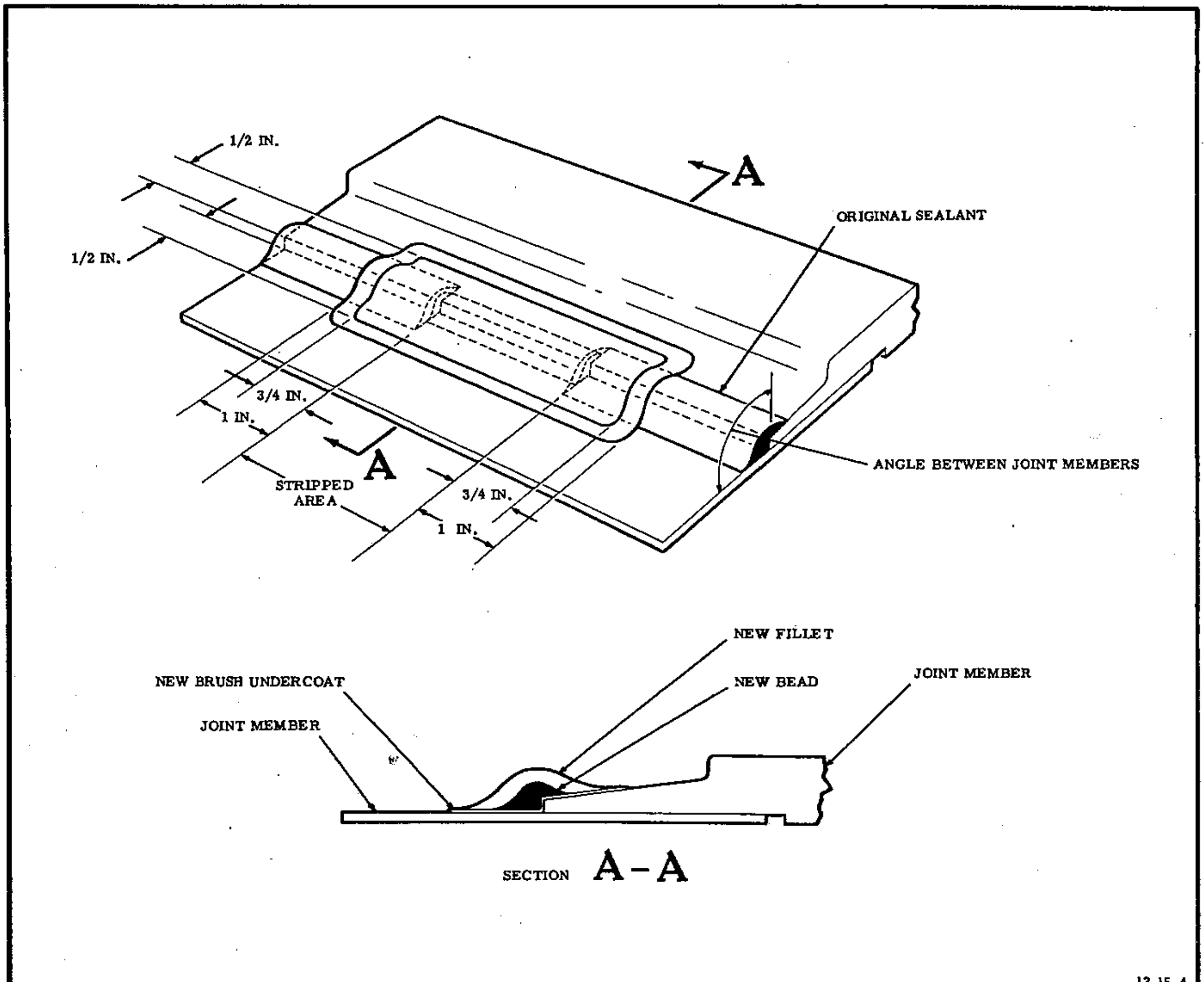


Figure 15-7 Typical Resealing Procedure

Cleaning Prior to Resealing

53 Prior to resealing, clean areas as follows:

(a) Remove all dirt and foreign matter, which may have accumulated during stripping operations and other structural repairs.

(b) Scrub the stripped area and surroundings with a clean cloth dampened with methylene chloride (Item 10). Apply the cloth to only a small area at a time and change the cloth frequently. Make sure that all wax residue from the stripper (Item 17) is removed completely, including any surfaces from which splashes or drips have been wiped.

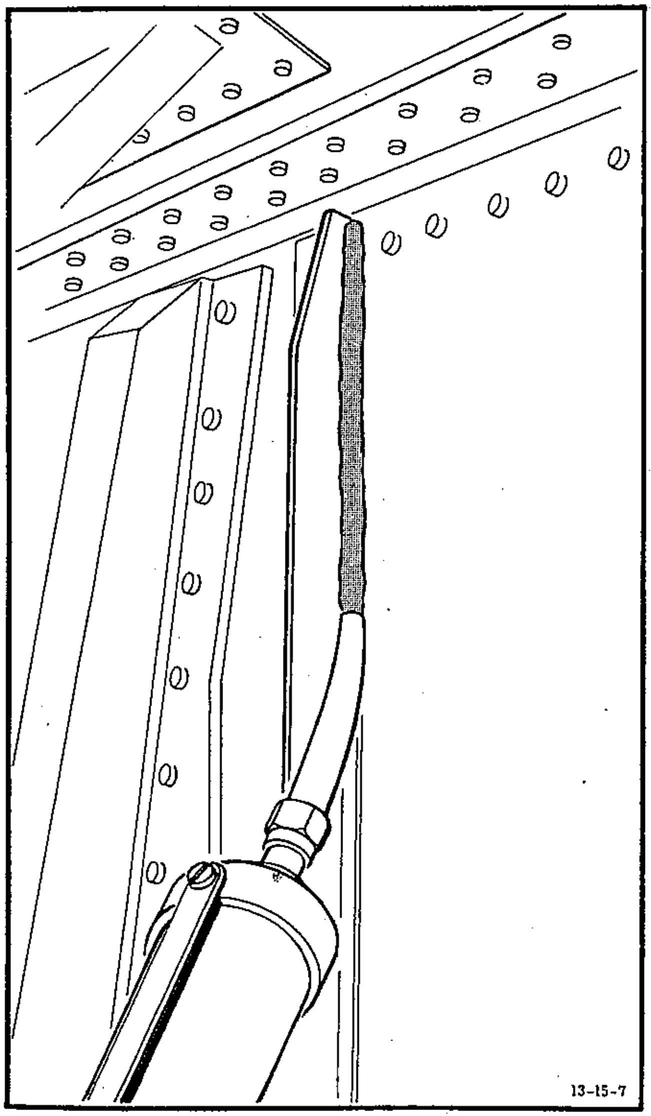


Figure 15-8
Applying Sealant Using Filletting Gun

(c) Wipe down the stripped area and surroundings thoroughly with a clean cloth dampened with butyl acetate (Item 3). Apply the cloth to only a small area at a time and wipe off again with a clean dry cloth before the butyl acetate dries. Change both cloths frequently.

(d) Apply similar treatments to any new repairs incorporated.

(e) Wipe down the whole area with a clean, dry cloth.

Sealant Application

54 Application of sealant is performed as follows: (See Figure 15-7.)

(a) Apply a heavy brush coat of the sealant (Item 2) to the stripped and roughened repair area and its surroundings as shown. Overlap the coating at least 1 inch onto the original sealant. Cure the coating for 30 minutes with infra-red heat lamps at a temperature not exceeding 160° F. The temperature may be regulated by adjusting the distance between the coating and the heat lamps.

(b) Apply a 1/4 inch bead of the sealant (Item 2) to fill the angle between the joint members in the stripped repair area. Apply the bead with an applicator gun, (see Figure 15-8), to not more than two feet of repair area at a time. Work the sealant into the angle with a spatula to exclude all entrapped air and to form a solid packing.

(c) Inspect the bead for blisters, bubbles and cracks. Remove sufficient sealant (Item 2) in such areas to enable the ensuing sealant fillet to flow in and fill pockets thus formed.

(d) Apply a fillet of the sealant (Item 2) directly onto the bead and its surroundings, completely covering the area, as shown. Apply the fillet with an applicator gun and work it into all designated bubbles, blisters and cracks with a spatula to exclude all entrapped air and to form a solid packing. The fillet should cover a width of 1/2 inch on either side of the repair. Joint should overlap at least 3/4 inch onto the original sealant, and should blend smoothly over all changes in section, such as joggles, in the repair area. Cure the bead and fillet at this juncture for 1-1/2 to 2 hours with infra-red heat lamps at a temperature not exceeding

160° F. When cured, the sealant should be tack-free, and should show a Shore Durometer hardness of 40 to 45.

(e) Where a finish such as primer or lacquer, has been removed during stripping, touch up the area around the new sealant with the same finish as was used originally.

Pressure Testing

55 After application of the sealant (Item 2) pressure test integral fuel tanks as follows:

(a) Close all openings, except air pressure inlet, by means of tight-fitting plugs. Use rubber plugs if opening has no threads, threaded plugs if opening is threaded. Use pressure test doors to close access door opening and similar openings which are too large for plugs.

(b) Attach pressure gauge or manometer to tank or to line between tank and pressure regulating valve.

(c) Attach safety valve between pressure gauge and tank, or directly to the tank.

(d) Prepare bubble fluid by diluting one part fluid (Item 4) to ten parts water.

(e) Apply air pressure to tank interior.

(f) Maintain pressure for five minutes before testing for leakage. Apply bubble solution over all seams, rivet heads and bolts in tank area.

(g) Observe and mark leaks.

Testing after Filletting and Slushing

56 After filletting and slushing, test the tank as follows:

(a) Install tank doors, liquidometers, booster pump, drain valves, etc.

(b) Blank off all openings with suitable plugs.

(c) Apply and maintain test pressure for five minutes.

(d) Apply bubble solution (Item 4) around access doors, liquidometer and fuel pump mounting flanges.

(e) Observe leaks and repair.

CAUTION

Since mercury is very harmful to aluminum, the use of a calibrated pressure gauge is recommended instead of the mercury manometer. The proper function of the relief valve is important. Excessive pressure may cause serious damage to structure and injury to personnel.

Reapplying Coating to Integral Fuel Tanks

57 After pressure testing, apply coating (Item 5) to repair areas, in integral fuel tanks only, as follows:

(a) Apply a heavy brush coat of the coating (Item 5) to the new sealant, completely covering the repair area and the adjacent original sealant.

(b) Cure the overcoat for 30 minutes with infra-red heat lamps at a temperature not exceeding 160° F. When cured, the overcoat should be tack-free.

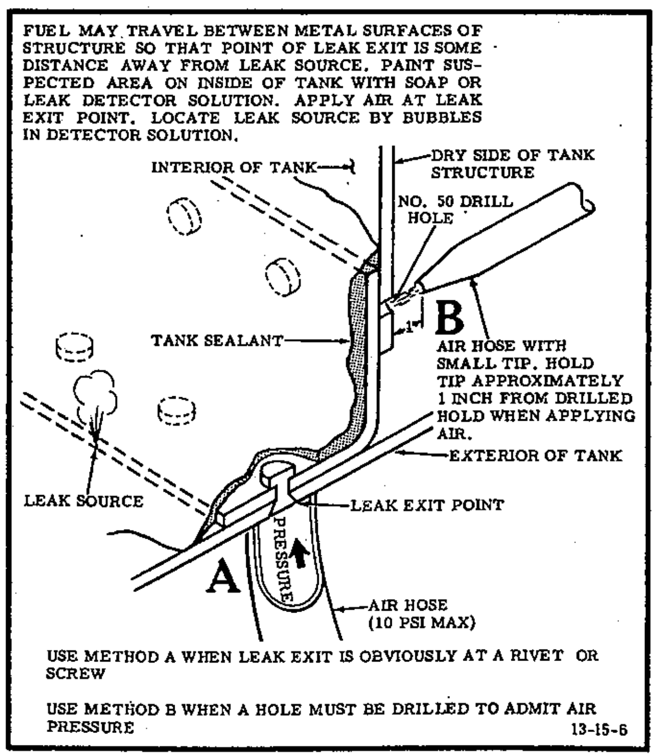


Figure 15-9
Leak Detection Using Air Blowback Method

Repair of Leaks when Source Cannot be Detected

58 When it is not possible to detect the source of leak by the method set out in Paragraph 51, preceding, the following method may be used:

(a) Drill a No.40 (.098) hole through the outside thickness of metal at the point of leak. A round-nosed drill should be used so as not to damage the underlying material. The hole should be drilled equidistant to adjacent rivets and at a minimum of 3/16 inch from the skin edge.

(b) Inject, by means of a pressure gun, sealant (Item 2) into the hole so that the faying surfaces are locally covered. Care should be taken not to inject too much sealant as bulging of the skin may occur. The injection should not be done too rapidly, otherwise the sealant may not spread.

(c) Where it is possible, the injection hole should be plugged by means of a 3/32 inch diameter rivet. Where this cannot be done, the hole may be filled with excess sealant (Item 2).

(d) More than four such repairs in one rib bay should not be made without specific approval from engineering authority.

Miscellaneous Instructions

59 The following miscellaneous instructions should be followed, where applicable:

(a) When the time available for stripping operations permits, the amount of hand labour involved may be reduced by applying stripper (Item 17) to the scraped sealant (Item 2) and covering the area with cellophane, attaching it around the edges with masking tape or equivalent and allow to stand for approximately 12 hours. The sealant will be stripped during this period, and the procedure set out in Paragraph 52(e) preceding will be obviated. Cellophane helps to prevent the drying out of the stripper.

(b) Where integral fuel tanks have never been filled with fuel, such as prior to going

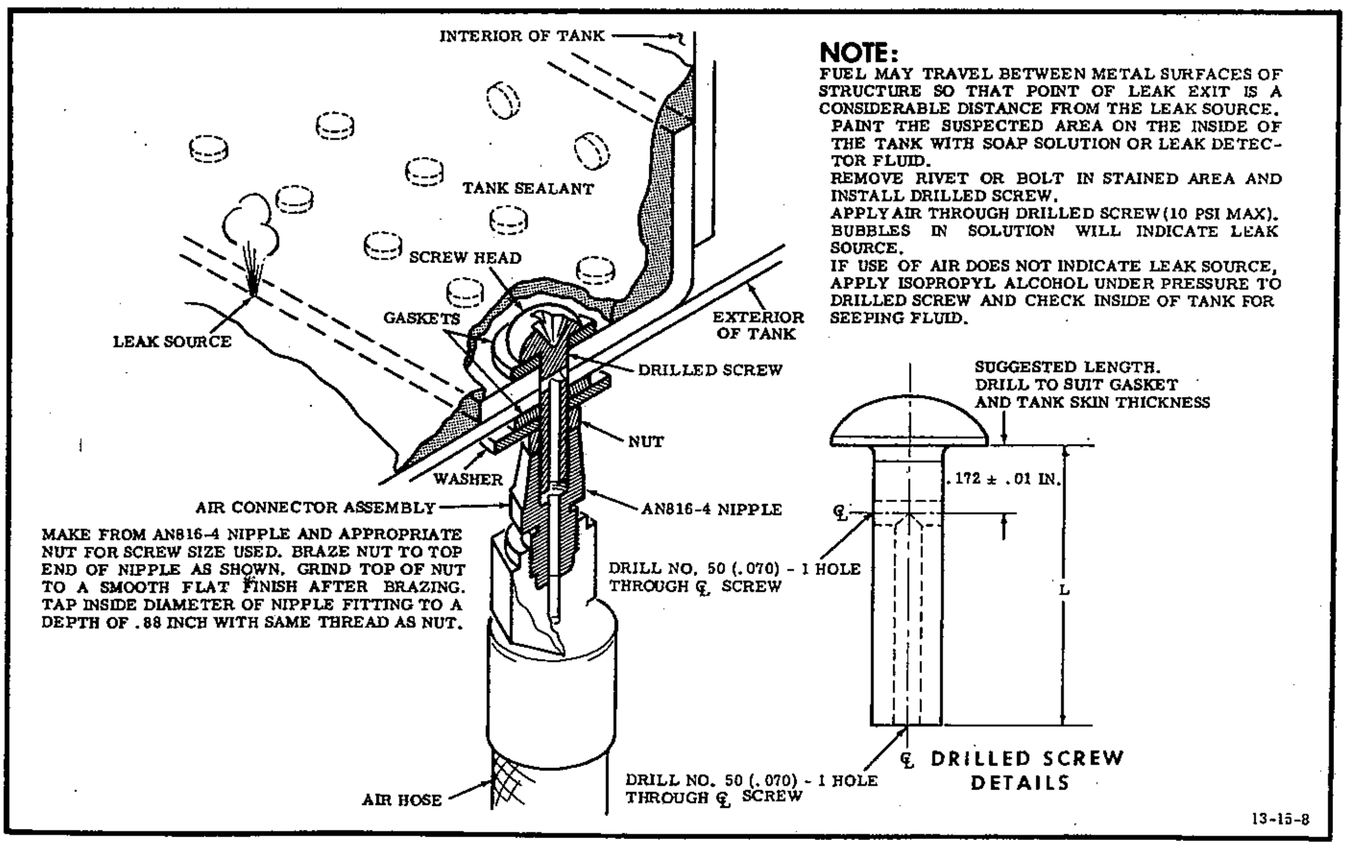


Figure 15-10 Leak Detection Using Drilled Screw Method

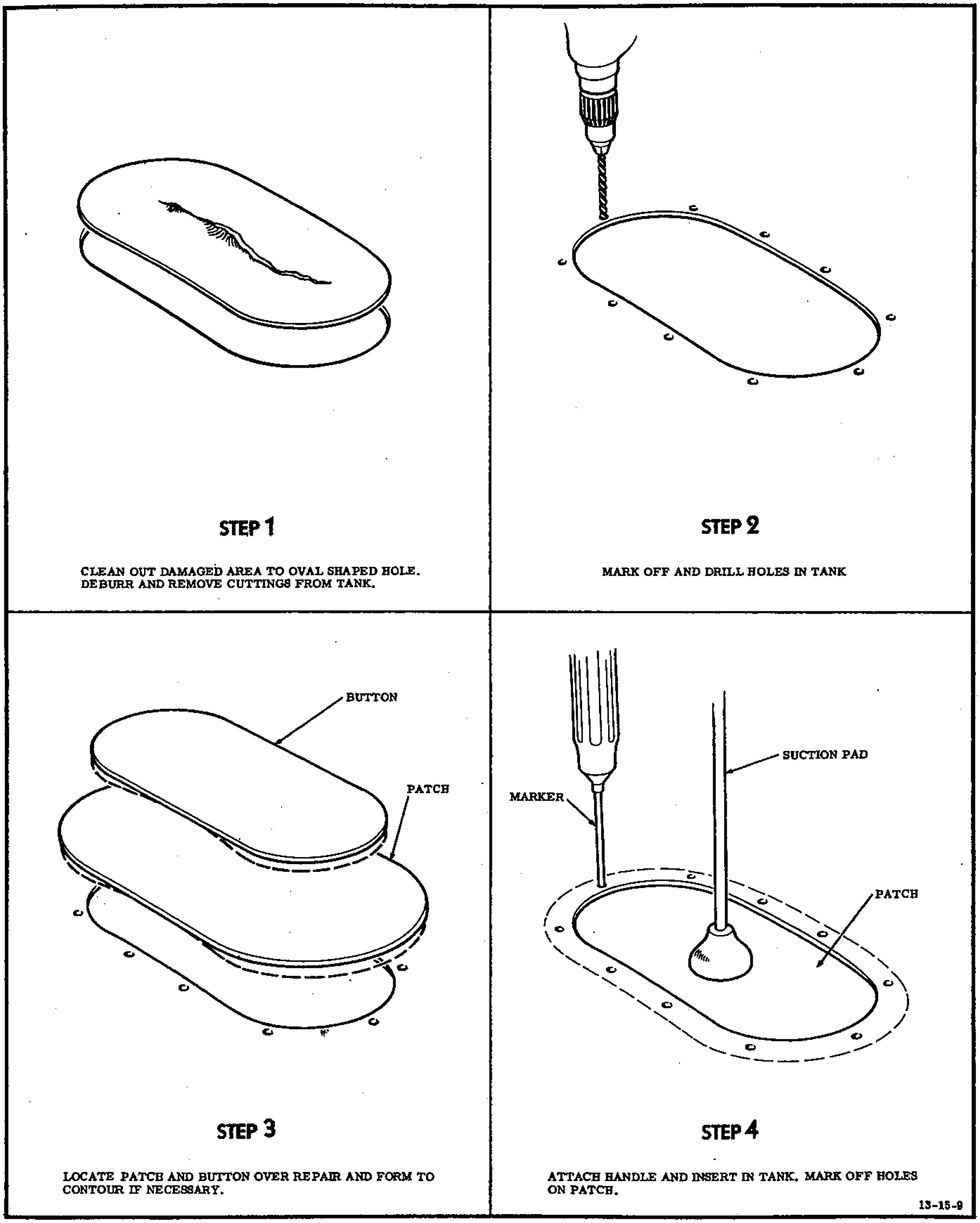


Figure 15-11 (Sheet 1 of 2) Making Flush Repair Patch, Reverse Side Inaccessible

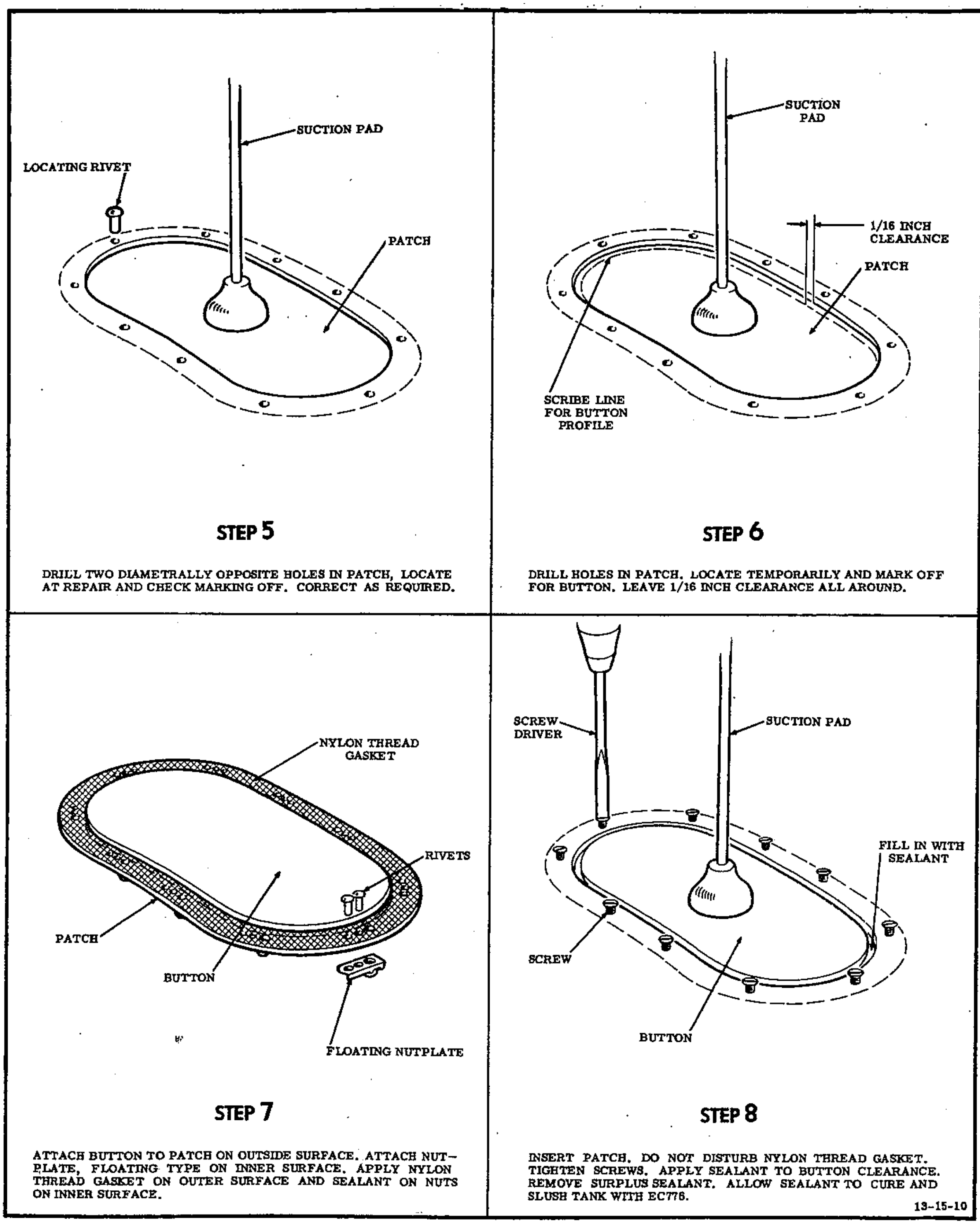


Figure 15-11 (Sheet 2 of 2) Making Flush Repair Patch, Reverse Side Inaccessible

Item No.	Material	RCAF Ref	Specification	Manufacturer
1	Sealant, PR 7001K		MIL-S-7502 Class B Type 2	Products Research, Los Angeles.
2	Sealant, EC801, with Accelerator	33G/43	MIL-S-7502 Class A Type 2	Minnesota Mining & Mfr., Co., London, Ontario.
3	Butyl Acetate			Technical Grade
4	Soap, Bubble (Dilute 1 to 10)	33C/NIC		B. W. Deane & Co. Ltd., 3620 Namur St., Montreal.
5	Cover Coating, Buna N Phenolic EC776	33G/38	MIL-S-4383A	Minnesota Mining & Mfr., Co., London, Ontario.
6	Methyl Ethyl Ketone	33C/520	TT-M-261	Shell Chemical Co., 380 Madison Ave., New York 17.
7	Sealer, NT Blend G			Armour Laboratories, 520 N. Michigan Ave., Chicago.
8	Alcohol, Denatured	34A/216	3-GP-530	
9	Stripper, Turco Paint L-800	33A/456	1-GP-78	B.W. Deane & Co. Ltd., 3620 Namur St., Montreal.
10	Methylene Chloride	33C/583	MIL-M-6998	
11	Alcohol, Isopropyl	34A/214	3-GP-525	
12	Lacquer, Aluminized	33A/424	AN-L-29	
13	Cleaner	33C/182	3-GP-8	
14	Ethyl Acetate	33C/294	C31-302	
15	Cement, 6136			U.S.Rubber Co., 48th St. & 6th Ave., New York.
16	Thread, Nylon, .015 dia.	32B/384		E.I.Dupont de Nemours & Co., Wilmington, Delaware.
17	Stripper	33C/584	LAR 388	
18	Toluol	33A/467	TT-T-548	
19	Accelerator, EC807			Minnesota Mining & Mfr., Co., London, Ontario.

Figure 15-12 Table of Material Specifications

into service, the application of the brush coat of sealant (Item 2) may be omitted when resealing.

(c) Where an applicator gun is not available, a spatula may be used to apply the bead and fillet of sealant.

(d) In an emergency, this bead and fillet of sealant may be applied in one operation. Work the sealant in with a spatula as before and the dimensions of the final fillet should be maintained as set out in Paragraph 54(d) preceding.

(e) In an emergency, integral fuel tanks may be put into service after pressure testing without the application of the coating (Item 5), as set out in Paragraph 57 preceding. However, this overcoat must be applied as soon as the schedule permits.

Fluid Blowback Method of Finding Leaks

60 This procedure is comparable to the method described in Paragraph 51, preceding. Isopropyl alcohol (Item 11) is applied (10 psi maximum) at the rivet or other leak exit point. A pressure pot, regulating valve and gauge arrangements may be used to apply the alcohol. In using this method, it is unnecessary to use leak detector fluid or soap suds (Item 3) inside the tank, as the leak source is identified when the alcohol emerges inside the tank. (See Figure 15-9.)

Other Leak Detection Methods

61 For particularly difficult leaks the drilled screw method, (see Figure 15-10), and the air blowback method, (see Figure 15-9), are very effective.

TANK REPAIRS

General

62 The following tank repairs are intended as a guide. Obtain the approval of engineering authority for specific repairs. Repairs to tanks that are pressurized or subject to structural loads, as in the case of integral tanks, must be governed by all the restrictions affecting a structural part of the aircraft, in addition to being fluid-tight. If the tank has been damaged in a flat or moderately curved section, it may be repaired using a soldered, silver brazed, welded, rivetted, or machine screw patch, as applicable.

NOTE

In any tank repairs, the provisions of EO 00-25-7 must be adhered to. All patches and doublers must be of the same material as the tank, and of the same or one gauge heavier material.

63 Clean the damaged area and inspect thoroughly. If the skin is broken, or if it has sustained a dent or scratch sufficiently sharp or deep to require a patch, clean out the damaged area to the smallest round or oval hole. If a doubler is to be used in a tank without access, an oval hole is required.

Dents

64 Dents can frequently be removed by tapping from inside the tank, by pulling on a piece of soldered-on wire by air pressure or a combination of these. Do not use air pressure unless the proof pressure of the tank is known. Do not exceed. Acceptability limits of sharp corners in dents, scratches and score marks must be assessed individually. As a general rule, scratches and similar defects not deeper than 10% of the skin thickness need only be blended out (not burnished), and given appropriate anti-corrosion treatment. Scratches deeper than this should be filled with silver solder if the tank material is suitable. If the local area appears to have been weakened, it should be brought up to strength with an overlay patch or an inserted doubler.

65 Soldering is permitted on terneplate, brass, copper and stainless steel. In cases of cracked skin, drill a stop hole (3/32 inch) at each end of the crack and seal the crack with solder. For soldering methods, refer to Part 20, following. If a break in the skin can be cleaned up to a hole less than two inches in diameter, cut a patch to shape and solder flush. If the tank is pressurized or the cleaned up hole larger than two inches, proceed as follows:

(a) Stainless steel: Weld in a patch.

(b) Brass or copper: Install a doubler with silver solder.

NOTE

Before silver soldering on brass, clean away all traces of soft solder for a distance of at least 3 inches in order to prevent the possibility of an embrittling attack on the brass.

(c) Terneplate: Install a doubler with rivets or machine screws, then install a plug filler as a soft soldered patch. Use rivets of mild steel, or screws of steel, and solder around the heads.

(d) Aluminum alloy tanks: Weld tanks made of 2S or 52S. Repair holes in tanks of the heat-treatable aluminum alloys with doublers and patches of the same alloy and heat treatment as the tank. If this data is unknown, use higher strength material. (Refer to Part 25, following.) If there is access for rivet bucking, install a rivetted patch, (refer to Paragraph 66, following). For rivet selections and spacing, refer to Part 5, preceding. If access is not available, use a machine screw patch, (refer to Paragraph 66, following).

Rivetted or Machine Screw Patch

66 The rivetted or machine screw patch must be large enough to overlap on all sides at least 5/8 inch. To install the patch, proceed as follows:

(a) Mark off and drill the tank for rivets or screws. Insert patch through oval-shaped opening or other access, centre patch over repair and mark location of drilled holes on patch. Drill two diametrically opposite holes, relocate and check marking. Drill holes in patch. Use patch as template for nylon thread (Item 16) gasket. Apply between faying surfaces, (refer to Paragraph 45, preceding).

(b) Re-insert patch over repair and complete repair by rivetting, inserting and bucking rivets from inside tank. Seal patch, (refer to Paragraph 46, preceding).

(c) If repair is inaccessible from inside tank, a screwed patch will be necessary. After drilling holes through patch, rivet Nut-plate, floating, all metal types only, (refer to Part 6, preceding), in position over these holes. Apply appropriate sealant over Nut-plates, apply nylon gasket on other side of patch and re-insert oval-shaped patch. Attach patch to tank and replace original finish. If a flush repair is required, radius dimple or countersink and use countersunk rivets or screws as applicable. (See Figure 15-11.)

NOTE

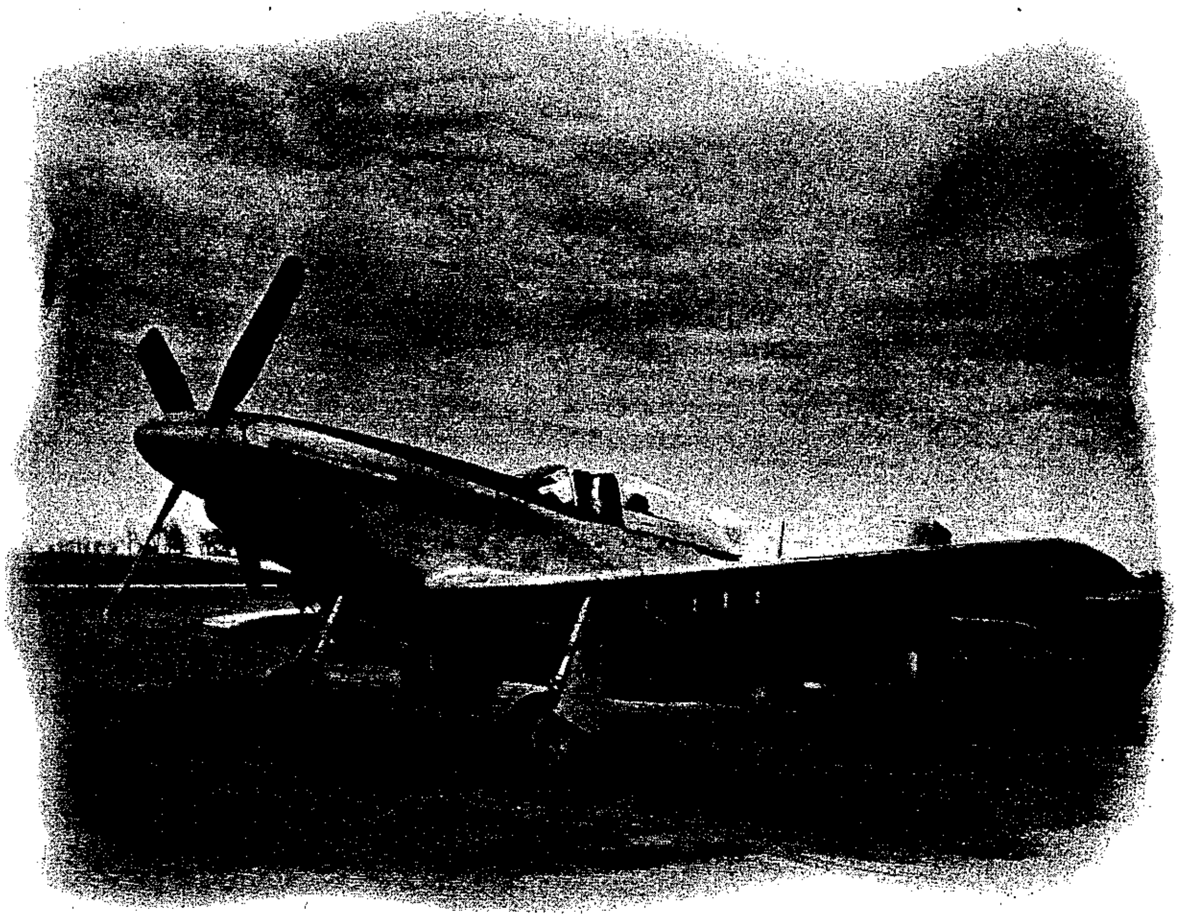
For smoothness, attach a plug filler by soldering, spotwelding or rivetting. If repair area is curved, form curve on patch and plug prior to marking for drilling.

Material Specifications

67 For table showing item numbers, materials, specifications and manufacturers, see Figure 15-12.

PART 16

HEAT EXCHANGE EQUIPMENT REPAIR



PART 16

HEAT EXCHANGE EQUIPMENT REPAIR

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HEAT EXCHANGER EQUIPMENT REPAIR

General

1 Heat exchangers are of three general types; air-to-air, air-to-liquid, and liquid-to-liquid. Repairs to the air to air type of heat exchanger are usually limited to those shown in Figure 16-1.

AIR CONDITIONING HEAT EXCHANGER

General

2 The air conditioning heat exchanger assembly is designed to cool pressurized air from the compressor prior to delivery to the refrigeration unit of the air conditioning system.

Description

3 The heat exchanger usually consists of dimpled aluminum alloy tubes held in position by a support plate and brazed header plate at each end. Side cover plates between the header and support plates form the unit into a rigid assembly. Inlet and outlet ducts are brazed and welded to the header plates.

Operation

4 Hot pressurized air from the turbo-engine compressor or an independent compressor unit is ducted to the heat exchanger assembly, where it passes through the tubes to the heat exchanger outlet. Air coolant from a ram air source passes across the tubes. Heat from the pressurized air is transferred through the walls of the tubes to the flow of ram air coolant. (See Figure 16-1.)

Overhaul

5 Cleanliness and care in handling are of first importance when working on the refrigeration unit. Personnel performing the work must be skilled mechanics, thoroughly familiar with the use of precision tools, gauges and micrometers. Close attention to tolerances and limits must be observed, especially during inspection and reassembly.

6 Disassembly, inspection and reassembly must be accomplished in a clean, dry, dust-free room. Clean all parts thoroughly as soon as disassembled. Oil and wrap steel parts or place under bell jars until inspection and reassembly.

7 Maintenance and overhaul on a typical air-to-air heat exchanger (AiResearch No. 80031) is given here. The following points should be noted.

(a) The work should be undertaken only in emergencies.

(b) The permissible number of damaged tubes is valid for this model only. A comparable number for other designs must be obtained from the manufacturer.

Removal of Turbine from Refrigeration Unit

8 To remove the turbine, proceed as follows:

(a) Remove the attaching bolts and lift the turbine off the heat exchanger. (See Figure 16-2.)

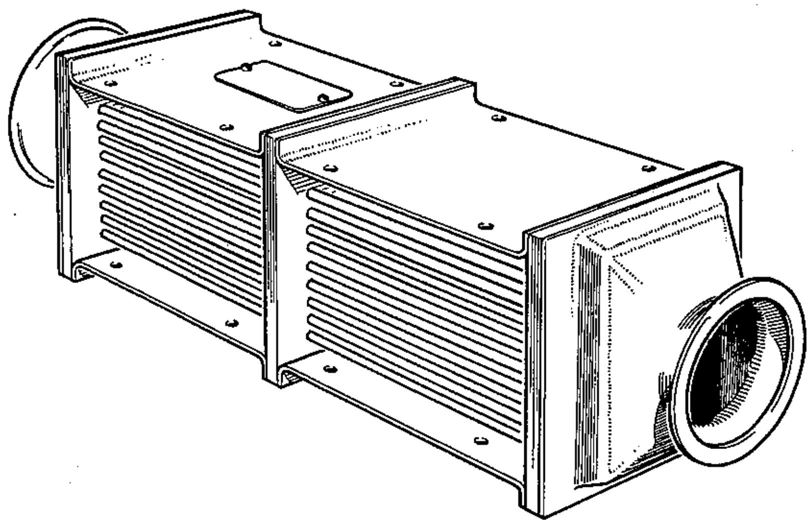
(b) Remove the spacer assemblies (5) and gasket (6) from the turbine assembly.

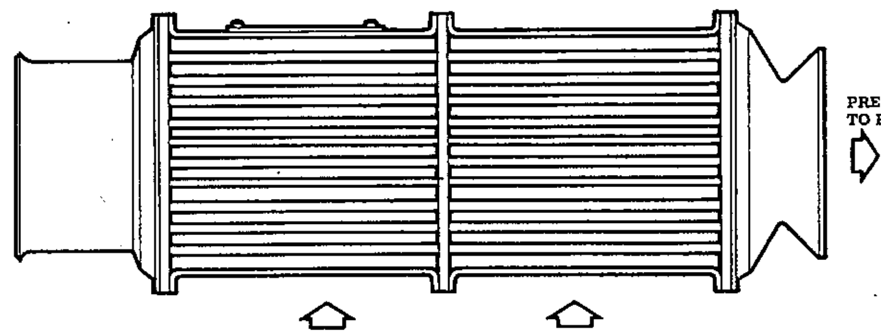
Disassembly of Heat Exchanger

9 Dissassemble the heat exchanger in accordance with the exploded view, (see Figure 16-2), following the numbering sequence.

Cleaning of Heat Exchanger

10 To clean the heat exchanger, proceed as follows:





TROUBLE	PROBABLE CAUSE	REMEDY
Failure to cool cabin air.	Clogged or damaged tubes.	Replace heat exchanger assembly.
Excessive leakage in system traced to heat exchanger.	Broken or damaged tubes.	Replace heat exchanger assembly.
	Loose duct connections.	Tighten duct connections.
Excessive pressure drop in the heat exchanger.	Clogged tubes.	Clean assembly with Stoddard solvent, and dry with compressed air.

Figure 16-1 Primary Heat Exchanger - Ram Air Type

(a) Remove all sealing compound from the heat exchanger flanges with methyl ethyl ketone (Item 9) or a suitable non-corrosive solvent.

WARNING

Use the solvent only under a forced draft hood or in a well-ventilated place. Do not inhale the fumes. Take adequate precautions to prevent igniting the fumes.

(b) Thoroughly clean the heat exchanger externally and internally with solvent (Item 10) or equivalent.

Inspection

11 Test the heat exchanger for leakage. Tube leaks may be detected by checking the heat exchanger in a suitable test bell, which must be approximately the size of the heat exchanger and constructed to withstand 30 psi internal air pressure. The heat exchanger must fit into the bell so that both ends of all tubes are exposed to atmosphere, with the header plates resting on neoprene gaskets. The bell must have a fitting for connection to an air pressure source. Test as follows:

(a) With the heat exchanger installed in the test bell, apply 20 psi air pressure to the out-

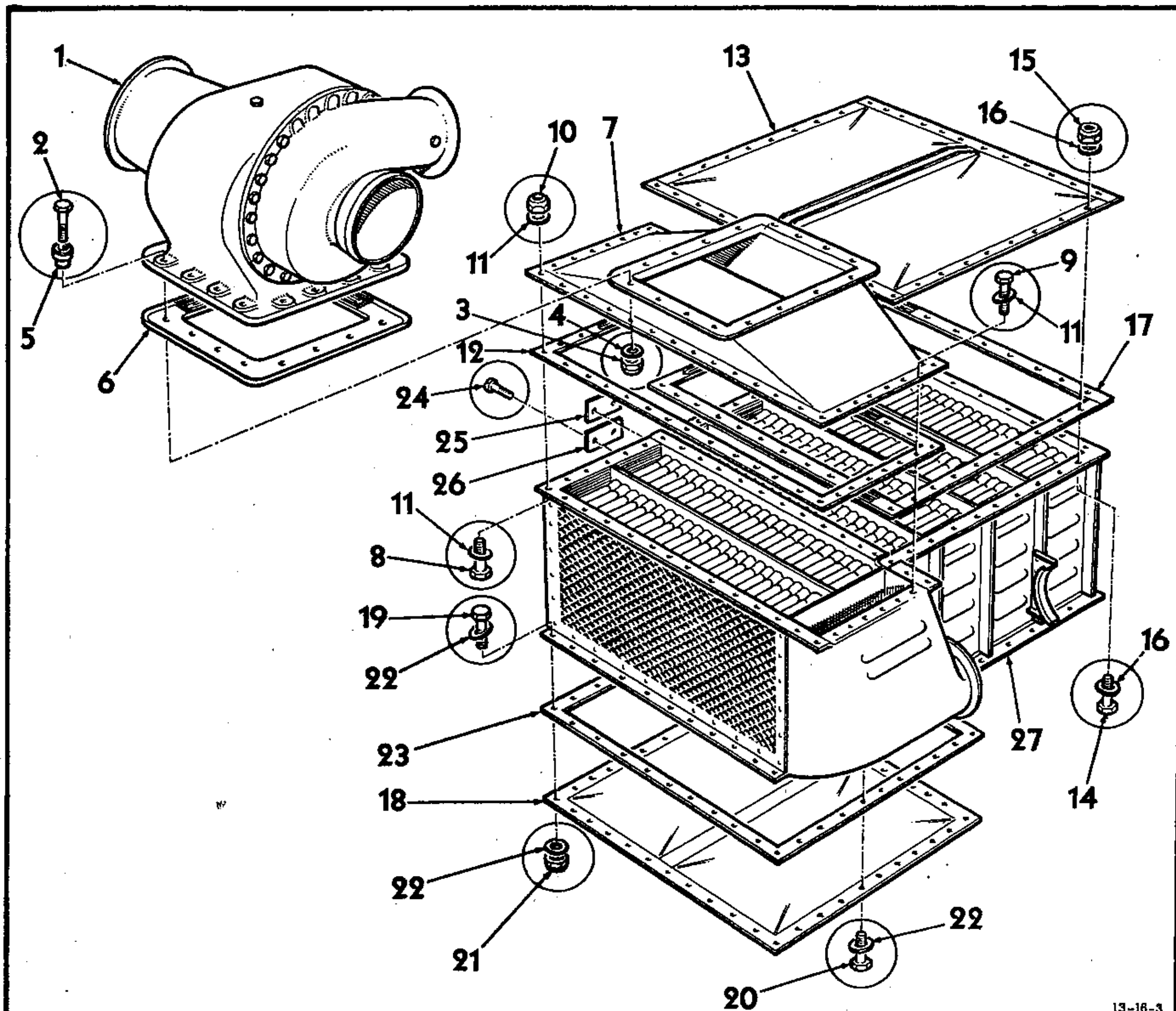


Figure 16-2 Aircraft Refrigeration Unit - Turbine Type

side of the tubes. Shut off pressure source and note that pressure does not drop to 15 psi in less than 45 seconds.

NOTE

Refer to applicable EO for inspection, test dimensions and specifications required for specific heat exchangers.

(b) Leakage may be detected by submerging the test bell under water with the heat exchanger installed in it and applying air pressure to the test bell. Leakage from ruptured or broken tubes is shown by large geyser-like bubbles at the header plates. Leakage between the tubes and header plates is shown by small bubbles around the tubes.

Repairs

12 The following repairs may be made:

(a) Ruptured or broken tubes may be plugged with blind ferrules, provided a total of not more than 64 tubes are plugged. Replace the heat exchanger if more than 64 tubes must be plugged.

(b) Leaks between the tubes and header plates may be stopped by lightly swaging the tube in the header plate with a polished drift punch.

Reassembly of Heat Exchanger

13 Assemble the heat exchanger in accordance with the exploded view, (see Figure 16-2). Tighten bolts evenly to avoid damaging gaskets.

Assembled Heat Exchanger Test

14 The assembled heat exchanger must be checked for leakage as follows:

(a) Install a block plate on the outlet duct assembly, another on the cooling air inlet flange and a third on the air inlet from the oil cooler. The plate on the duct assembly flange must have a fitting installed to provide for the attachment of a vacuum line.

(b) Attach the fitting in the block plate on the duct assembly flange to a vacuum source, with a mercury manometer between the vacuum shut-off valve and the fitting in the block plate.

(c) Draw a vacuum of 11.0 inches of mercury on the heat exchanger and close the shut-off valve. The maximum pressure drop allowable is 2.0 inches of mercury in a period of 30 seconds. If the leakage is greater than this, stop the leaks by applying compound (Item 1) at the seams.

Installation of Turbine on Heat Exchanger

15 Assemble the turbine (1) to the heat exchanger assembly with the bolts (2), nuts (3), washers (4), gasket (6) and spacer assemblies (5) as shown in Figures 16-2 and 16-3.

NOTE

Replace the spacer assemblies (5) and gasket (6), each time the turbine is removed from the heat exchanger.

LIQUID-TO-AIR HEAT EXCHANGERS

General

16 This type of heat exchanger includes oil coolers and coolant radiators.

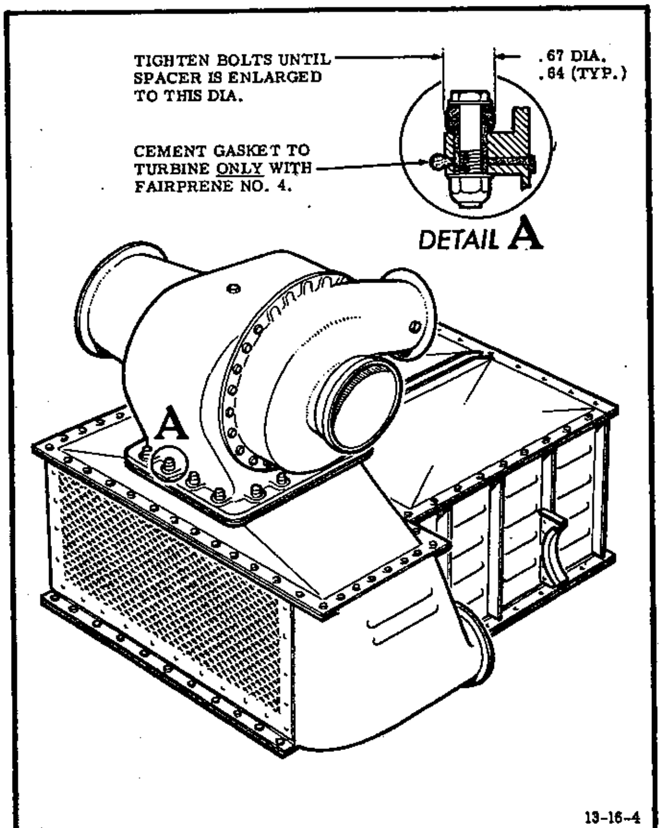


Figure 16-3 Refrigeration Unit Assembly

Testing

17 If it is necessary to locate leaks in oil coolers or coolant radiators, seal all openings except one, connect a pressure line and apply an air pressure not exceeding 75 psi for oil coolers or 15 psi for coolant radiators. Slowly submerge the unit in warm water. Where bubbles appear, mark the location with a wire clip. Continue the examination until the entire unit has been covered. Remove the unit, disconnect the pressure line and allow the unit to drain.

NOTE

Before testing an oil cooler for leaks, it must be cleaned in a hot soda bath, (Item 2).

Repairs to Oil Coolers

18 To repair or rebuild an oil cooler, proceed as follows:

(a) Dip cooler in hydrochloric acid (Item 3) diluted for cleaning and soldering purposes.

(b) Loosen solder, remove tubes (see Figure 6-4), and blow out with maximum air pressure of 75 psi, if possible.

(c) After the jacket is cleaned and ready for reassembly, repack the tubes and baffle plates in the jacket. Pack tubes tight enough to keep them from slipping out when they are put in position for soldering.

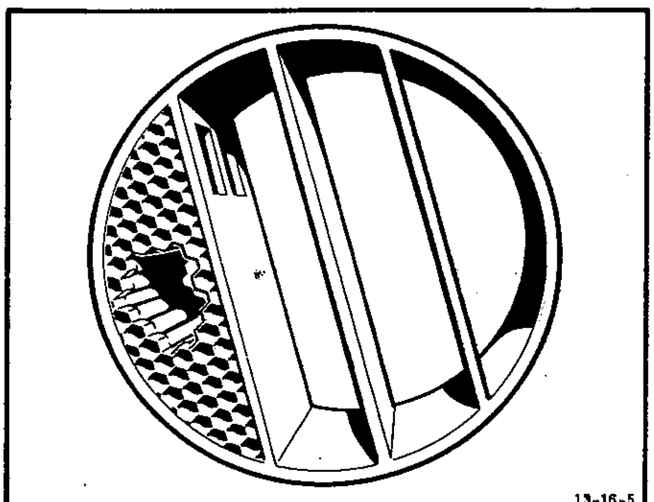


Figure 16-4
Oil Cooler with Damaged Tubes Removed

(d) Dip the oil cooler in diluted hydrochloric acid, tube end down, so as to clean the tubes 1/2 to 3/4 inch from the end of the tubes. This operation takes from two to three minutes.

(e) Dip the tube end of the oil cooler in hot solder to a depth of 1/4 to 3/8 inch and cool by air.

(f) Wash in hot water to remove acid from the core and jacket.

NOTE

The solder (Item 4) used in repairing oil coolers is a high melting point solder, (refer to Part 20, following). See Figure 16-5 for details of a typical oil cooler tube repair.

Repairs to Coolant Radiators

19 Use similar methods in cleaning and removing tubes. Hand solder rather than dip the unit in solder.

Repairs to Oil Cooler and Coolant Radiator Shells

20 The following repairs are used for both units:

(a) Dents in Shell - Large dents in the shell not indicating sharp radii may be corrected by the following procedure:

(1) Apply an air pressure of 30 to 40 psi to the inside of the cooler or a pressure of 15 psi to the radiator.

(2) Using an acetylene flame, carefully heat the area affected by the dent. Under the air pressure from within, the material should return to its normal contour.

(3) Sharp dents sometimes may be corrected by soldering the end of the silver solder wire to the centre of the dent. After this is done, gradually pull the shell back into position.

(b) Holes in Shell - Small holes not exceeding one-quarter inch in diameter may be patched by thoroughly cleaning the area with steel wool (Item 5) and soft soldering (Item 7) a patch over the hole using a piece of .040 or

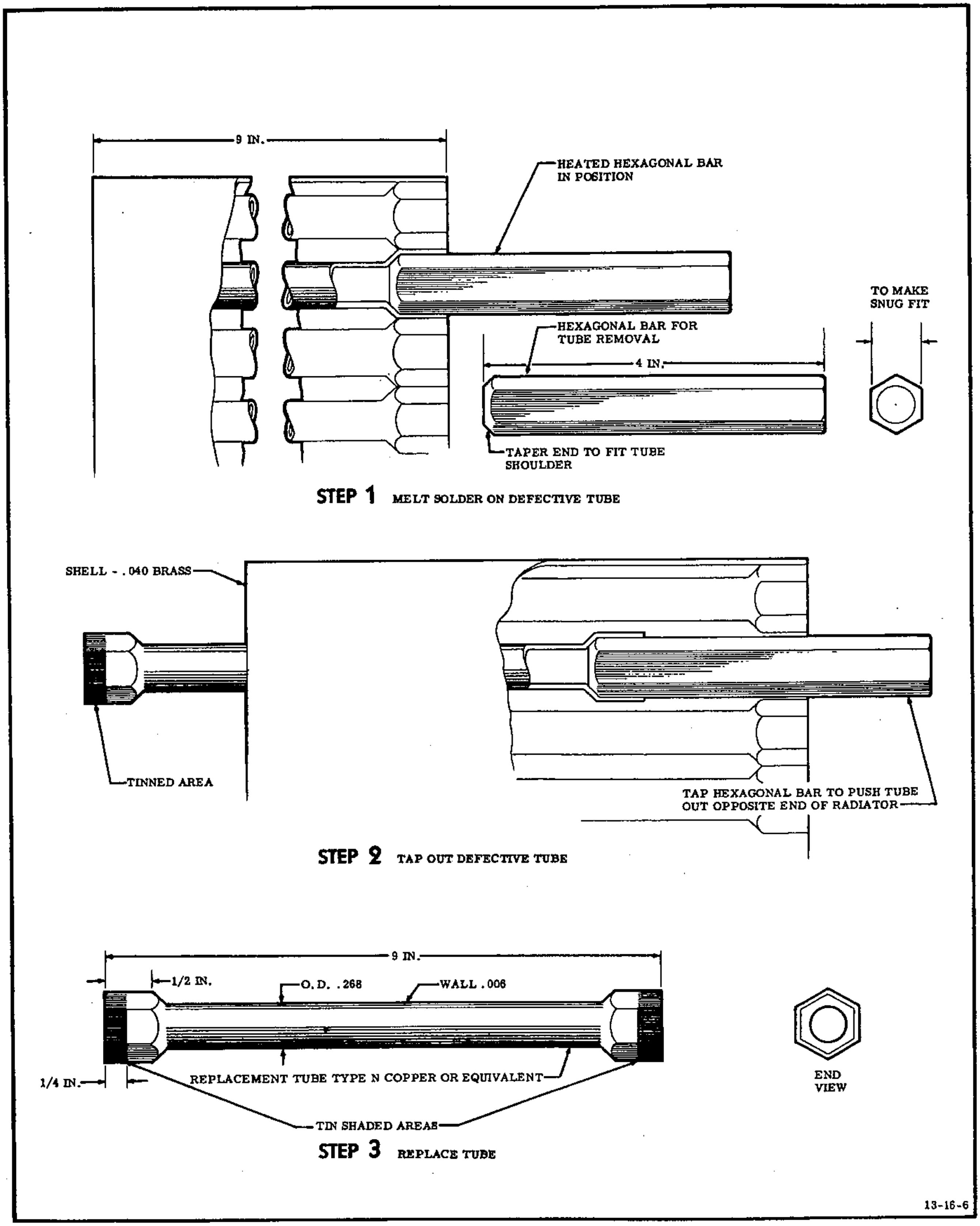


Figure 16-5 Typical Oil Cooler Tube Replacement

.050 inch brass. Repair large holes in the shell by silver soldering (Item 4), provided the core is properly protected from excessive heat by utilizing wet cloths. For silver soldering procedure, refer to Part 20, following. Holes in the inside shell are extremely difficult to repair and the cooler should be replaced rather than repaired.

(c) Shell casing - To repair external leaks on outer shell or casing, proceed as follows:

(1) Ascertain the exact location of the leak by testing as previously described.

(2) Thoroughly clean the defective area and apply flux.

(3) Fit a patch of brass over the damage, tin and solder in place with high melting point solder (Item 4). Perform this operation quickly to prevent annealing tubes in core or melting soft solder.

(4) Cracks around the damaged solder seams of casings may also be repaired by high melting point soldering.

(5) Test the oil coolers and radiators prior to installation on the aircraft.

Intercoolers

21 Supercharger intercoolers are made of aluminum tubes and cannot be soldered, but must be aluminum welded.

Testing of Oil Coolers, Coolant Radiator and Intercoolers

22 Test as follows:

(a) After repairs, seal all openings except one. Apply air pressure to this opening not to exceed 15 psi for coolant radiators and 75 psi for oil coolers or intercoolers.

(b) Slowly submerge the unit in warm water and, where bubbles appear, mark the location with a wire clip. Continue the examination until the entire unit has been covered.

(c) Remove the unit, disconnect the pressure line and allow the unit to drain.

NOTE

Pipes annealed by excessive heat during the soldering operation will collapse under pressure. Replace where necessary.

23 If test shows that the repair is satisfactory, thoroughly flush the oil cooler with light oil (Item 8) at 127°C (260°F) or the coolant radiator with kerosene (Item 6). Reassemble and re-install the unit.

Material Specifications

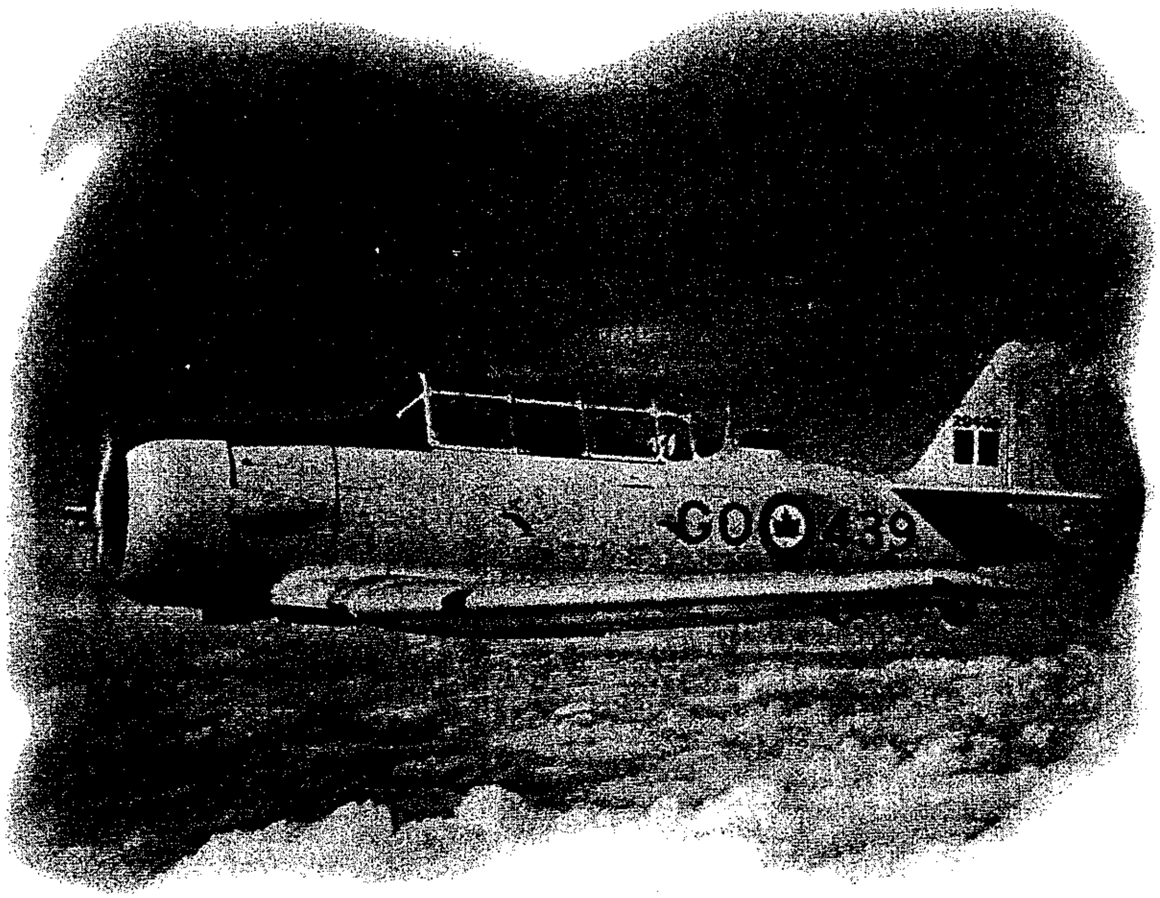
24 For table showing item numbers, materials, specifications and manufacturers, see Figure 16-6.

Item No.	Material	RCAF Ref.	Spec.
*1	Compound	33G/ Type as required	MIL-S-7502
2	Soda	33C/680	2-GP-25
3	Acid, Hydrochloric	33C/1	
4	Solder, High Melting Point 6% Silver	30B/NIC	
5	Steel Wool	29/1880 to 1884	
6	Kerosene	34A/217	3-GP-3
7	Solder, Soft	30B/400	QQ-S-571 comp Sn50
8	Oil, Light	34A/35	3-GP-45
9	Methyl Ethyl Ketone	33C/520	TT-M-261
10	Cleaner	33C/182	3-GP-8
*Manufacturer: Minnesota Mining and Mfr. London, Ontario.			

Figure 16-6 Table of Material Specifications

PART 17

EXHAUST STACK AND TAIL PIPE REPAIR



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EXHAUST STACK AND TAIL PIPE REPAIR

EXHAUST STACK AND TAIL PIPE REPAIR

General

1 Repairs that may be made to exhaust or tail pipes are limited by the characteristics of the metal used in the fabrication of these components. Inconel and stainless steels are the common metals used that may be repaired by welding. Other high temperature, corrosion resistant metals, such as Hastelloy and the chrome or chrome nickel steels, are difficult or perhaps impossible to weld without changing the characteristics of the metal.

Tail Pipe Repairs

2 For removal of corrosion products, refer to Part 23, following. For repairs to tail pipes refer to the specific Structural Repair Manual for the aircraft. Repair of tail pipes without specific instructions is hazardous and must not be attempted.

Exhaust System Repairs

3 Repairs to the exhaust system are confined to welding small cracks, patching holes and replacing parts when necessary. For typical exhaust assembly repairs, see Figure 17-1. Remove the part from the aircraft before welding. Clean the part, (refer to Part 20, following) and use the proper flux for the material to be welded. Remove flux completely after welding to reduce corrosive action induced during engine operation.

Dents

4 Repair dented members by hammering the dent to its normal position. After repair, inspect the metal to check that it has not been cracked by hammering.

Short Cracks

5 Locate the crack and ascertain the extent of the damage. All cracks having a length of less than 2 inches should be welded.

Small Holes

6 In the case of holes up to 1 inch diameter, apply a surface patch, using similar material of same gauge as the component being repaired. Make patch large enough to cover approximately 2 inches beyond the ends and sides of the crack. Make the patch oval in shape in order to prevent heating along a straight line when welding, (see Figure 17-1).

Major Damage

7 In case of major damage, such as long cracks and large holes, in any section of the exhaust assembly, replacement is preferable. If a replacement section is not available, use a flush butt welded patch of same material as component being repaired, as shown in Figure 17-1. First cut the patch to shape as shown and bend to the curvature of the damaged component. In order to ensure proper shape of the cutout of the damaged section, make guiding marks for cutting by scribing the contour of the already cut patch on the section with a scratch awl. Tack weld patch at several places and then butt weld. After welding has been completed, clean up weld by using a wire brush.

CAUTION

When marking on exhaust stacks, tail pipes or any part of any power plant, do not use pencil. Use chalk only. The use of pencil on metal surfaces that become heated can result in a condition of local case-hardening, creating a possible starting point for failure.

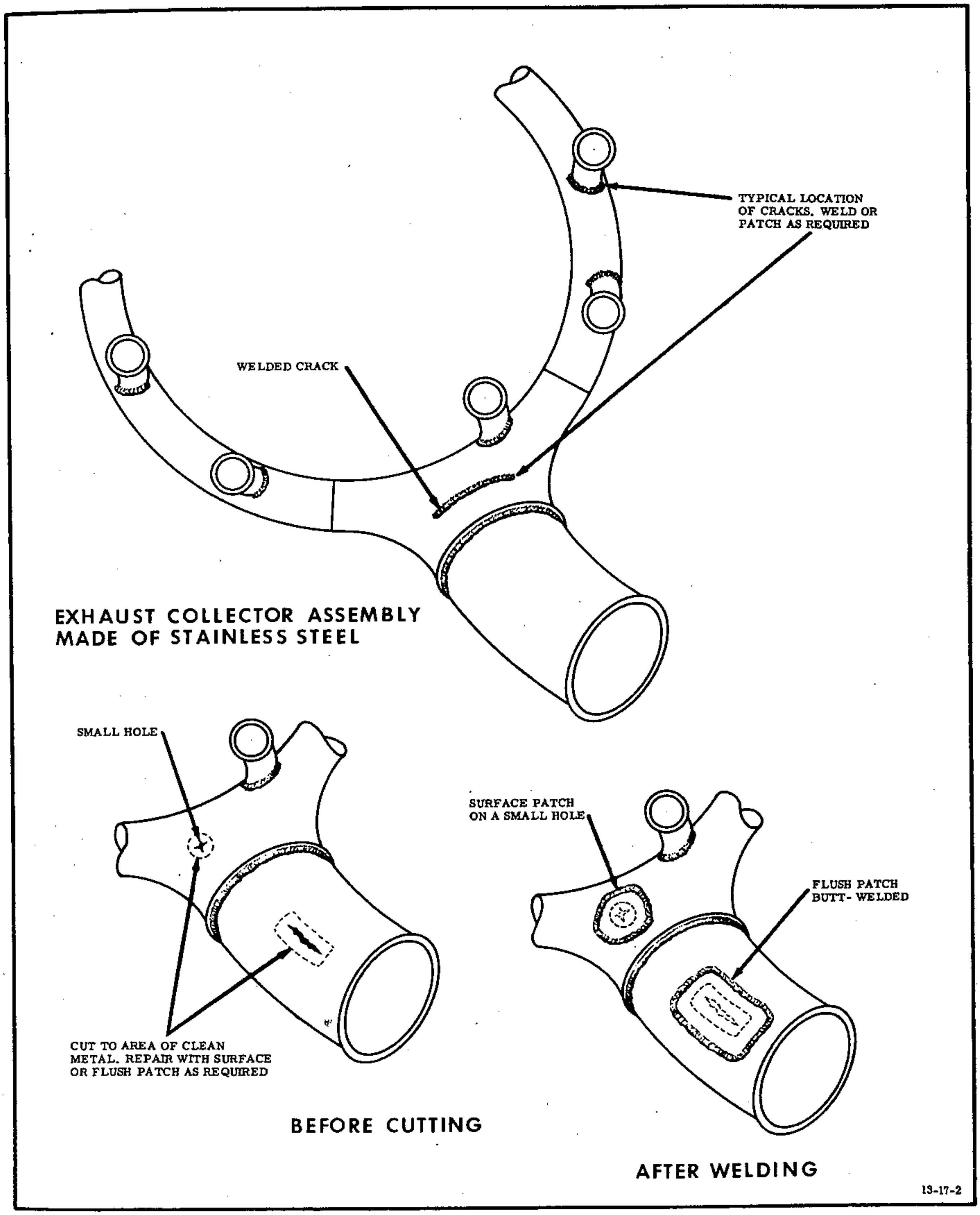
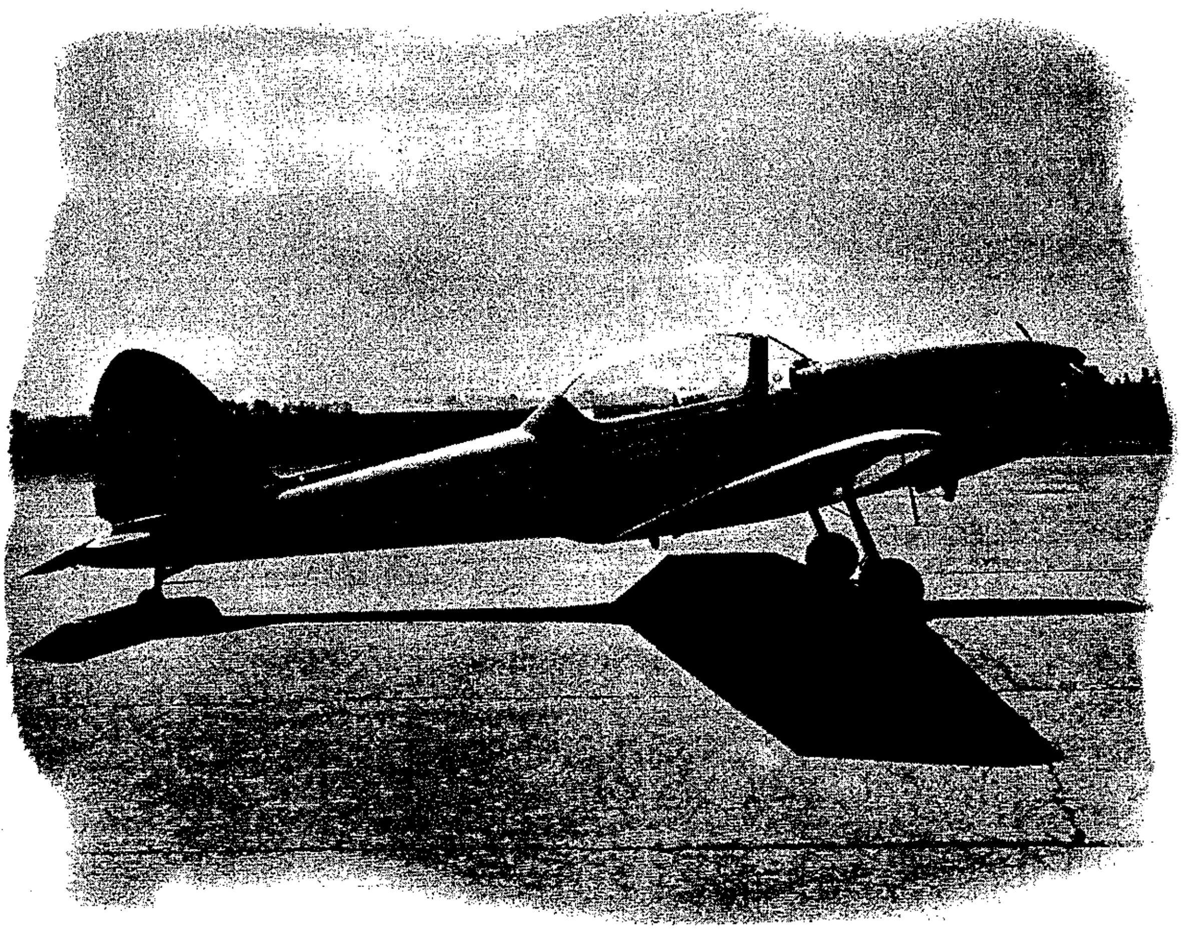


Figure 17-1 Exhaust Assembly Repairs

PART 18

FABRIC COVERING APPLICATION AND REPAIR



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MATERIALS AND DOPING

General

1 The materials commonly used in dope and fabric work are listed in Figure 18-1. In column six of the table, a brief description of the use of each material is given. This description does not cover all of the intended uses of the material; only those related to dope and fabric work. When more than one material is indicated for the same purpose, any of the specified materials may be used.

Dopes and Thinners

2 To obtain satisfactory results in thinning dopes, always use the thinners specified because of the incompatibility of certain ingredients used in the make-up of various dopes and thinners. Failure of tautening properties, separation of ingredients, orange peel effect, blushing and other similar dope troubles result from using thinners improperly. In any case, the proper action of the dope is destroyed if it is not thinned with the correct thinner.

Fire Retardant Fabric

3 To prepare fire retardant fabric, use new fabric of a sufficiently large size to allow for shrinkage. Prepare the fire retardant solution as follows:

(a) Dissolve 1-1/2 to 2 pounds of C.I.L. CM Fire Retardant Crystals in one gallon of warm water and stir until dissolved.

(b) Immerse fabric until completely saturated, remove and wring completely. Dry at room temperature or not over 180°F.

NOTE

Avoid skin contact with solution. Use an alkaline or acid resistant container and rinse thoroughly after use.

Dopeproofing

4 Treat all parts of the structure which come in contact with doped fabric with a protective coating which resists the solvent action of the dope. Use aluminum foil, cellulose tape or sheets as dopeproofing materials. Attach these materials to the surface to be covered with marine glue, shellac or other non-hygroscopic material. Where zinc chromate primer is the finishing material on metal structures, dopeproofing is not required. A slight bleeding of the primer through the first coat of dope may be observed but this is not objectionable.

NOTE

Aluminum, alclad, and stainless steel parts need not be dopeproofed.

Rejuvenating Old Nitrate Dope Films

5 Where nitrate dope films become deteriorated and cracked and the condition is not considered serious enough to warrant recovering, it may be improved temporarily with the following mixture:

(a) Make up the mixture using one fluid ounce of tricresyl phosphate and one ounce of castor oil mixed with one gallon of solution made up of two parts of clear dope and one part of blush retarding thinner.

(b) Remove all the old pigmented coats of dope from the surface to be treated by applying a 50-50 mixture of dope and blush retarding thinner. As soon as the old dope has softened, wipe off or remove by scraping with a dull tool such as a putty knife having rounded corners. Apply a heavy coat of the rejuvenator dope mixture by brush, followed by one spray coat. Finish to match adjacent surfaces. Where excessive quantities of pigmented dope are not present and tautness of the fabric is satisfactory, the application of lightly pigmented rejuvenating mixture over the old dope is satisfactory. Never apply clear dope over this pigmented rejuvenating mixture.

(c) Where there is any question concerning the condition of the fabric, remove and recover the surfaces. Any indication of staining of the fabric at cracks after removal of the dope finish with dope and lacquer is considered as deterioration of fabric, which must be replaced.

Doping for Emergency Repairs

6 In making fabric repairs of an emergency type, it is often necessary to apply dope under conditions which prevent obtaining a satisfactory job. Use blush retarding thinner to alleviate the severity of blushing conditions. In all cases where the job must be performed under unfavorable conditions and which result in an unsatisfactory repair, the repair is to be considered temporary and is to be accomplished properly at the earliest practicable time. Always try to avoid high humidity conditions, strong draughts, moist sea breezes and temperature extremes. Proceed as follows:

Fabric Used	Use of Fungicidal Dope	Finishing Dope	
AN-C-121 Mercerized Cotton Airplane Cloth	None	AN-TT-D-514 and AN-TT-D-551 or AN-D-1 and AN-D-2	Cellulose Nitrate Clear Dope Cellulose Nitrate Clear Dope (for) Aluminum Cellulose Acetate Butyrate Clear Dope Cellulose Acetate Butyrate Pigmented Gloss Dope
AN-C-113 Cellulose Nitrate Predoped Airplane Cloth	None (Fabric Predoped with Cellulose Nitrate.)	AN-TT-D-514 and AN-TT-D-551	Cellulose Nitrate Clear Dope Cellulose Nitrate Clear (for)Aluminum Dope
AN-C-121 Mercerized Cotton Airplane Cloth	AN-D-34 Fungicidal Dope	AN-D-1 and AN-D-2	Cellulose Acetate Butyrate Clear Dope Cellulose Acetate Butyrate Pigmented Gloss Dope
AN-C-132 Cellulose Acetate Butyrate, Predoped Airplane Cloth	None (Fabric Predoped with Fungicidal Dope) (CAB)	AN-D-1 and AN-D-2	Cellulose Acetate Butyrate Clear Dope Cellulose Acetate Butyrate Pigmented Gloss Dope

Figure 18-1 Table of Dopes used in Patching

(a) Apply a brush coat of dope (see Figure 18-1) to the area as a prime coat and allow to dry.

(b) Apply a second coat and apply the patch.

NOTE

Do not use nitrate dope in conjunction with cellulose acetate butyrate dope during repair procedures.

(c) Press the patch firmly into place on the wet dope. Smooth out the fabric and pull as taut as possible. Make certain that all edges are adhering and that no voids or bubbles exist under the lapped area.

NOTE

Apply a coat of dope, if necessary, to that portion of the patch which overlays the old fabric.

(d) Refer to Paragraph 35, following, for finishing procedure.

Testing of Dope Film for Flexibility

7 To test dope film for flexibility, proceed as follows:

(a) Cut a 2 x 4 inch sample from the area to be tested. Make the cut along the thread of the fabric. Fold the specimen lengthwise with doped surface outermost and place on the specimen a 2 kilogram (4.4 pound) weight, having a flat circular base about 2 inches in diameter, so that the crease formed will be directly below the diameter of the weight. Allow to remain for 10 seconds, then remove and examine the crease for cracks or breaks in the film.

(b) Fold the strip in a new position which does not intersect the first crease and repeat the test using a 1 kilogram weight.

(c) A dope film which does not crack at the fold under a 1 kilogram weight is considered to have satisfactory flexibility. The presence of a few slight cracks is acceptable provided there are no long sharp cracks with the 2 kilogram weight test which indicates brittleness.

(d) During production of a doped fabric finish, make a fabric covered panel simultaneously with the aircraft part, thus avoiding the necessity of cutting out a section from the structural surface.

(e) Use the flexibility test on doped fabric which has been air dried at 66°C (150°F) for 16 hours.

Alternate Procedure

8 Where the required test equipment is not available or it is not practicable to perform the tests as indicated above, carefully inspect the covering. Give consideration to the age of the covering as indicated by the code markings, loss of tautness and flexibility, excessive patching, general condition of the doped finish, extensive damage and security of attachment. Where the dope film cracks readily under light thumb pressure, make further inspection to determine whether the surface should be recovered or whether redoping will permit further service.

Finishing Plywood Surfaces

9 For application of sealer and dope to fabric covered plywood surfaces, refer to Paragraph 43, following. For repairs and finishing procedure, and instructions for the use of Madapollan on plywood surfaces, refer to Part 19, following.

FABRIC COVERING APPLICATION AND REPAIRS

General

10 Make repairs to fabric covered surfaces so that the repair procedure will restore the original strength and tautness of the fabric. Two types of repair are permitted, sewed and unsewed.

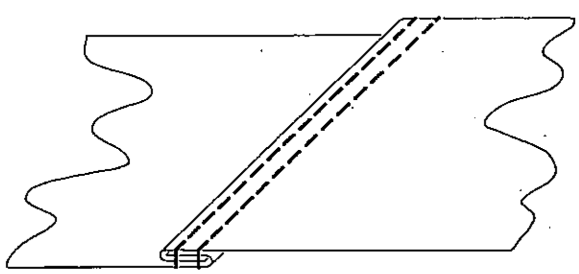
Machine Sewing

11 For all machine-sewed seams use plain lap or folded fell seams with two rows of stitches. For inside seams (not occurring at edges) use type LSc-2 seams, (see Figure 18-2). Use plain lap seam type LSa-2, (see Figure 18-3), only where selvage edges are joined. On seams for closing wing and tail surface coverings use type LSb-2 or LSq-2 or equivalent, (see Figures 18-4 and 18-5). No raw edges of fabric are exposed on the outer surfaces. Use a two thread loop stitch or

double-locked stitch, with eight to ten stitches per inch. Make rows of stitches from 1/4 to 3/8 inch apart placed approximately 1/16 inch from the edge of seam. Run all longitudinal or fore and aft seams parallel to the line of flight. Do not let seams cover a rib or be so placed that the rib lacing will be through or over a seam. The only seam extending along the span of the wing will be at the trailing edge of the wing, except in the case of a tapered wing where an additional seam may be made at the tapered position of the wing at the leading edge. Cover the seams where it is impracticable to avoid a seam at the leading edge. Where widths of fabric are sewed together, use selvage edges in seams as much as possible.

Hand Sewing or Tacking of Covers

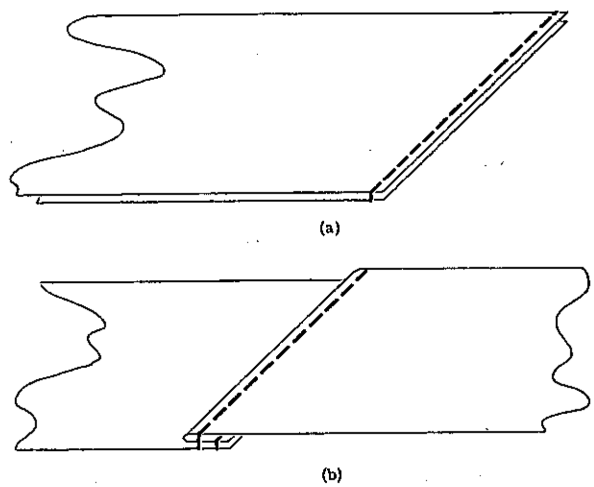
12 Begin hand sewing or tacking where machine sewing stops and continue as necessary. Temporarily tack fabric in place to facilitate hand sewing. Avoid permanent wrapping of metal members to facilitate attachment of fabric covers as such wrappings tend to induce early corrosion of the metal. After hand sewing has been completed, remove the tacks by a straight pull to avoid tearing the fabric. At the points where hand sewing or tacking is necessary, cut the fabric so that it can be doubled under approximately 1/2 inch. Use a baseball stitch for hand sewing and lock-stitch at intervals of six inches. Finish the seam with a lock-stitch and knot. In hand sewing use a minimum of four stitches per inch. (See Figure 18-6.)



FORM THIS TYPE OF SEAM BY TURNING THE EDGES OF BOTH PLIES OF THE MATERIAL AND LAPPING THEM. UNITE THEM WITH TWO ROWS OF STITCHES WHICH SECURE THE TURNED PORTIONS. CONCEAL THE EDGES OF THE MATERIAL.

13-18-1

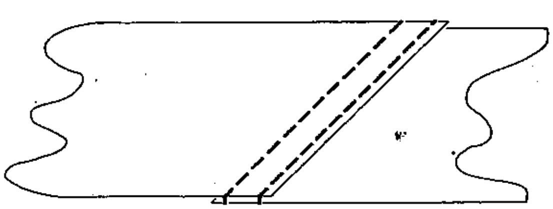
Figure 18-2 Type LSc-2 Seam



IN FORMING THIS TYPE OF SEAM THE PLIES OF MATERIAL FIRST ARE SUPERPOSED AND JOINED, AS IN (a). ONE PLY IS THEN TURNED BACK AND STITCHED DOWN WITH ONE ROW OF STITCHES (b).

13-18-2

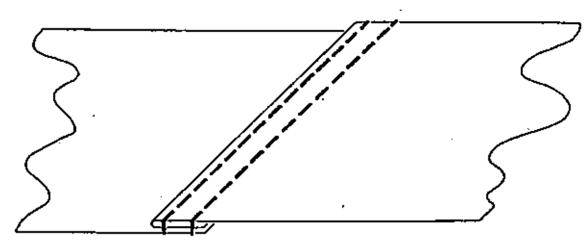
Figure 18-4 Type LSq-2 Seam



FORM THIS TYPE OF SEAM BY OVERLAPPING TWO OR MORE PLIES OF MATERIAL. UNITE THEM WITH TWO ROWS OF STITCHES.

13-18-3

Figure 18-3 Type LSa-2 Seam



FORM THIS TYPE OF SEAM BY TURNING THE EDGE OF ONE PLY OF THE MATERIAL AND LAPPING IT OVER ANOTHER PLY. UNITE THEM WITH TWO ROWS OF STITCHES, WHICH ALSO SECURE THE TURNED-UNDER PORTION OF ONE PLY. CONCEAL THE EDGE OF THE MATERIAL ON THE OUTER SURFACE.

13-18-4

Figure 18-5 Type LSb-2 Seam

Sewing Torn Fabric

13 When sewing torn fabric together before making the patch, use a baseball stitch with a minimum of four stitches per inch. Fully wax the thread. Make the first stitch a lock-stitch and use a lock-stitch every eight to ten stitches. Finish the sewing with a lock-stitch. Extend the stitches back away from the edge of the tear approximately 1/4 inch, (see Figure 18-6). Cut and apply the patch as described in Paragraphs 32,33 and 34, following.

NOTE

Maintain sufficient thread tension to draw the torn edges together. Be careful that the stitches do not pull out, since sewing thread pulls through doped fabric very readily.

Lacing Knot

14 The following method may be used for securing lacing cord at stitching points. (See Figure 18-7.)

(a) Loop hitch over needle (B) with right hand.

(b) Pull needle and cord with both hands, leaving enough slack for later insertion of needle.

(c) Hold hauling end (A) with left hand and insert needle with right hand.

(d) Take in remaining slack with left hand, leaving needle in knot.

(e) Shift right hand from butt of needle to point and pull double section of cord through knot, keeping strain on hauling end (A) with left hand during this operation.

(f) Cinch hauling end (A) from left to right until hitch has been pulled tight on rib. Hitch is slightly to right of centre of rib.

(g) Pull needle end of cord completely through with both hands and centre knot.

Lacing of Fabric to Structures

15 Lace fabric coverings to structures for

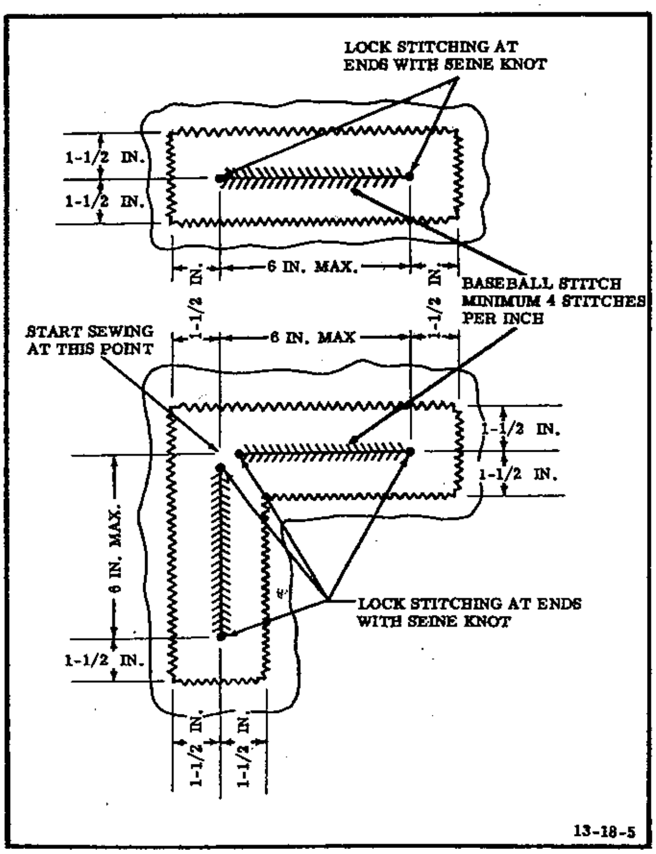


Figure 18-6 Repair of Tears

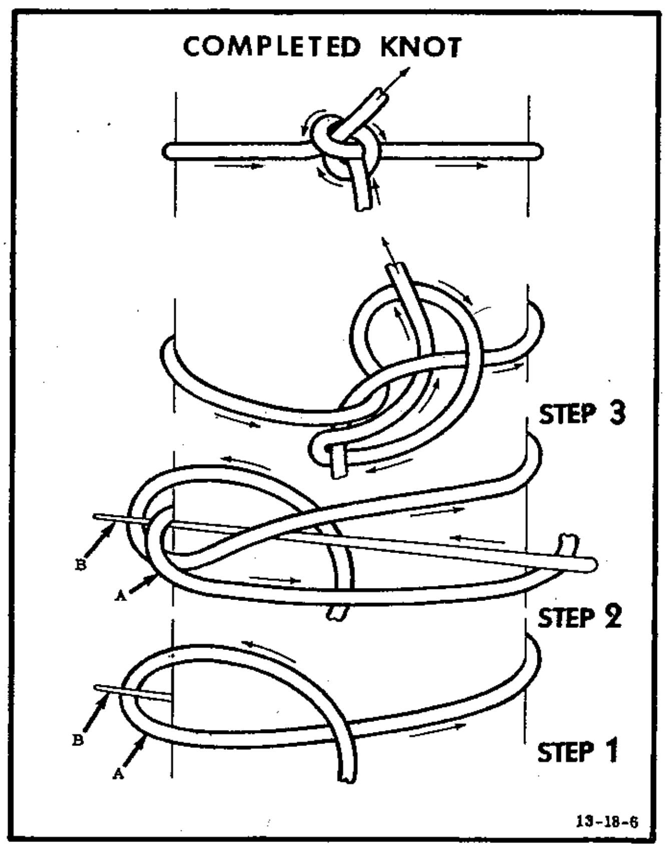


Figure 18-7 Standard Knot - Rib Lacing

the purpose of maintaining the contour of the airfoil or fuselage, and to prevent lifting and whipping of the fabric in flight. Lacing also provides for better utilization of the fabric strength. Use reinforcing tape under all lacing.

16 Make the width of the reinforcing tape equal to the width of the member over which the tape is applied. In some cases where the rib is very wide, it may be necessary to sew together widths of tape to cover the rib. Pass the reinforcing tape from the trailing edge up to and around the leading edge and back to the trailing edge. Apply moderate tension to the tape and tie the tape at the trailing edge to maintain this tension until the first coat of dope is dry. For lacing fabric to structures use lacing cord. Thoroughly wax the cord by drawing it through a bar of wax at least four or five times. Rewax the cord every five or six lacing points. At the first point of lacing use a slip knot for tying the lacing cord. At all subsequent points, tie the lacing by seine knots as shown in Figure 18-8. At the end point of lacing secure the lacing cord by a double lock knot.

Inter-rib Bracing

17 Tie wing ribs, which do not have permanent inter-rib bracing in position by means of cotton tape running parallel to the spars. Apply the tape bracing to both the bottom and top capstrips, keeping the tape parallel to the plane of the cover rather than diagonally between the top and bottom capstrips. Apply the tape continuously with one turn around successive capstrips; so that the tape between ribs is separated from the cover by a distance equal to the depth of the capstrip. Tie the turn of tape around each catstrip by means of a short length of lacing cord. See Figure 18-9.

Chafe Points

18 Cover all points of the structure such as sharp edges, bolt heads and rivets which come in contact with and are likely to chafe or wear the covering with doped fabric strips or with an adhesive tape. Where adhesive tape is used, cover with a dopeproofing material to prevent the dope from affecting the adhesive. After the cover has been installed reinforce the chafe points of the fabric by doping on fabric patches. Where a stronger reinforcement is required, sew a cotton duck patch of suitable size and weight to a fabric patch, then dope in place. Install reinforcing patches with the second coat of dope. Reinforce all portions of the fabric pierced by wires, bolts, or other types of projections.

Use of Anti-tear Strips

19 On aircraft with a maximum permissible speed in excess of 250 mph, use anti-tear strips under the reinforcing tape on the upper surface of wings, and on the bottom surface of that part of the wing in the slip-stream. Outside the slipstream, the use of anti-tear strips is optional on the bottom surface of the wing. Where the anti-tear strip is used on both the top and bottom surfaces, pass the strip continuously up to and around the leading edges and back to the trailing edge. Where the strip is used only on the top surface, carry up to and around the leading edge and back on the lower surface as far aft as the front spar.

20 Cut anti-tear strips from the same material as used for the covering. Cut wide enough to extend beyond the reinforcing tape on each side so as to engage the lacing cord.

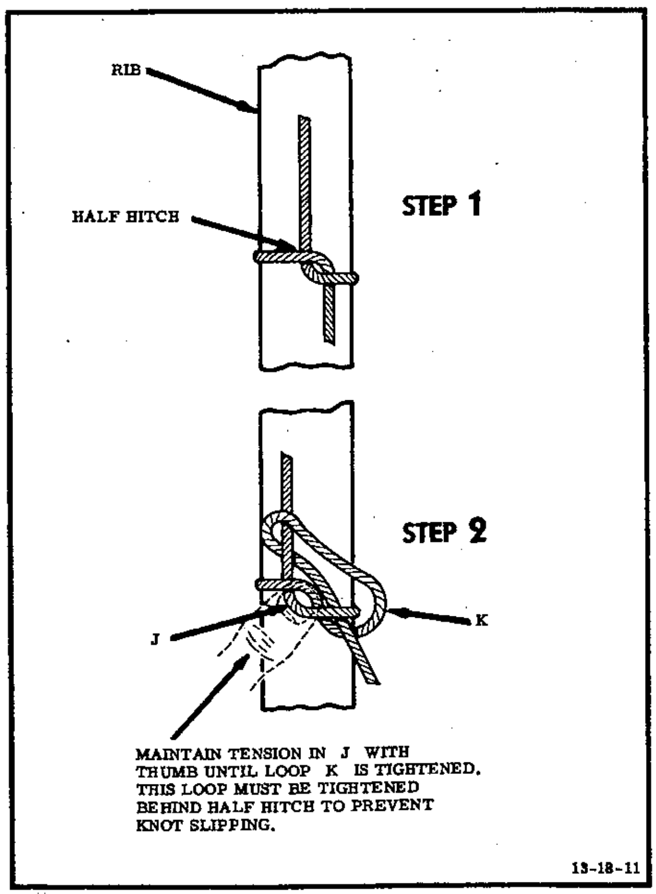


Figure 18-8 Seine Knot

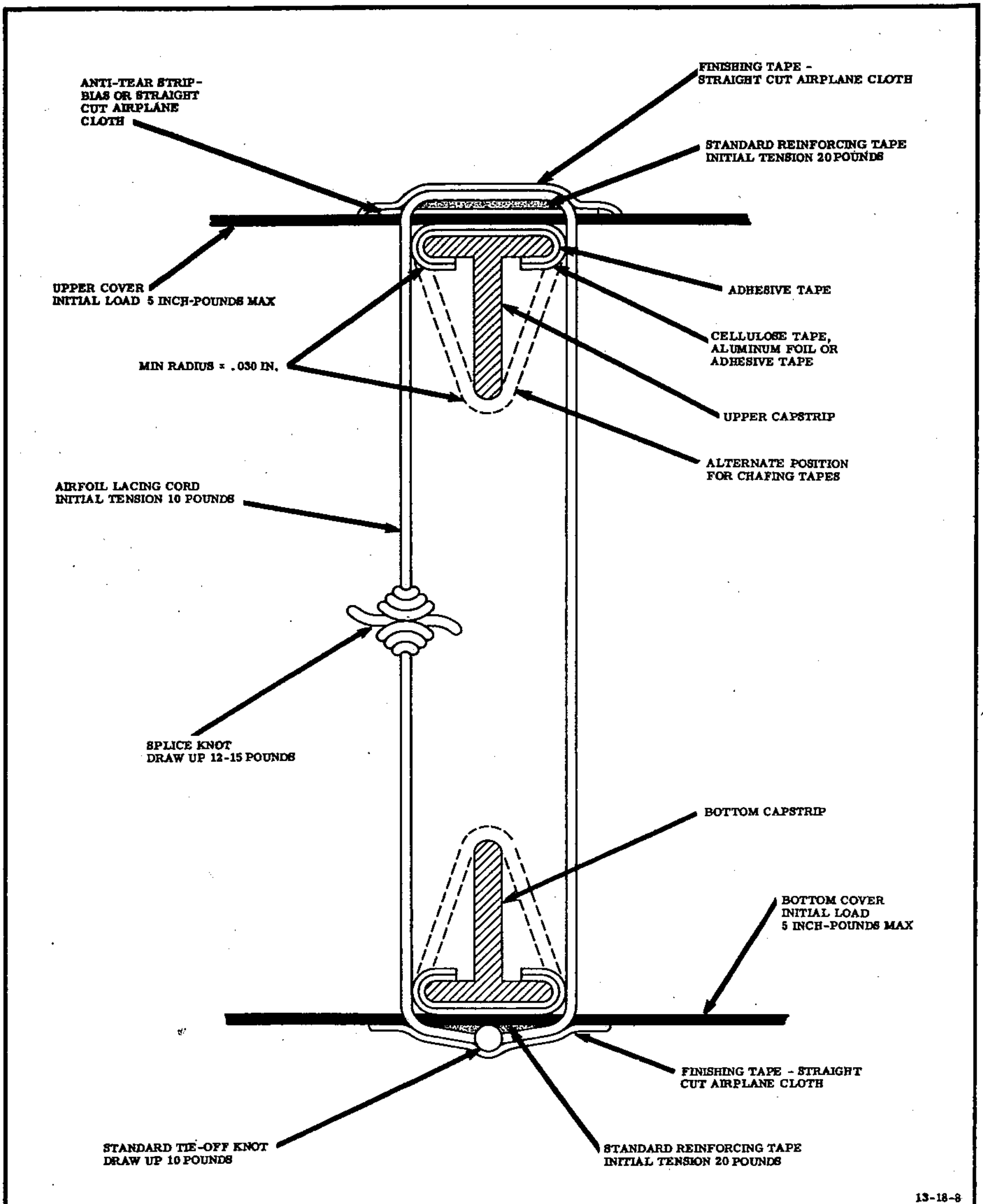


Figure 18-9 Cover to Cover Non-flush Type Rib Lacing

Attach the strips by applying dope to that part of the fabric to be covered by the strip, laying on the anti-tear strip and applying dope freely over the strip.

Inspection Openings

21 When applying fabric coverings, make provision for inspection of interior points of the structure. On metal frames, sew flaps with provisions for lacing or interlocking fasteners to fabric patches and then dope to the covering at the points where inspection openings are required.

Metal Frames

22 Where metal frames are used for inspection openings, attach doors to frames with cowl fasteners or flush type screws driven into self-locking nuts attached to the frames. Sew the frame securely to the fabric patch with the fabric extending at least two inches beyond all sides to provide sufficient dope adhesion of the patch to the cover.

Protecting Slide Fasteners

23 To prevent failure of slide fasteners due to the effects of oil and weather, cover the entire length of fastener with doped-on surface tape. In applying tape, take care that the dope is kept away from the metal scoops or teeth of the fastener, since dope clogs the fastener and prevents operation. Apply a strip of cellulose tape, wide enough to cover the metal parts of the fastener, prior to doping-on the surface tape.

CAUTION

Do not use oil or grease as a lubricant for slide fasteners, as such materials eventually cause failure of the fastener. The only recommended lubricants for slide fasteners are beeswax or a solution of paraffin dissolved in benzine. In the preparation of the paraffin-benzine solution, the operation should be performed under good ventilation, and the benzine kept away from any open flame or source of ignition.

Static Unbalance

24 Make repairs to fabric covered control surfaces in the same manner as other fabric repairs. Inspect for static unbalance created by the repair. The static unbalance of a control surface is defined as the product of the weight of the surface and the chordwise distance between the hinge line and the centre of gravity of the surface. The centre of gravity is a point on the surface about which the surface is balanced with respect to gravity, that is, if the surface were suspended at the centre of gravity, the plane of the surface would remain in any position in which it was initially located.

Finding Centre of Gravity of Surface

25 Since it is not convenient to find the centre of gravity of a surface directly, the following procedure is used to measure the static unbalance:

(a) Support the surface at its hinge line on supports which impose negligible restraint to rotation of the surface about its hinge line. Make supports so that the hinge line is level. (See Figure 18-10.)

(b) Apply a force to the surface near the leading or trailing edge so that the chordline of the surface is approximately level. For symmetrical sections, take the chordline as the line from the centre of the leading edge to the centre of the trailing edge. For sections which have a flat lower surface and a curved upper surface, take the lower surface as the chordline. For other sections, a line between the two mentioned above is used.

(c) Calculate static unbalance and correct as indicated in Figure 18-9.

Repairing Fabric when Damage is Extensive

26 Where the damage to the fabric covering extends across a rib or other supporting structure of a wing or is over 16 inches, do not patch but recover the damaged area. Also recover where coverings are old and deteriorated. (Refer to Paragraphs 38 and 39, following.)

Cutting of Fabric for Covers

27 In fabricating fabric coverings for airfoils, cut the fabric in sufficient lengths to pass completely around the frame, starting at the trailing edge, passing up to and around the leading edge, and returning to the trailing edge. Machine sew the covering wherever possible and complete installation by hand sewing or tacking.

Envelope Method of Covering

28 Sew together widths of fabric cut to specific dimensions to fit the airframe and then machine sew to form an envelope. Pull and draw envelope over the frame. Machine sew the trailing and outer edges of the covering, unless the frame is not suitably shaped for such sewing, in which case hand sew. Alternately, make up the cover as a sleeve by sewing the trailing edge only, then finish by hand sewing.

Blanket Method of Covering

29 Sew together widths of fabric of sufficient length to form a blanket covering for all surfaces of the frame, with the blanket installed on the airframe by hand sewing, using a baseball stitch. On wooden frames, temporarily tack the covering to the frame to facilitate sewing. On metal frames, use friction or other types of tape temporarily wrapped around members with the covering pinned in place to facilitate sewing.

CAUTION

Do not use permanent wrapping of members to facilitate sewing as the wrapping absorbs moisture and causes corrosion.

General Precautions when Installing Covers

30 Design and apply the covering, whether envelope, blanket, or sleeve type, in a manner that will ensure that the fabric has proper and equal tension over all parts of the surface. In order to stress each system of threads, apply tension to the cover in all directions. Ensure that excessive tension is not applied to the covering, resulting in warping the structure when dope is applied to the covering. The fabric covering, when correctly designed and installed under the proper condition, is free of all wrinkles and has sufficient tension to prevent sagging of the fabric.

NOTE

Changes in temperature and humidity cause changes in the tension of the fabric covering. If temperature and humidity conditions are not controlled during sewing and covering operations, a poor job will result.

Installing Covers

31 To cover a structure with fabric, proceed as follows:

(a) Support the structure to be covered on suitable stands.

(b) Cover all parts of the structure which are likely to chafe the fabric covering with fabric or adhesive tape. Dopeproof the structure where required. If a plywood surface is being covered, prepare by cleaning, applying sealer, and two coats of dope.

(c) Prepare covering by sewing together widths of fabric, and sew in a manner to form an envelope or sleeve, or apply as a blanket covering.

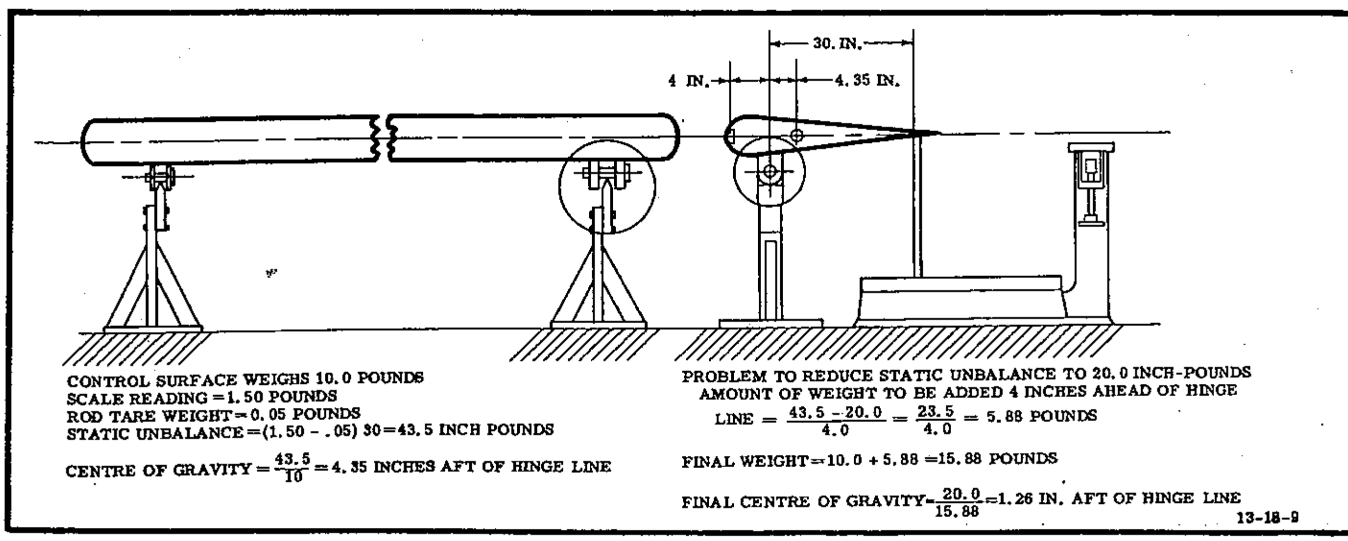


Figure 18-10 Static Unbalance Measurement of Control Surfaces

(d) Pull the cover over the frame. Apply tension to the fabric in all directions and temporarily pin or tack in place to facilitate hand sewing. Complete the installation of the cover by sewing or tacking. Where mechanical fabric attachments are provided, install these.

(e) Apply anti-tear strips to fabric where required.

(f) Install reinforcing tape and lace to the structure, or install mechanical types of attachments where provided. After reinforcing tape has been laced to the structure, do no further work until after the first coat of dope has been applied.

(g) Install face tape, fabric reinforcements and inspection openings with the second coat of dope.

Unsewed Patch Under Six Inches

32 Repair of holes in fabric up to six inches may be made without stitching the new fabric to the old, providing the patch falls entirely within the supporting members. When patches are made to areas from four to six inches in greatest dimensions, the distance of the patch from the structural members should not be less than 2-1/2 inches. For damaged areas smaller than four inches in greatest dimension, the distance of the patch must not be less than 1-1/2 inches from the structural members or ribs. Make overlap of the fabric a full 1-1/2 to 2 inches in all directions from a break or tear. Patches for holes up to six inches in size should have pinked edges.

Preparing the Patch

33 Prepare the patch as follows:

(a) If the damage is such that it will not permit sewing the edges of the tear together, cut out the damaged section.

(b) Trim to a smooth contour around the edge of the opening, either round or oval-shaped. When cutting the fabric, avoid making sharp corners.

(c) Thoroughly clean the area over which the patch is to be applied. (See Figure 18-11 for dope removing agents.)

(d) Wash off the area with dry cleaning solvent. Clean uniformly and remove all lacquer and layers of pigmented dope previously applied to the area. Produce a surface that is smooth and free from blemishes. Ensure that the cleaning agent does not drip onto any other portion of the surface or drip through the injury.

Installing the Unsewed Patch

34 For installation procedure, see Figure 18-12.

Finishing Procedure

35 Finish as follows:

(a) After the patch has been placed in position, apply a coat of dope. (See Figure 18-1.)

(b) After the first coat has dried, apply a second and a third coat.

NOTE

Sand between each coat with No. 7/0 sand paper or rub with doped canvas rubbing pads. Exercise care to avoid weakening the fibres of the fabric by unnecessary sanding.

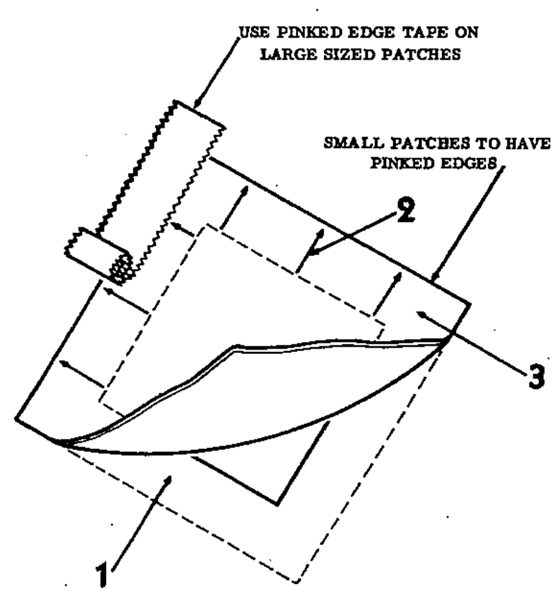
Dope	Removal Agent
AN-TT-D-551 Cellulose Nitrate Clear Dope (For) Aluminum	AN-TT-T-256 Cellulose Nitrate Dope and Lacquer Thinner
AN-D-2, Cellulose Acetate Butyrate Pigmented Gloss Dope	AN-D-1 Cellulose Acetate Butyrate Clear Dope, thinned as required with AN-T-27, Cellulose Acetate Butyrate Dope Thinner or Fed. O-A-51, Acetone

Figure 18-11 Dope Removing Agents

(c) Apply two coats of cellulose nitrate clear dope for aluminum, or cellulose acetate butyrate pigmented gloss dope when required, (see Figure 18-12), allowing time to dry between each coat until the patch has blended completely into the surrounding surface. These pigmented coats may be sprayed, in which case three coats should be applied.

Unsewed Patch Over Six Inches

36 The procedure will be the same as that for making unsewed patches under six inches except that the distance of the patch from the rib or structural member must not be less than 2-1/2 inches and the patch does not have pinked edges. The edges of the patch, however, should be finished with pinked edge tape. The overlap of the patch must be two inches for holes from six to eight inches in greatest dimension and one-fourth the size of the hole for holes eight to sixteen inches in greatest dimension.



STEPS

1 APPLY DOPE TO AREA OF OLD FABRIC TO BE COVERED BY THE PATCH.

2 PUT PATCH IN PLACE, SMOOTH OUT, AND STRETCH TAUT; DOPE THAT PART OF PATCH WHICH LAPS THE OLD FABRIC.

3 AFTER DOPE ON EDGES OF PATCH HAS DRIED, APPLY SUCCESSIVE COATS OF DOPE OVER ENTIRE PATCH AREA.

4 ON LARGE-SIZED PATCHES, DOPE MAY BE APPLIED ALONG TWO EDGES OF PATCH FIRST; AFTER THIS HAS DRIED, APPLY DOPE TO THE REMAINING EDGES, STRETCH THE FABRIC TAUT, AND LAY PATCH IN PLACE. AFTER DOPED EDGES HAVE DRIED, APPLY SUCCESSIVE COATS OF DOPE OVER ENTIRE PATCH AREA TO FINISH.

13-18-7

Figure 18-12 Patch Repair Procedure

(a) Apply the dope, (see Figure 18-1) along the two edges of the opening. Place the patch and allow the dope to dry. Apply the dope to the remaining edges and stretch the fabric as taut as possible, sealing the patch into position. Allow the dope to dry.

(b) After drying, apply a second coat of dope to the edges of the patch. Allow the dope to dry.

(c) Install surface tape over the patched edges with the third coat of dope.

(d) Finish with regular finishing procedure. (Refer to Paragraph 35, preceding.)

Sewed-in Repair Patch

37 To apply a sewed-in patch, proceed as follows:

(a) Expose all damaged parts. Repair structural damage in interior.

(b) Sew tear with baseball stitch.

(c) Tack down reinforcing tape.

(d) Cut patches to shape with pinking shears. Cut fabric 1 inch larger than the opening. (See Figure 18-1 for dopes and fabrics.)

NOTE

If the damage is such that it will not permit sewing the edges of the tear together, cut out the damaged section, making a rounded or oval-shaped opening. Avoid making sharp corners.

(e) Clean the area of the old fabric to be doped. (Refer to Paragraph 33, preceding.)

(f) Turn under the edges of the patch 1/2 inch and sew them to the edges of the opening.

NOTE

Before sewing, fasten the patch to the

corners with a few temporary stitches to facilitate sewing the seams.

(g) After sewing is completed, apply a coat of cellulose nitrate clear dope, or cellulose acetate butyrate clear dope to the patch.

(h) Apply a second coat of dope and apply surface tape over the seams.

(j) Finish with the regular procedure. (Refer to Paragraph 35, preceding.)

Repair by Sewing-in Repair Panel

38 When the damage is over 16 inches in length or over half of the bay or section is damaged, make the repair by sewing in a new panel. Sew the new fabric to the old cover at a point beyond the ribs adjacent to the damage and extending from the trailing edge up to and around the leading edge. Lace the new cover to the ribs over the old reinforcing tape and lacing, which is not removed. Proceed as follows:

(a) Remove the surface tape from the ribs adjacent to the damaged area and from the trailing and leading edge of the section being repaired. Leave the old reinforcing tape in place.

(b) Cut the fabric along a line approximately one inch from the centre of the ribs on the sides nearest to the injury. Continue the cuts to remove the damaged section.

(c) Cut a fabric panel of a sufficient length to extend from the trailing edge over the upper surface of the wing up to and around the leading edge. Return the fabric on the under side of the leading edge approximately to the front beam. Cut the panel of sufficient width to extend approximately three inches beyond the ribs adjacent to the damage.

(d) Clean the area of the old fabric that is to be covered by the panel.

(e) Put the panel in place, stretch taut, and pin. After the panel is pinned in place, fold under the trailing and leading edge of the panel 1/2 inch and sew to the old fabric. Fold the side edges of the panel under 1/2 inch and sew them to the old cover.

(f) After completion of the sewing, place reinforcing tape over the ribs under moderate tension and lace down in accordance with Figure 18-9. Remove the temporary pinning.

(g) Give the panel a coat of clear dope and allow to dry. Install surface tape with the second coat of dope, over the reinforcing tape and over the edges of the panel.

(h) Finish using regular doping procedure. (Refer to Paragraph 35, preceding.)

Sewing-in Repair Panel - Flush Type Cover Fastening

39 Where the cover is fastened to ribs with flush type reinforcement, remove reinforcement and then sew the repair panel to the old cover as specified in Paragraph 38, preceding. Have the repair fabric extend beyond the ribs to approximately the centre of the sections adjacent to the damage. Some of the tautness of the cover will be lost by removal of the reinforcements, but the added doping area will restore tautness. After the cover is in place, install the reinforcements and finish the repair as outlined in Paragraph 38, preceding.

Repairs to Loosened Fabric Tape

40 Repair fabric tape over joints in the plywood or over fabric seams by removing all tape within the loosened area, using thinner to facilitate removal and prevent harming the wood surface. Then proceed as follows:

(a) Remove the finish from the remaining tape to a point two inches back from where the loosened tape was removed. Remove the finish from the wood in an area approximately two inches on either side of where the tape was located, leaving a feathered edge on the remaining finish.

(b) Apply one brush coat of clear dope to the wood and allow to dry for 45 minutes. Remove all dope lapped over the edges of the original finish by wiping with a cloth before the dope has dried.

(c) Apply a second coat of clear dope, also covering the two inches of old tape from which the finish has been removed. While still wet, apply a strip of pinked fabric equal in width to the original strip and sufficiently long to cover the two inches on the original fabrication. Work out all air bubbles by brushing to ensure maximum adhesion. Allow to dry for 45 minutes and refinish as necessary.

REPAIRS TO FABRIC-COVERED PLYWOOD SURFACES

General

41 Before applying fabric to plywood surfaces, prepare the surface for covering by cleaning and application of sealer and dope.

Cleaning

42 Plywood surfaces, prior to application of sealer, must be free from excess glue extruded a distance greater than 1/8 inch beyond glue joints. Sand all surface areas which have been smeared with glue in order to expose a clean wood surface. Remove loose deposits such as dust, wood chips and sawdust by wiping with dry cloths or other suitable means. Remove oil or grease spots by carefully washing with naphtha in such a manner as to prevent the spread of oil or grease.

Application of Sealer and Dope

43 The specified minimum protective finish for exterior fabric-covered plywood is one brush coat or two dip coats (wiped) of sealer, thinned to 30% non-volatile content, and two brush coats of clear dope. Apply the sealer and allow to dry for two to fours hours, then apply two brush coats of clear dope. Allow the first coat of dope to dry for approximately 45 minutes before applying the second coat. After the second coat of dope has dried, the surface will be ready for covering.

Procedure

44 Repair the damage to fabric covering on plywood by cutting out the damaged section of fabric and applying a fabric patch of the same size and shape. Finish the edges of the patch with pinked tape. Proceed as follows:

(a) Cut the fabric to form a regularly shaped opening. After the damaged section of fabric is removed, clean the surface of the plywood and smooth out any rough spots. Clean the area of the old fabric, which is to be lapped by the pinked edge finishing tape, using dope or thinner.

(b) Apply two coats of clear dope to the surface of the plywood and that part of the old fabric to be covered by the tape, allowing 45 minutes between coats.

(c) After applying the second coat, lay the patch in the wet dope and dope over the patch area. Brush sufficiently to work out all air bubbles and to ensure maximum adherence.

(d) Allow this coat to dry, apply dope to pinked tape and finish with three additional coats of clear dope. Follow by aluminum dope or other finish as required.

Repairs to Small Loosened Areas

45 Wash off the dope on the loosened fabric by repeated application of cellulose nitrate thinner, or cellulose acetate butyrate dope thinner, whichever is applicable. Follow by scraping, then wipe with thinner. Proceed as follows:

(a) Beginning approximately in the centre of the loosened area, carefully cut the fabric towards the securely cemented area so that the cuts form a cross. Lay each quarter of fabric back away from the wood surface.

(b) Apply one brush coat of clear dope to the entire exposed wood area and allow to dry 45 minutes.

(c) Taking each quarter of fabric in sequence, apply a brush coat on the wood beneath it and press the fabric into the wet dope. Apply sufficient dope to ensure the wetting of all loosened fabric up to the line where cloth is satisfactorily attached. When all four quarters have been properly cemented in place, allow the dope to dry for 45 minutes and apply a brush coat of clear dope over the entire repair area. Allow this coat to dry for 45 minutes.

(d) Cement pinked tape over the cuts and apply clear dope over the tape and the entire repair area. Allow the dope to dry for 45 minutes, then scuff lightly with fine sandpaper. If the area is small, apply a circular pinked-edge patch over the cuts instead of taping.

(e) Spray or brush on two coat of clear dope. Allow each coat to dry for 45 minutes.

(f) Spray two coats of aluminized dope or pigmented dope to match the colour of adjacent areas.

Material	Specification		Remarks
	RCAF Ref	Procurement	
Acetone	33C/725	O-A-51b	Used for cleaning fabric before patching.
Aluminum, Foil		AN-A-20	For use in protecting structural parts and finishes against dope in the covering of airplane wings, etc.
Aluminum, Pigment Paste, Aircraft	33A/349,350	AN-TT-A-461 1-GP-24a	Used in the preparation of aluminized dope, lacquer and enamel.
Aluminum, Pigment Powder	33A/457	1-GP-22a	Used in the preparation of aluminized dope, lacquer and enamel.
Beeswax, Technical Grade	33C/5	C-30-536	Used for waxing lacing cord and hand sewing thread.
Castor Oil		AN-JJ-O-316	Used as plasticizer in dopes.
Cellulose Tape or Sheet			Type II for use in protecting strucural parts and finishes against dope in the covering of airplane wings, etc.
Cloth, Mercerized Cotton, Airplane	32B/305	MIL-C-5646	For use as a covering for the wings, control surfaces and fuselages of aircraft.
Cloth, Cellulose Nitrate, Pre-doped, Airplane			For use as a covering for the wings, control surfaces and fuselages of aircraft. This type, principally type 1, of cloth used mostly by manufacturers to speed up production. May be used by others instead of MIL-C-5646, if available.
Cloth, Cellulose Acetate Butyrate Pre-doped Airplane			To be used when fungicidal cloth is required for patching.
Cloth, for Plywood Covering			For application to plywood skin surfaces only, where the design is such that no portion of the loading is carried by the fabric.

Figure 18-13 (Sheet 1 of 5) Table of Material Specifications

Material	Specification		Remarks
	RCAF Ref	Procurement	
Cloth, Glider Cotton			Used in the construction of gliders. For fabric covered plywood surfaces.
Cord, Braided, Cotton	32B/382	MIL-C-5648A	Used for lacing fabric on airplane fuselages and wings.
Cord, Special, Cotton			Used for lacing fabric to wings and fuselages.
Cord, Lacing, (Airfoil) Linen and Linen Hemp			Use type II, 11-ply, polished, RH twist, for lacing fabric to structures.
Dope, Cellulose Acetate Butyrate Clear			For use as an undercoat on aircraft fabric surfaces and for making repairs to doped fabric surfaces. For thinning, use thinner 1-GP-506.
Dope, Cellulose Nitrate, Clear	33A/420,421	1-GP-31	For use as an undercoat on aircraft fabric surfaces and for making repairs to doped fabric surfaces. For thinning, use thinner 1-GP-506.
Dope, Cellulose Nitrate, Clear For Aluminum	33A/420,421	1-GP-31	For use as a vehicle for aluminum paste in the preparation of aluminized dope for aircraft fabric surfaces. For the preparation of aluminum dope, add approximately 6 ounces of aluminum paste, RCAF Ref.33A/349, to 1 pint of the dope and mix thoroughly, then add sufficient dope to make 1 gallon of the aluminized dope. For thinning, use thinner 1-GP-506 as required. Apply only over 1-GP-31 dope.
Dope, Cellulose Acetate Butyrate, Pigmented, Gloss	33A/	1-GP-31	For use on aircraft fabric surfaces over 1-GP-31 dope. If thinning is required, use thinner 1-GP-506.
Dope, Cellulose Acetate Butyrate, Pigmented, Camouflage	33A/	1-GP-31 MIL-D-5550	For use as top coats on aircraft fabric surfaces doped with 1-GP-31 for obtaining a camouflage finish. For thinning, use thinner 1-GP-506.

Figure 18-13 (Sheet 2 of 5), Table of Material Specifications

Material	Specification		Remarks
	RCAF Ref	Procurement	
Dope, Cellulose Nitrate, Pigmented Camouflage	33A/	1-GP-31	For use on aircraft fabric surfaces doped with 33A/420, for obtaining camouflage finish. For thinning, use thinner 1-GP-506. For brush application, use not more than one part of thinner to four parts of dope. For spray application, use not more than one part of thinner to one part of dope.
Dope, Cellulose Nitrate, Pigmented	33A/	1-GP-31	For use on aircraft fabric surfaces doped with 33A/470 for obtaining coloured glossy dope finish. For thinning, use thinner 1-GP-506. For brush application, use not more than one part of thinner to four parts of dope. For spray application, use not more than one part of thinner to one part of dope.
Duck, Cotton	32B/		Type II, 12-ounce duck used to make up fabric reinforcements.
Eyelets, Brass	29/		For making up inspection openings.
Glue, Aviation Marine, Waterproof	33G/40		Used for fastening aluminum foil to structural parts as a protection against dope.
Grommets, Drain Plastic	28/		Installed at low points of structure to provide for drainage and ventilation. The No.4 grommet is shielded.
Grommets, Brass	28/		Installed at low points of structure to provide for drainage and ventilation. Use No.2 on wings and fuselages, No.1 on airfoils in empennage unit.
Thinner	33A/119	1-GP-70a	Used to clean oil and grease from wood surfaces, used also for thinning various varnishes and enamels.

Figure 18-13 (Sheet 3 of 5) Table of Material Specifications

Material	Specification		Remarks
	RCAF Ref	Procurement	
Paper, Abrasive, Artificial, Waterproof	29/1868-67	FED-PP-101-1	Used for sanding doped surfaces.
Paste, Masking	33G/52	MIL-C-6799A	Used as a masking material for windows and other surfaces on which the adhesion of dope or paint is not desired.
Primer, Zinc Chromate	33A/462	MIL-P-6889A	Used to protect metal surfaces from corrosion, and to provide improved adhesion of finished coats. Thin with 33A/98 Thinner.
Slide Fasteners	29/	VF-106	Use grade II, semi-automatic locking for making up inspection openings.
Cleaner	33C/182	3-GP-8	For use when cleaning fabric before patching.
Tacks	29/		Used for installing fabric to wood structures. For permanent tacking, use Monel metal, tinned iron or brass. No.18 BWG gauge x 3/8 to 1/2 inch long. Where tack will pass through member, use shorter tack. Copper tacks may be used for temporary tacking.
Tape, Cotton, Reinforcing	32B/		Type I tape used as reinforcing tape on fabric and under lacing cords of airfoil sections. Type III used for inter-rib bracing.
Tape, Masking (Paper-backed)	33G/99, 100,101	UU-T-106A	Used as a masking material to protect parts from dope during finishing of aircraft.
Tape, Non-hygroscopic Adhesive	33G/		May be used to cover edges which are likely to wear fabric covering.
Tape, Surface	32B/		Used as a finishing tape over lacing, sewing, etc.

Figure 18-13 (Sheet 4 of 5) Table of Material Specifications

Material	Specification		Remarks
	RCAF Ref	Procurement	
Thinner, Cellulose Acetate Butyrate Dope	33A/466	1-GP-50b	Used in thinning cellulose acetate butyrate dopes.
Thinner, Cellulose Nitrate Dope and Lacquer	33A/466	1-GP-50b	Used in thinning cellulose nitrate dopes and lacquers.
Thinner, Cellulose Acetate Butyrate Dope, Blush Retarding	33A/466	1-GP-50b	Used as a blush retarding thinner in cellulose acetate butyrate dopes. Use between 10 and 25 percent of this thinner in the regular dope thinner.
Thinner, Cellulose Nitrate Dope and Lacquer, Blush Retarding	33A/466	1-GP-50b	Used as a blush retarding thinner in cellulose nitrate dopes and lacquers.
Thinner, Toluene Substitute	33A/98	1-GP-4a	Used for thinning zinc chromate primer.
Thread, Cotton	32B/		For hand sewing, use size 10/3 ply type IIIB, RH twist. For machine sewing of fabric, use size 16/4 to 20/4 ply type IBI. Use fully waxed thread for hand sewing.
Thread, Hand Sewing. Linen and Linen Hemp	32B/		Use type 1 for hand sewing, and type II for lacing.
Thread, Hand Sewing and Lacing Cord, Cotton	32B/		Use style B, size 30, RH twist for hand sewing. Use style A, type II, ticket No.10, RH twist for lacing.
Toluene	33A/467	TT-T-548A	Used for thinning zinc chromate primer.
Tricresyl Phosphate	34A/227	TT-T-656a	Used as a plasticizer in dopes.
Varnish, Spar, Glyceryl Phthalate	33A/475	TT-V-119	Used as a sealer on fabric covered plywood surfaces prior to application of dope and fabric. Thin with Thinner 33A/100.

Figure 18-13 (Sheet 5 of 5) Table of Material Specifications

Repairs to Large Loosened Areas

46 Proceed as follows:

(a) Remove the loosened fabric and cut back a little into the securely cemented fabric. Cut out the fabric in straight lines to conform to the taping pattern in adjacent areas.

(b) Apply two coats of clear dope to the bared wood areas.

(c) Cement in place a piece of new cloth cut with straight edges to fit the opening.

(d) Apply a coat of clear dope to the area and allow to dry for 45 minutes.

(e) Cement pinked-edge surface tape, not less than two inches in width, over the cuts and the adjacent mating areas. Apply clear dope over the tape and the entire repair area. Allow the dope to dry for 45 minutes; then scuff lightly with fine sandpaper.

(f) Spray or brush on two coats of clear dope and allow each coat to dry for 45 minutes.

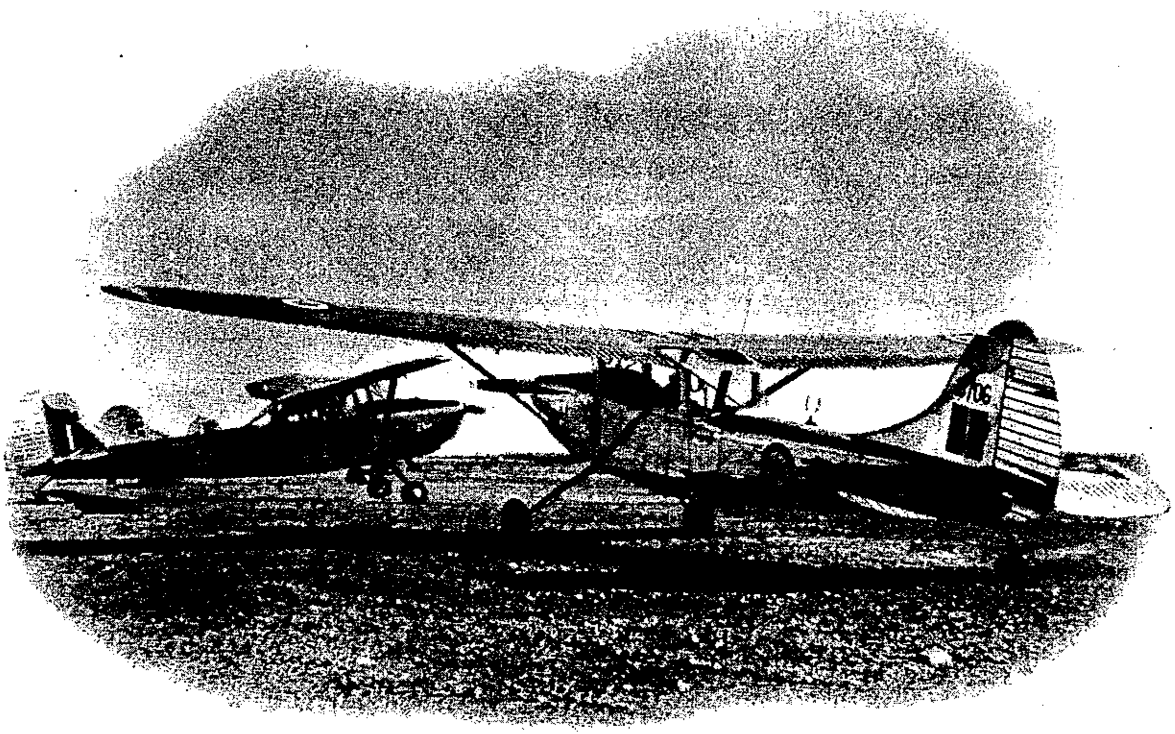
(g) Spray two coats of aluminized dope or pigmented dope to match the colour of adjacent areas.

Material Specifications

47 For table showing materials, specifications and manufacturers, see Figure 18-13.

PART 19

WOODEN AIRCRAFT STRUCTURE REPAIR



PART 19

WOODEN AIRCRAFT STRUCTURE REPAIR

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PART 19

WOODEN AIRCRAFT STRUCTURE REPAIR

MATERIALS USED IN WOOD CONSTRUCTION

General

1 Aircraft use wood in three general forms; solid wood, plywood and laminated wood. In addition, several kinds of modified wood are used for special purposes, among them resin-treated wood, or impreg; resin-treated, compressed wood, known as compreg; and heat-treated, compressed wood, known as heat-stabilized wood or staypak. The first three forms are important, as they constitute the bulk of all wooden aircraft construction materials. Almost without exception, glues are used to bond joints of wood aircraft parts, such as wing ribs, box spars, fuselage rings and plywood skin surfaces. Wood screws are rarely used in United States aircraft, although employed in some British aircraft. Nails are employed chiefly to provide pressure in gluing. All exterior surfaces of wooden aircraft are finished with either gloss enamel or camouflage paints, depending upon their use. Interior surfaces such as the enclosed surfaces of wings, are usually covered with a sealer. The main structural advantage of wood is its ability to resist local deflections because of its bulk.

Specifications	Grade A (PSI)	Grade B (PSI)	Grade C (PSI)
Compression	5,000	4,000	2,000
Modulus of Elasticity	1,500,000	1,200,000	1,000,000
Shear along Grain	900	800	400
Crushing across Grain	600	550	300
Tension	10,000	8,000	4,000

Figure 19-1 Strength Values for Sitka Spruce

Solid Wood

2 The usefulness of wood in aircraft construction is based largely upon its ratio of strength to weight, which compares favourably with that of many metals. The ease with which it can be manufactured, assembled and repaired, and the relative simplicity of such repair steps as cutting, gluing and splicing, are also an advantage. Different species of wood vary markedly in their properties and certain species are much more adaptable to the requirements of aircraft than are others.

Species Substitution

3 To repair a part, replace with the same species as that of the original, whenever possible. For permissible substitution based on a general comparison of properties and their use, refer to Paragraphs 9 to 24 inclusive, when the species listed are not available. Substitutions are considered as individual cases, and approval must be obtained for specific applications. Guard against change in weight in all repairs to movable control surfaces such as the ailerons and rudders, and to a lesser degree, wing tips and tail surfaces.

4 The face and interior plies in the plywood being used for repair must be of the same species as, or a permissible substitute for, the face and interior plies of the original. The repair plywood thickness must be nominally the same as that of the original plywood and whenever possible of the same construction and number of plies. When necessary, the construction and number of plies may be varied, provided the other conditions given are maintained.

Aircraft Spruce

5 For strength values for Sitka spruce, as supplied to Specification DTD 36B, see Figure 19-1.

6 Grade B spruce may be used instead of Grade A, provided the structural strength is

not less than that required, when calculated on the value quoted for Grade B spruce. (See Figure 19-1.)

7 Grade C spruce may be used when failure will not cause collapse of the structure or loss of control in flight, or where it is supported by Grade A or B spruce in such a way that it cannot fail until failure has taken place in the Grade A or B spruce.

Substitute for Sitka Spruce

8 Douglas fir is accepted as an approved substitute for Sitka spruce and may be used as circumstances necessitate. Douglas fir must comply with the requirements of Specification DTD 36B, except that the density of the fir must be not less than 32 pounds per cubic foot to replace Grade A spruce and not less than 29.5 pounds per cubic foot when replacing Grade B spruce. Douglas fir having either of these densities may be expected to give the minimum values shown in Figure 19-2 when containing 15% moisture. These expected minimum strength values must be corrected by being increased or decreased by the correction shown for each 1% moisture respectively below or above 15%.

SPECIES OF AIRCRAFT WOODS

General

9 Woods are grouped into two general classes; hardwoods, such as birch and mahogany, which come from trees with broad leaves; and softwoods, such as spruce and noble fir, which come from conebearing trees with needlelike or scalelike leaves. The terms hardwoods and softwoods are not truly descriptive of mechanical hardness, since some of the so-called softwoods (Douglas fir) are harder than some of the so-called hardwoods (yellow poplar). For classification of aircraft woods, see Figure 19-3.

Douglas Fir (Coast Type)

10 The strength properties of Douglas fir (Coast type) generally exceed those of spruce but it is heavier. For purposes of aircraft design and construction, two weight classes of Douglas fir are specified, Class L (lightweight) and Class N (normal weight). For repair purposes, only Class N is considered. Douglas fir may be used for general repair, including parts highly stressed in bending or compression. (Refer to Paragraph 8, preceding.)

Noble Fir

11 Noble fir is slightly lighter in weight than spruce and is equal or superior to spruce in all properties except hardness, shear parallel to the grain and shock resistance. It is suitable for use in aircraft structural parts that must carry heavy loads in bending and compression, such as spars, spar flanges and longerons.

Port Orford Cedar

12 Port Orford cedar exceeds spruce in all strength properties, but is slightly heavier. Its heartwood, like that of other cedars, is highly resistant to decay. It may be used for structural parts in spruce sizes.

Spruce

13 Spruce species used are red, Sitka and white. Of the three, Sitka spruce is by far the most important and common because it is available in large sizes which are relatively free from defects. The strength of spruce is high with relation to its weight, a characteristic that makes it the standard of comparison for determining the suitability of most other species for general aircraft purposes.

Western Hemlock

14 Somewhat heavier than spruce, western hemlock is very similar to that species in strength properties. It has the same stiffness, is slightly lower in shock resistance and is slightly higher in all other strength properties.

Specifications	Grade A (PSI)	Grade B (PSI)	Correction (PSI)
End Grain Compression Strength	7,000	4,700	400
Modulus of Elasticity (E)	1,900,000	1,600,000	55,000
Modulus of Rupture	11,000	8,200	600

Figure 19-2 Strength Values for Douglas Fir

Material of aircraft quality is suitable for highly-stressed parts in bending and compression.

Ash

15 Biltmore white, blue, green and white ash species are similar in density and mechanical properties and cannot be distinguished from one another by means of the wood alone. They are marketed as white ash or commercial white ash. Commercial white ash is a favoured wood in aircraft where bending and compressive strengths, stiffness, shock resistance and capacity for bending to a required shape are requisites. It seasons satisfactorily, stays in place well and presents no manufacturing difficulties. It serves as a standard of comparison where these properties are essential.

A = Good B = Medium C = Poor	Characteristics					Strength Properties					
Kind of Wood	Low weight	Freedom from Shrinkage	Freedom from Warping	Ease of Working	Decay Resistance of Heartwood	Bending Strength	Stiffness	Strength as a Short Column	Hardness	Toughness	Nail Holding
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Ash, white	C	B	B	C	C	A	A	A	A	A	A
Balsa	AA										
Basswood	A	C	B	A	C	C	B	C	C	C	C
Birch, yellow	C	C	B	C	C	A	A	B	A	A	A
Cedar, Port Orford	B	A	A	A	A	B	A	B	B	B	B
Douglas fir	B	B	B	C	B	A	A	A	B	B	B
Noble fir	A	B	B	B	C	B	A	B	C	B	B
Hemlock, western	B	B	B	B	C	B	A	B	B	B	B
Mahogany	B	A	A	A	A	B	B	B	B	B	B
Maple, hard	C	C	B	C	C	A	A	A	A	A	A
Oak, white	C	C	B	C	B	A	A	B	A	A	A
Spruce, Sitka	B	B	A	B	C	B	A	B	C	B	
Sweetgum	B	C	C	B	C	B	B	B	B	B	B
Walnut, black	A	B	A	B	A	A	A	A	A	A	
Poplar, yellow	B	B	A	A	C	B	B	C	C	C	B
For Specific Engineering Data see Table Part 25											

Figure 19-3 Classification of Aircraft Woods

Balsa

16 Balsa is an extremely light tropical American wood, used chiefly as a low-density core material in sandwich-type construction and fairing material.

Basswood

17 A light wood, basswood is low in strength properties. Its use in aircraft is largely limited to core stock in plywood.

Birch

18 Sweet and yellow birch are similar in their properties and cannot be distinguished from each other by the wood alone. Although heavy, it finds many uses in aircraft construction because of high strength and shock resistance. It is extensively used in the manufacture of plywood, propellers, bearing blocks, and occasionally in the fabrication of framing members.

Mahogany

19 Mahogany from Central America is heavier than spruce and higher in all strength properties with the exception of stiffness. Mahogany is extensively used in aircraft plywood. It has excellent resistance to shrinking, swelling, warping and is easy to work.

Maple

20 Black maple and sugar maple are classed as hard maple. Both are heavy, hard and stiff, and cannot be distinguished from each other by appearance of the wood alone. Hard maple is a good wood for face veneer of plywood where abrasion resistance is important. It is used for bearing blocks where bolts pierce beams.

Oak

21 The various species of commercial oaks both red and white, are fairly similar in properties. They are very heavy and hard and are extremely variable in strength.

Sweetgum

22 Sweetgum is heavier than spruce and higher in its strength properties with the exception of stiffness. It is a common veneer and plywood species.

Black Walnut

23 Black walnut is a medium dense wood. It has good wear-resistant properties and retains its shape well. It has a number of uses in aircraft as bearing block material, plywood and propellers.

Yellow Poplar

24 Yellow poplar is a little heavier than spruce and although somewhat low in shock-resisting capacity has excellent working qualities, ability to retain shape, and freedom from checks and shakes. It is extensively used in plywood and also finds some use in solid members.

SPECIFIC GRAVITY

General

25 Broadly speaking, the strength of wood depends upon its weight when dry. For a given moisture content, the higher the specific gravity, the greater the strength of the wood. To compare the weight of various woods, all must be at the same stage of moisture content. Specific gravity is commonly used to compare woods in this respect. Specific gravity is of basic importance in selecting aircraft woods. Specifications provide minimum specific values for all woods to be used. For some species, maximum weights are also specified.

Determination of Specific Gravity

26 A simple method of determining the specific gravity of wood is by the flotation method. Essentially, the method consists of determining the proportion of a piece of wood with parallel sides that is submerged when floated in water.

Moisture Content

27 Green wood contains moisture in two forms; as free water in the cell cavities, and as moisture retained within the cell walls. In drying, wood gives up the free water first. After the free water has been removed and as the wood begins to lose the moisture that is within the cell walls, it will start to shrink. Conversely, dry wood will absorb moisture and swell when exposed to damp conditions.

28 Because of this shrinking and swelling, according to the conditions under which it is used, aircraft wood being worked into finished parts should be, as nearly as possible, in equilibrium with the atmospheric conditions to which it will be subjected in use. Wood exposed to constant temperature and relative humidity will, in time, reach a definite moisture content, called the equilibrium moisture content. Temperature and relative humidity values fluctuate with seasons and localities. The strength of wood is lowered as its moisture content increases. The approximate rate of loss in several important strength properties is shown in Figure 19-4.

DEFECTS

General

29 No tree is made completely of perfect wood. There may be imperfections of grain or defects, such as knots, compression wood, compression failures, checks or decay although the extent and kind of defects vary widely from tree to tree. Aircraft wood receives careful inspection for such defects at time of manufacture but repair personnel should be alert to their presence, since even aircraft grades of wood contain a certain amount of defective material per shipment. The usefulness of material is governed by the seriousness of the defect in a particular piece and by the position in the finished part that the defective piece may occupy. Following is a brief summation of the more important wood defects.

Grain Defects

30 The direction in which the fibres of a piece of wood extend determines its grain direction. Grain may be parallel to the length of the piece, or growth defects may cause cross grain which may be spiral, interlocked, wavy, or curly. All of these grain defects weaken wood objectionably for aircraft use. Various inspection methods have been devised for detecting excessively sloping grain. Cross grain often causes the surface to chip and roughen when a piece is planed against the grain, thus signalling its presence. The direction of grain can be ascertained by dropping a little free-flowing ink on the tangential surface of a board and noting that the ink spreads in the fibre direction.

Strength Property	Percentage Loss with 1% Gain in Moisture Content
Bending	4
Strength as a Short Column	6
Stiffness	2

Figure 19-4
Strength Loss due to Moisture Content

31 Slope of grain is measured conveniently in inches of length per inch of deviation from straightness. A slope of 1 inch in a length of 12 inches is steeper than a slope of 1 inch in 15 inches. Thus, limitations on slope of grain are usually expressed as 1 in 15, 1 in 20, and so on.

CAUTION

The slope of grain in a piece of solid wood used in repair must not be steeper than 1 in 15 with respect to the longitudinal axis of the piece being repaired.

Knots

32 A knot is that portion of a branch or limb that has become incorporated in the body of a tree. It may be round, oval, or spiked in shape, depending upon how it is cut through when the log is sawn into lumber or cut into veneer. The chief objection to knots is the localized grain deviation they cause, with its attendant weakening of the wood at that point. If a knot is sound and tight, its size determines whether the piece containing it is acceptable for aircraft. In spruce, for example, a knot for most repair purposes must not be greater than 1/8 inch in diameter or one-eighth the width of the face, whichever is smaller.

Compression Wood

33 Softwood species sometimes develop a growth defect known as compression wood, which is formed on the lower side of leaning trees. Because it is weak, heavy, and shrinks excessively and unevenly along the grain, compression wood is not permitted in aircraft except in limited amounts. Compression

wood ordinarily has relatively wide annual rings and an unusually large percentage of summerwood, which is not as dark when dry nor as hard as in normal wood, thereby giving the wood a lifeless appearance.

NOTE

Confusion will be avoided if it is clearly understood that compression wood and compression failures are two distinct and totally unrelated wood defects, despite the fact that the word compression is common to both.

Compression Failures

34 Excessively rough handling, such as the felling of a tree across a log, may cause buckling of the wood fibres. This defect, known as compression failure, seriously weakens the bending strength and shock resistance of wood and makes it unfit for structural parts of aircraft. A compression failure appears as a series of irregular, threadlike lines across the grain of a piece, (see Figure 19-5). It can best be seen on smooth surfaces.

Checks, Shakes and Splits

35 Checks, shakes and splits are superficially similar and seriously lower the strength of wood when pronounced. A check is a longitudinal crack running more or less radially across the annual rings in a board caused by seasoning, (see Figure 19-6). A shake develops when two annual rings break apart and may be found in green or dry wood. A split is a lengthwise separation of wood due to the tearing apart of the wood cells. Delamination refers to separation of pieces of wood along the glue joint.

Figure 19-5
Compression Failure in Sitka Spruce

Stains and Decay

36 While not all stains are evidence of decay, stain generally accompanies even the early stages of decay. Discolourations caused by decay usually appear as streaks that may extend several feet along the grain from the decayed area. As a rule, discolourations that uniformly discolour the annual rings are evidence of decay. Rotted wood characteristically ranges from brown to white in colour.

Pitch Pockets

37 Pitch pockets are small openings within annual rings that contain resin and sometimes bark. They occur in Douglas fir and spruce and may be several inches long. They tend to weaken small members and exude pitch, thus damaging some aircraft finishes.

Bark Pockets

38 A bark pocket is a patch of bark enclosed in the wood. Found most often in spruce, it definitely weakens the wood because it causes some separation of the wood substance.

Pitch Streaks

39 Pitch streaks are easily seen infiltrations of pitch (resin) in the fibres of wood. They are objectionable chiefly because they add weight to the piece and may exude pitch to damage the finish of aircraft.

Other Defects

40 Various minor defects may be found in aircraft woods. As a rule, their effect on strength is sufficiently small to warrant

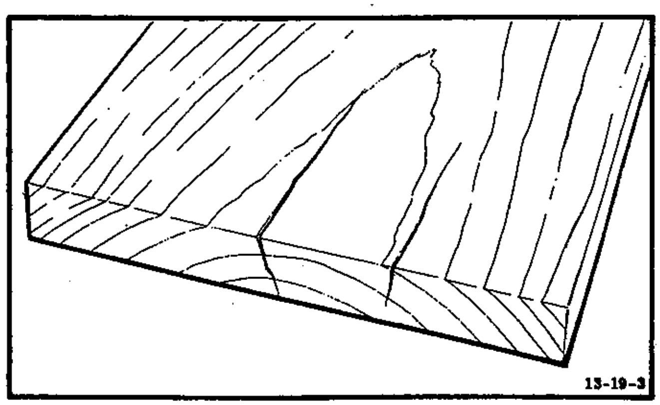


Figure 19-6 Checks

ignoring them. Such defects include mineral streak, indented rings, giant resin canals in spruce, red streak in spruce, floccosoids (white spots that are not decay) in western hemlock and bird peck. Such defects as bird's-eye in maple are important according to the frequency of their appearance. In thick clusters they cause enough grain deviation to decrease strength seriously.

LUMBER

General

41 Aircraft lumber must pass Government inspection for conformity with species specifications. It is usually either plain-sawn or quarter-sawn. Plain-sawn lumber is usually referred to as flat-grain stock because its wide surfaces expose the annual rings in broad parabolic shapes. Quarter-sawn lumber is called edge-grain stock because its wide surfaces expose the edges of the annual rings in parallel lines.

42 Generally, quarter-sawn lumber shrinks and swells less than flat-sawn lumber across its width, and also twists, cups, slivers and surface checks less, while wearing more evenly. On the other hand, the round or oval knots characteristic of plain-sawn lumber weaken the board less than do the spike knots found in quarter-sawn stock. The flat surfaces of plain-sawn lumber are often referred to as tangential surfaces, while those of quarter-sawn lumber are called radial surfaces.

STORAGE

General

43 Stocks of lumber used in repair of aircraft must be given warehouse storage. The warehouse should be well ventilated with no artificial heat. Such storage, for several weeks or more, will help to relieve drying or case hardening stresses as well as preventing undue changes in moisture content and checking stain and decay. A well ventilated warehouse will permit the stock to come to equilibrium with the prevailing atmospheric moisture content. This is necessary since the aircraft to be repaired will be in equilibrium with that moisture content. Ensure that warehouse is thoroughly dry before storing lumber.

Piling

44 Follow good piling practice. All lumber must be piled wherever stored and labeled according to items and nomenclature. Pile foundations should permit circulation below the pile, with the lowest layer of lumber 18 inches above the ground. In floored warehouses, 4 inches clearance is permitted. Piles should be at least 2 feet apart, not nearer than 2 feet to outside walls, and not more than 6 feet wide. Place 1 inch thick stickers between layers of stock not more than 1-1/2 inches thick; for thicker materials of random length, use 1-1/2 inch stickers. Align stickers not more than 2 feet apart over the stringers in the foundation of the pile. Leave vertical flues, or chimneys, 4 inches wide for each 12 or 14 inches of board width in the pile, so that air may circulate up and down through the pile. Avoid solid piling without stickers because the stock near the top and sides of the pile will, under changing weather conditions, develop a different moisture content from that of the material toward the centre of the pile. Store small pieces, such as accumulate in carpenter shops, on shelves off the floor, preferably in unheated areas.

PLYWOOD

General

45 Plywood consists of thin sheets of wood, called veneers, which are glued together, usually with the grain of one ply, at right angles to that of adjacent plies. Built in this manner, plywood achieves two purposes; in large panel sizes, it supplies a material that has more nearly equal strength properties in its length and width than solid wood, and at the same time it shrinks and swells only about one-tenth as much across the grain as does solid wood.

46 Plywood usually has a single core ply, on opposite sides of which are glued additional plies in pairs. The outer plies are called face plies, those between the faces and the core are called interplies. Plywood is made in a varying number of plies to meet special strength requirements. Generally speaking, an increase in the number of plies results in a decrease in the tensile and bending strengths parallel to the grain of the face plies and an increase in these strengths at right angles to the grain of the faces.

47 Aircraft veneer is produced mostly by two methods, rotary cutting and slicing, although sawing is permitted. Rotary-cut veneer can be cut in much greater widths than either sliced or sawn veneer, but the latter types are cut from longer logs and hence the individual sheets are longer in the grain direction.

48 Aircraft plywood is made with synthetic-resin glues of the hot-setting, phenolic type, or glues of equivalent properties which are highly water-resistant. Resin-bonded plywood will absorb moisture in much the same manner as does solid wood, but the arrangement of the plies and the gluing with highly water-resistant glues enable plywood to resist changes in width and length due to moisture changes. These resin glues do not make the wood itself plastic.

Species

49 Aircraft plywood may be constructed of veneer of a single species or of several species. When veneers of several species are used in the same panel, the heavier and harder species are used for face plies and the lighter, softer species for cores and cross bands.

50 Aircraft flat panel plywood is required to have a moisture content of 8 to 12% when shipped. Some change in moisture content may occur during shipment. It is desirable to have the moisture content of plywood to be used for repair purposes as close as possible to the moisture content of the aircraft part being repaired. For this reason, it is the best practice to keep several months supplies on hand, using oldest stock first.

DEFECTS

General

51 The type and number of defects permissible in the face, back and core plies of aircraft plywood are limited by specifications. No open defects are permitted in the face ply, but certain limited open defects, such as small knot holes, splits, worm holes and open joints, are permitted in the back ply and core veneers. The inclusion of such defects may result in weakening of small parts cut from large panels. Use judgement when choosing small pieces cut from large panels for repair purposes.

52 Plywood surfaces that are glazed, show bleed-through of glue, or contain heavy tape marks or other foreign materials that may interfere with gluing, should be lightly hand sanded before gluing.

Storage

53 Store plywood in a dry, well ventilated unheated warehouse as soon as removed from crates and shipping boxes. Pile plywood flat on a platform supported by suitable stringers, not less than 4 inches from the floor to permit ventilation. Adequate clearances for ventilation, inspection and handling must be left between piles. Dry plywood may be piled as high as the building will permit, provided a base is used, either a platform or closely laid boards. If the material arrives in a wet condition, it must be piled with wooden spacers between each piece. Spacers, the full width of the sheets, should be placed in vertical rows to prevent distortion of the plywood. The spacers between any two sheets must be of the same size. Use spacers of dry wood not less than 1/2 inch, nor more than 3/4 inch thick, and not less than 1-1/2 inch wide. Space as follows:

(a) Plywood 3/8 inch thick or over - 24 inches apart.

(b) Plywood 3/16 inch to 5/16 inch thick - 12 inches apart.

(c) Plywood 5/32 inch thick and less - 8 inches apart.

54 When plywood has dried to a moisture content of 12% or less, the spacers may be removed.

AIRCRAFT GLUES AND GLUING

General

55 The adhesives most commonly used in wood working are divided into five classes; animal liquid glues, vegetable (starch) glues, casein, vegetable protein glues and albumin glues. There are various other adhesive substances including silicate of soda, mucilages, pastes, rubber cements, cellulose cements, phenol-aldehyde and urea-aldehyde compounds, gums, asphalt and shellacs, some of which are used to a considerable extent for gluing wood. Only a few of the these types of

adhesives include glues which are approved for use in aircraft fabrication. To date, approved types of aircraft glues include the caseins, urea-formaldehydes, phenal-formaldehydes and certain modifications of the latter two.

Casein Glues

56 Casein glues are obtained by mixing water and certain chemicals with casein, which is obtained from milk. They are often referred to as glue cements because, when allowed to set, they become entirely different in properties from the original mixture and most of them cannot be redissolved by water. The main advantage of casein glues is their water resistance. Casein glue is supplied in a dry powder form. When mixed in accordance with directions, it yields a homogeneous pasty fluid, free from grit. Casein glue is intended for use in repairing wooden members of aircraft. The glue provides a water resistant joint which will withstand tensile loads as high as 1000 pounds per square inch.

Mixing Casein Glue

57 For mechanical or hand mixing, use mixing bowls of porcelain, enamel or tinned steel. Steel or iron bowls may cause discolouration of the glue. All bowls and mixing equipment must be kept clean. Disposable paper cups are satisfactory for use as dispensing containers. Use low speed mechanical mixers at 60 to 140 rpm only, to prevent aeration of the mix. Hand mixing may be accomplished by wooden paddles of local manufacture. The manufacturers recommended mixing and proportion directions, printed on each container label, must be followed in preparing glues for use. The usual mix is one part of dry glue powder to 1-3/4 to 2 parts water by weight. The temperature of the water should be between 60° to 70°F for best results. Add the glue powder slowly to the water while mixing, mix for five minutes or until the glue is a stiff paste. Do not overmix. Allow the mixture to stand for 20 to 30 minutes and mix again for a period of three to five minutes. After the final mixing, the glue should have a creamy consistency and be free of lumps, undissolved glue and air bubbles. The glue is now ready for use.

Application of Casein Glue

58 A satisfactory gluing surface is smooth, uniform, true and clean, free from loose and crushed fibre. Such surface permits maximum adhesion of the glue and is prepared by the use of sharp cutting tools such as planers, jointers, knives, handplaning, spokeshaves, chisels, etc.

CAUTION

Do not sand contacting surfaces, as the resulting dust will impair adhesion. The only possible exception will be in the case of plywood surfaces which are hard to glue. (Refer to Paragraph 97 following.)

59 Apply the glue liberally with a clean brush or wooden paddle to both joint surfaces. Keep open assembly time to a minimum. The parts should be assembled, jigged and clamped as soon as possible. Ensure that sufficient glue remains between the surfaces to form the bond. Remove the squeezed out glue with a clean cloth or wooden scraper while still liquid. Leave pressure on joints until set. The period of time varies according to temperature and pressure application. A time lapse of three times the pressure period must be allowed before the glued numbers are stressed in machining or finishing operations, except for minor skin and rib repairs.

Hazards

60 Store casein glue powder in tightly closed containers to prevent caking and deterioration. Discard mixed glue after a maximum period of four hours, or earlier if excessive thickening or ropiness occurs. Never add water to the glue mix; add the powder to the water during the original mixing. The shelf life of properly stored casein glue powder is in excess of 12 months. Procure only minimum requirements.

Animal Glue

61 Animal glues may be used for all general (non-aircraft) woodworking requirements. Warm the liquid glue slightly, by immersing the can in hot water, to aid in penetration of the wood surfaces. Prepare the dry glue by adding water in the ratio of two ounces by weight of glue to three fluid ounces of water and allow to soak for several hours until the glue is a hard jelly consistency. Then warm the water and glue in a water bath or glue pot until a smooth liquid state is reached.

Do not allow the liquid glue to reach a temperature above 60°C (140°F). Apply the glue by brush or wooden paddle to both surfaces. When the glue is tacky, assemble and clamp parts. Maintain pressure for approximately 24 hours. A further 24 hour time lapse is recommended before the glued members are stressed in machining or finishing operations. The glue procured as a liquid may lose up to half its strength after a storage period of six months. Procure only minimum requirements.

NAILS AND SCREWS

General

62 The holding power or resistance to withdrawal of wire nails is proportional to the embedded length, to the diameter of the nail where the wood does not split and to $G^{2.5}$, where G is the oven-dry specific gravity of the wood. The safe resistance to withdrawal (safety factor of 6) of common wire nails soon after driving into the side grain of seasoned wood is shown in Figure 19-7. Cement and other coatings on nails may add materially to their resistance in softwoods. Drilling lead holes slightly smaller than the nail adds somewhat to the resistance and reduces the danger of splitting.

Nails

63 Efficient joinings of aircraft parts cannot be made with nails because nails cannot efficiently transfer important stresses from one aircraft part to another. Nails are used both in original construction and in repair only to produce pressure on glued joints and to hold parts in position and alignment while fitting or gluing. They are used to produce pressure only when other and more effective means, such as clamps or presses, are not available or the use of such appliances is inconvenient or impractical.

64 Nails used for the purpose of obtaining pressure on a glue joint are commonly driven through a nailing strip. Nailing strips have

Species	Specific gravity	Size of nail									
		Sixpenny	Eightpenny	Tenpenny	Twelvepenny	Sixteenpenny	Twentypenny	Thirtypenny	Fortypenny	Fiftypenny	Sixtypenny
Birch, yellow and sweet	.69	51	60	67	67	74	87	94	102	111	120
Douglas fir	.51	24	28	32	32	35	41	44	48	52	56
Maple, sugar	.68	50	57	65	65	71	84	91	99	107	115
Oak, red and white	.69	51	60	67	67	74	87	94	102	111	120
Pine, longleaf	.64	34	39	45	45	47	50	55	59	64	69
Pine, northern white	.37	13	15	17	17	19	22	24	26	28	30
Pine, ponderosa	.42	15	17	19	19	21	25	27	30	32	35
Pine, shortleaf	.59	28	32	36	36	38	41	44	48	52	57
Redwood	.42	15	17	19	19	21	25	27	30	32	35
Spruce, Sitka	.40	14	17	19	19	21	25	27	29	31	34

Figure 19-7 Nail Withdrawal Resistance

three important functions: They spread and distribute the pressure; they provide for easy withdrawal of nails either by pulling them away with the nails or by leaving nails accessible to withdrawal tools when the strips are split and removed; they prevent the marring of surfaces when nails are overdriven or driven flush to produce maximum pressure.

65 The character of the nail point is of more importance in aircraft work than the character of the shank. The point affects both the holding power and splitting, but the difference in the tendency of the point to split the wood is generally more important than its influence on holding power. Blunt points cause less splitting than do long sharp points but the latter have a higher holding power when there is no splitting. Blunt points are usually preferable for nailing into small members but sharp points are acceptable for nailing into heavier members that are not readily split. The grooved, square, and triangular shanks all have higher resistance to withdrawal than does the plain shank and consequently may be expected to give greater pressure.

Number of Screw	Diameter of Shank	Max. Diameter of Head of Round Head Screw	Drill Number First Hole	Drill Number Second Hole
1	.073	.138	48	56
2	.086	.162	44	54
3	.099	.187	40	51
4	.112	.211	33	47
5	.125	.236	30	41
6	.138	.260	28	36
7	.151	.285	24	32
8	.164	.309	19	29
9	.177	.334	16	26
10	.190	.359	12	20

Figure 19-8
Drill and Guide Hole Sizes for Screws

Wood Screws

66 Wood screws are commonly used in aircraft repair for the same purpose as nails and their use for these purposes is limited by like considerations. They are also frequently used to attach cabin trim and to fasten metal parts to wood. They are not suitable for connecting highly-stressed parts, but may be useful for supplementing the glue. Screws should be used and left in place where employed in the original design. Screws may also be left in place where the glue line is subjected to severe tensile stresses perpendicular to the glue line and where the screws will aid in transferring the load. Drill guide holes for screws when used for permanent fastenings. Two holes, the sizes of which should correspond with the number of the screw to be used, (see Figure 19-8), must be drilled when the screw is used to fasten two pieces of wood or plywood. One hole should be drilled through the first piece, and if necessary, into the second piece just large enough to accommodate the shank of the screw without binding. The other hole should be drilled into the second piece, just large enough to provide clearance for the core (diameter at root of threads) of the screw, thus leaving enough wood to permit the threads of the screw to be anchored in the sides of the hole. Drill final depth of the hole slightly less than overall length of the screw.

67 When screws are used to apply pressure through pressure strips or plates for gluing plywood patches, a hole the size of the screw shank is drilled in the pressure strip or plate and the patch. No guide hole is necessary for the second piece.

NOTE

Do not start screws with a hammer.

68 The safe lateral resistance of wood screws embedded not less than 7 diameters in the side grain of seasoned wood is about 2.4 times that of wire nails of the same diameter. Other general rules for wood screws are:

(a) The size of the lead hole should be about 70% of the root diameter in softwood, 90% in hardwood.

(b) Lubricant, such as soap, may be used without appreciable loss of holding power.

(c) Long slender screws are generally preferable, but in hardwood slender screws may reach the limit of their tensile strength.

(d) Where splitting can be avoided, the end grain should support 75% of the load safe for the side grain.

(e) In the screws themselves, holding power is favoured by screws with thin sharp threads, rough unpolished surface, full diameter under the head, and shallow slots.

FINISHES

General

69 Repair of wooden aircraft necessarily involves repair of the finish. Exterior surfaces of aircraft are finished to provide protection against weathering of the wood, a smoother surface to minimize skin resistance in flight and suitable appearance. There are two methods by which external surfaces of plywood may be finished, directly on the wood and by applying fabric covering.

(a) The directly on the wood finish is utilized where it is desired to apply a minimum number of coats to provide the necessary protection. This type of finish tends to develop cracks over glue joints and areas of localized stress.

(b) Fabric covering is applied to wood surfaces because it affords a smooth covering for plywood and veneer joints and edges, thereby protecting the finish against cracking. It conceals any checking that may occur in plywood faces, imparts greater resistance against abrasion by sand during landing and take-off, and permits easy removal of the old finish and application of new without weight increase.

70 Interior surfaces are finished with sealer to afford a measure of protection against moisture, especially that entering through vents, bullet holes, cracks and joints and that caused by high atmospheric humidity.

Finishing Materials

71 Paint materials required for finishing wood are of the following types; sealers, wood fillers (pigmented sealers), sanding surfacers, patching putties, varnishes, lacquers, enamels and clear and pigmented dopes. The lacquers, enamels and pigmented dopes are used in the glossy and camouflage types.

Sealers

72 The application of sealer on both interior and exterior surfaces is required in order to protect the wood against rapid changes in moisture content. In addition, the sealer on exterior surfaces prevents absorption of subsequent topcoats by the wood, thereby permitting satisfactory finishes with a minimum number of coats.

Wood Filler

73 Wood filler is usually sealer containing relatively large proportions of pigments, and is used to fill and level off the pores of mahogany and other hardwoods to provide smoother base for subsequent finish coats. Apply filler to bare wood before sealer coats.

Sanding Surfacers

74 Sanding surfacer is applied in direct on wood finishes when a finish of greater smoothness is required. The dried surfacer is sanded to provide a smooth foundation for lacquer or enamel.

Patching Putty

75 Patching putties are essentially sanding surfacers which are thick enough to be applied with a putty knife or with the fingers to fill any holes, cracks or other surface blemishes. Nail holes left in nail-strip gluing, for example, may be filled with patching putty before finishing enamel is applied.

Lacquers and Enamels

76 Lacquers differ from enamels in the basic film forming ingredients used and in the manner in which they dry.

Dopes

77 Dopes are special materials intended for application to fabric surfaces. They also serve to cement fabric to wood surfaces. Cellulose nitrate dope is generally used but where fire-resistant qualities are required, cellulose acetate butyrate dope is used.

Application

78 Brush or spray are the most practical methods of application of finish. Using a brush, the painter can easily avoid coating surfaces that are to be glued. When using spray guns, such surfaces are protected by masking tape. Where entire wing assemblies are rebuilt or where major rebuilding of fuselages is undertaken, the use of dipping tanks for the application of sealer to interior surfaces of wings and spraying equipment for the finishing of outer surfaces may prove economical.

JOINTS IN PLYWOOD

General

79 Three types of joints are employed in plywood skin. These are lap, butt and scarf joints. Lap joints are not recommended. Butt joints must never be employed unless plywood splice plates are used and sufficient glue area is provided. Scarf joints are the most satisfactory type and are employed whenever possible. When plywood joints are made on top of relatively large wood members such as beam flanges, it is desirable to use splice plates regardless of which type of joint is to be made. All repairs must be such as to ensure that the repaired members are at least equally as strong as the originals, because of their importance as load-carrying members. When a splice is required, strength equal to the original member can be obtained only by the use of reinforcing plates. Reinforcement is also usually required at points of attachment of fittings to spars and other members. When such reinforcement is repaired or affected by repair work, special care must be exercised to obtain strength at least equal to that of the original construction.

Glued Joints

80 Glued joints must be designed to minimize the risk of failure due to differential shrinkage of the component parts. Precautions must be taken to shield glued joints from rain and accumulated rain water when the aircraft is flying and on the ground. Drainage holes must be provided at all points where water could accumulate. Glued joints in positions where moisture is likely to accumulate must be ventilated. Splices for the insertion of new lengths of members should not be used except in such cases where it is possible to secure adequate clamping along the complete length of the joint.

81 Structurally important joints are those whose failure or deterioration would ultimately cause collapse of the structure or cause the pilot to lose control of the aircraft. The following joints must always be treated as structurally important.

(a) The junctions between the plywood webs of spars and the spar flanges.

(b) The attachment of strips and packing blocks to spars when such strips and packing blocks are required to contribute to the strength of the spar.

(c) The joints which transmit the main forces from the skin of plywood monocoque

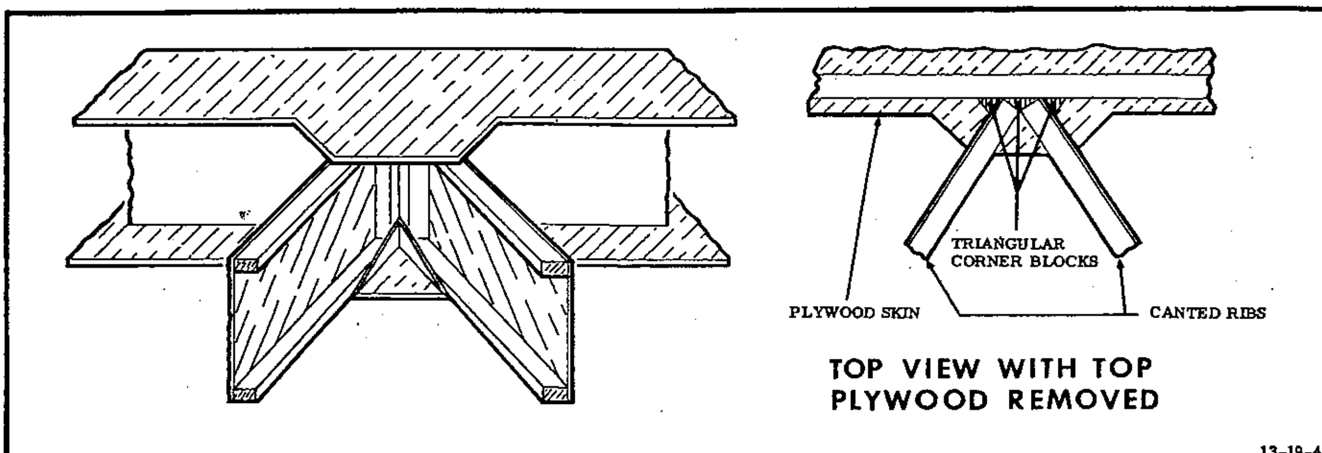


Figure 19-9 Canted Rib to Spar Attachment

components. Stringers whose chief function is to act as plywood stiffeners are not included.

(d) The attachment of gussets, i.e. the gussets used in wooden ribs.

(e) Joints in the plywood of main structural components made subsequent to the manufacture of the plywood.

(f) Repair splices in spar flanges.

(g) Repair splices in longerons.

82 These joints must either be made with synthetic resin cement, Specification DTD 335 or casein glue, or the glued joint must be reinforced with screws or clinched brads so spaced that the distribution of pressure is reasonably uniform over the glued area and the average pressure between the glued surfaces is not less than 30 pounds per square inch.

Reinforcement of End-grain Glue Joints

83 Glue joints on end-grain will carry no appreciable load. Strength of such joints is increased by providing additional gluing surfaces that utilize corner blocks or gussets. Such reinforced joints are typical in joining rib members, in attaching ribs to beams, or intercostals to frames. Canted ribs may be attached as shown in Figure 19-9.

84 Spars and spar flanges may be either horizontally or vertically laminated. Individual laminations may be made up of pieces edge-glued together. Stagger such edge-glued joints in adjacent laminations not less than the thickness of the thicker laminations. (See Figure 19-10.) In laminated members the longitudinal distance between the nearest scarf tips in adjacent laminations must be not less than ten times the thickness of the thicker lamination.

85 In addition to the foregoing specific requirements, limit the number of scarf joints as much as possible and locate them in portions of the member where margins of safety are most adequate. Where necessary tapering produces an angle between the grain and edge of the piece greater than that corresponding to the allowable slope of grain, reinforce the piece to prevent splitting by gluing plywood reinforcing plates to the side faces which have been cut to the undesirable angle. Use special care in the construction and repair of ribs to maintain the shape, since any change in shape of an airfoil section changes its aerodynamic characteristics.

Attachment of Metal Fittings to Wood

86 Whenever metal fittings are attached to wood members it is generally advisable to reinforce the wood against crushing by the use of bearing plates (usually high-density plywood) and to use a coat of bitumastic paint, or similar material between the wood and the metal to guard against corrosion. Bearing plates will help to prevent splitting of the solid wood member if they are crossbanded. High-density crossbanded material will thus serve both purposes. Use fittings with wide base plates to prevent crushing at the edges. Separate wood washers have a tendency to cone under tightening loads. Where possible, it is desirable to use a washer plate for groups of bolts.

Repair of Local Damage Due to Bolt Head Crushing

87 To repair local damage caused by crushing under bolt heads, proceed as follows:

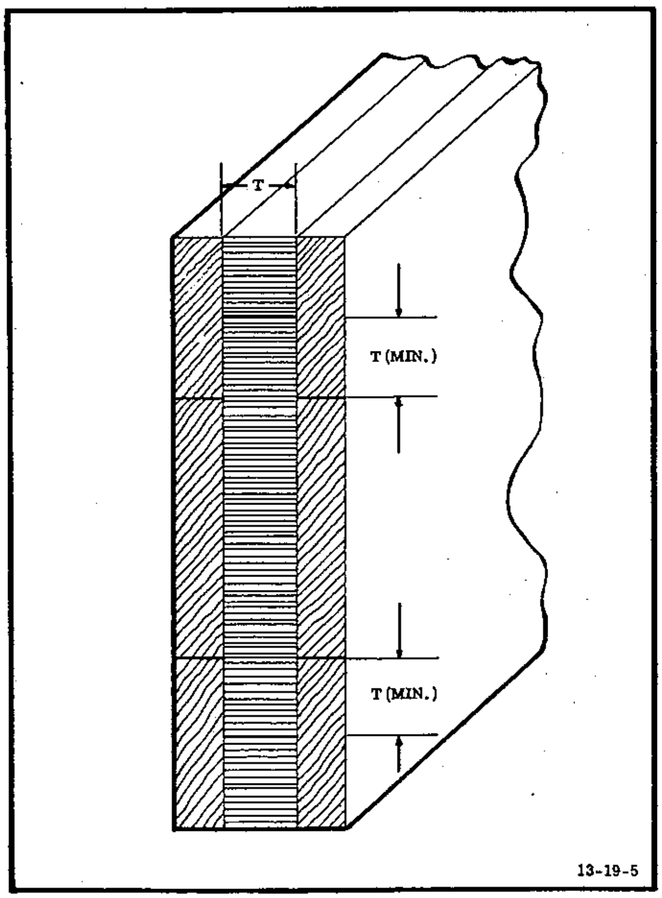


Figure 19-10 Staggering of Glue Joints

(a) Use a convex router to trim the area around the bolt hole so that depression is uniform for the area.

(b) Cut a plug from three-ply wood with a concave router of the same contour as that used to trim the spar.

(c) Glue the plug into position and clamp for drying with washer and bolt.

(d) When plug has set and dried, cover the area with a plywood plate.

(e) This repair is limited to cases where the diameter of the crushed area is less than 1-1/2 inches and the depth at no point is greater than 1/8 inch.

BENDING PROCESSES

General

88 Where it is desirable to use solid wood rather than laminated wood and it is necessary to bend the wood, select only the best, clear, straight-grained material. Most bent parts are of ash, spruce or oak and replacement parts will be of the same species or permissible substitutes.

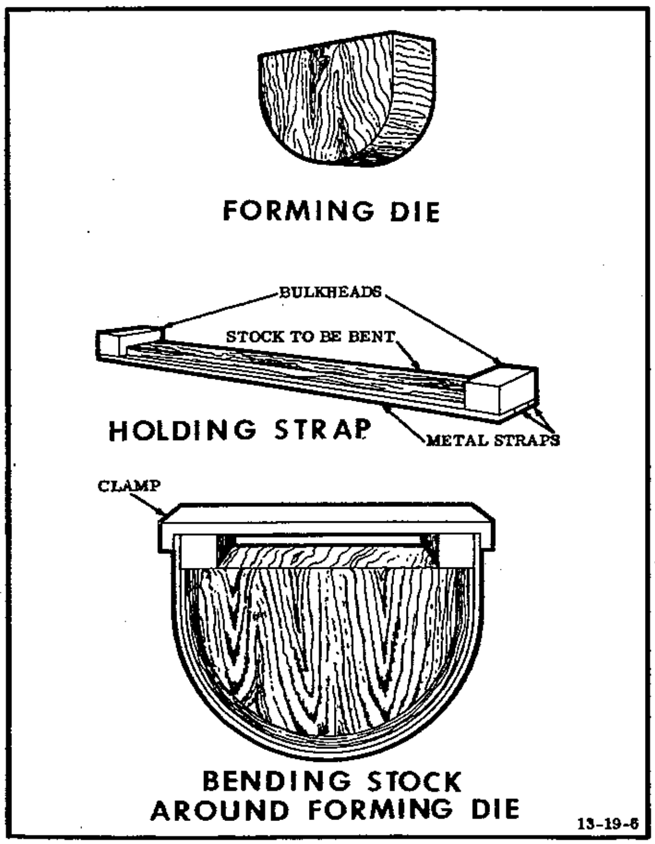


Figure 19-11
Bending Form and Holding Strap Application

89 Wood must be softened before bending by the addition of moisture or heat, and for best results a combination of the two is recommended. Wood can be softened by soaking in water or by steaming. Subject the wood to boiling water or steam for about one hour per inch of bending thickness to prepare wood for bending. Boiling or steaming the wood for more than four hours is not recommended as the strength of the wood may be impaired. A typical bending form is shown in Figure 19-11. Leave the piece in the form until it reaches the same moisture content as that of other wood members of similar size in the aircraft being repaired. The radius of curvature to which wood can be bent depends on the thickness, species, quality of material, preparation and bending technique. Do not bend hardwoods to a radius smaller than 7 times the thickness. For the softwoods, the recommended minimum radius is 18 times the thickness.

NOTE

If the part being repaired or replaced was originally steam bent, the repair or replacement may be made by steam bending or laminating. If the part being repaired was originally laminated, it must be repaired or replaced by a laminated part in order to avoid springback.

Bending of Plywoods

90 Boiling for more than two hours or steaming for more than one hour is not recommended and will not be necessary on the thickness of plywood used in aircraft. The degree of curvature to which a piece of plywood can be bent will depend upon the direction of the grain and the thickness. Use Figure 19-12 as a guide in determining which process of bending to use for the curvature being considered.

91 After softening, plywood may be bent on a cold ventilated form or it may be bent over the surface near the part being patched, if space permits. In either method, allow it to dry completely on the form. When bending

plywood over a leading edge, drying is hastened by laying a piece of coarse burlap over the leading edge before using it as a bending form. A fan to circulate the air over the bent piece will speed the drying.

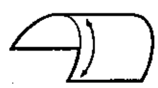
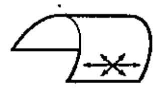
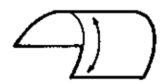
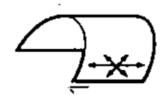
Laminating

92 Constructing a straight or curved member by gluing several thin strips or laminations together is usually called laminating. Typical examples of laminated parts are spar flanges, wing tip bows, leading edge rib caps and fuselage frames. Cold-setting urea-resin or casein glues are generally used for these operations. Pressure is normally applied by large screw presses. The maximum thickness of laminations for curved members may be determined from Figure 19-12. Apply the clamps loosely at first to bring the material nearly to shape and then tighten, starting at the centre of curvature and working toward both ends.

BORING HOLES FOR BOLTS AND BUSHINGS

General

93 The smoothness of the walls of bolt holes in wood and plywood has a marked effect on the bearing capacity of aircraft bolts. Use a drill

Plywood Thickness	No. Plies	10% moisture content, bent on cold mandrels		Thoroughly soaked in hot water and bent on cold mandrels	
		At 90° to face grain 	At 0° or 45° to face grain 	At 90° to face grain 	At 0° or 45° to face grain 
(1)	(2)	(3)	(4)	(5)	(6)
.035	3	2.0	1.1	0.5	0.1
.070	3	5.2	3.2	1.5	.4
.100	3	8.6	5.2	2.6	.8
.125	3	12	7.1	3.8	1.2
.155	3	16	10	5.3	1.8
.185	3	20	13	7.1	2.6
.160	5	17	11	6	2
.190	5	21	14	7	3
.225	5	27	17	10	4
.250	5	31	20	12	5
.315	5	43	28	16	7
.375	5	54	36	21	10

Columns (1) and (3) may also be used for determining the maximum thickness for single laminations for curved members.

13-19-7

Figure 19-12 Bend Radii

of a diameter equal to the nominal bolt diameter. The size of the resulting hole must be such that the bolt can be inserted by light tapping. Boring undersize holes, which are subsequently reamed to size, should not be done unless the reamer is used in conjunction with a steel template having hardened steel inserts. Bolts may be best inserted by pushing them in through the use of a C-clamp, placing a short length of tubing on the far side of the hole into which the threaded end of the bolt may project. Where the hole is oversize, a loose fit will result which causes the bolt to bear on a narrow line and produce either excessive deformation or unequal load distribution, whereas too tight a fit tends to cause splitting of the wood as the bolt is forced or driven in with resultant weakening of the fastening. Holes bored for fittings must align with corresponding holes in the metal. This requires that the holes be accurately positioned and that each hole be carefully aligned.

Use of Bushings

94 Plastic or light metal bushings are frequently used in wood to provide additional bearing area without appreciable increase in weight. Thin steel bushings are used to prevent crushing of the wood when the bolts are tightened. Smoothness, positioning, fit and alignment of bolt holes are equally important in boring holes for bushings.

GLUING PRACTICE

General

95 A satisfactory glue joint must develop the full strength of the wood under all conditions of stress. To produce this result, the conditions involved in the gluing operation must be carefully controlled so as to obtain a continuous, thin and uniform film of glue in the joint with adequate adhesion to both surfaces of the wood. High quality glue joints cannot be made on wet wood. Aircraft parts to be repaired must be permitted to dry out if they are wet. Members to be glued should be as close to the same moisture content as possible, since this will ensure glue joints free from objectionable stresses resulting from unequal swelling and shrinking of the wood with moisture changes.

Preparation of Wood Surfaces for Gluing

96 A satisfactory gluing surface is smooth, uniform, true and clean, free from loose and crushed fibre. With normal wood, smooth, even surfaces produced on planers and jointers with sharp knives and correct feed adjustment are best for gluing. Surfaces prepared by hand planing, chisels, spokeshaves and similar cutting tools are equally satisfactory for gluing if they are smooth, uniform and true. Surfaces prepared with scraping tools are satisfactory for gluing if they are smooth, uniform, true and free from loose and crushed fibre.

Sanding of Plywood Surfaces

97 Sanding is only recommended for plywood surfaces that are normally hard to glue. Only light sanding of plywood is permitted and this is all that is necessary to correct unfavourable surface conditions.

Previously Glued Surfaces

98 When glue joints are made to previously glued surfaces, satisfactory gluing surfaces can be produced by removing the glue and the thinnest possible layer of wood that will provide a fresh wood surface.

Modified Wood Products

99 Densified and resin-impregnated wood products, such as compreg, which are frequently used as bearing plates, must be flat and hand or machine sanded before satisfactory glue bonds can be made to them.

Other Surfaces

100 It is normally more difficult to make satisfactory glue joints to end-grain than to side-grain wood surfaces. For this reason, scarf joint surfaces must be very carefully prepared and every precaution must be taken to see that the surfaces are smooth, true and well fitted. Straight end-grain butt joints cannot be made as strong as scarf joints, and when such joints are made, reinforcing plates must be provided. End-grain to side-grain joints are likewise not strong and are usually reinforced with corner blocks, gussets or plywood angles.

NOTE

Too much emphasis cannot be placed on proper preparation of wood surfaces for gluing. Unless this is accomplished, uniform and high quality glue joints will not result regardless of how carefully the gluing operation may be carried out. Whenever sanding is practiced, ensure that the surfaces remain smooth, uniform and true. Avoid sanding except for special cases, (see Paragraphs 96 and 97, preceding).

Nail-strip Gluing

101 Nail-strip gluing is a method of applying pressure to a glue joint by driving nails through a thin strip, through one of the parts being assembled and into the other. The application of plywood skins to wing or fuselage frames is a typical example. The nails in the nailing strip should extend through the plywood and into the framing member a minimum of three times the thickness of the plywood. Use No. 18 to 20 treated flathead steel nails of the proper length. Drive the nails with several moderate blows of the hammer rather than by one hard blow. The tops of all nail heads after driving should be flush with the surface of the nailing strip. When removing the nailing strips, avoid damage to skin.

NOTE

In nail-strip gluing and in nail gluing, start at the centre and proceed to the edge of the panel, or progress from one edge to the opposite edge. This will prevent bulges caused by nailing simultaneously from both edges of the panel toward the centre. In applying leading edge skins, start at the leading edge and progress simultaneously toward both edges of the panel. To ensure good glue joints, fit curved skins accurately to the curved framework.

Nail Gluing

102 Nail gluing applies gluing pressure directly to a glue joint by nailing through one part and into the other. In this operation the nails are left in, and therefore brass, copper or plated nails are recommended. Use a nail spacing of 1/2 inch for plywood of 1/8 inch or less in thickness and a spacing of 1 inch for thicker plywood. Avoid nail gluing whenever possible on plywood greater than 1/8 inch thick. Extend the nails through the plywood and into the framing member a minimum of three times the plywood thickness.

Screw Gluing

103 Screw gluing applies pressure to a glue joint by means of wood screws. The most common method of applying this pressure is by inserting permanent screws through drilled and countersunk holes in the pieces being glued. Extend the screws through the plywood into the framing member a minimum of twice the plywood thickness. Use the minimum screw diameter available for the length required.

Time Required to Apply Pressure

104 When nails or screws are used to apply pressure to a glue joint between plywood and framing members, ensure the application of pressure on the complete joint within the permissible assembly period.

Assembly Time

105 Apply pressure to the joint before the glue becomes too thick to flow. Where the surfaces are coated with glue and exposed freely to the air (open assembly) a much more rapid thickening of the glue occurs than when the pieces are laid together as soon as the glue is spread (closed assembly). With casein and cold-setting resin glues, assembly periods should not exceed 10 minutes if open or 20 minutes if closed for temperatures not exceeding 32° C (90°F). Since most gluing operations involve both open and closed assembly periods, the permissible limits for any operation is computed from the fact that one minute of open assembly results in as much thickening of the glue as does two minutes of closed assembly. Because relatively low pressures are the rule in repair work, make every possible effort to stay within the recommended assembly periods.

Application of Pressure

106 The application of adequate and well-distributed pressure is one of the most important factors in producing consistently high quality glue joints. The functions of pressure include spreading of the glue to form a continuous thin film between the wood layers,

forcing air from the joints, bringing the wood surfaces into intimate contact with the glue and holding them in this position while the glue sets. The best results in gluing are obtained when the pressure is distributed uniformly over the entire joint area. The amount of pressure required to produce strong glue joints varies over a wide range. The minimum pressure permissible for any assembly is one that will ensure close contact of the wood surfaces and hold the members in close contact while the glue sets. Although the amount of pressure that may be applied with various clamping devices will vary with the individual clamp and operator, a rough approximation for some common clamping is shown in Figure 9-13.

Type of clamp	Total load in pounds delivered
Wood parallel clamp (with wood screws)	100 to 200
Wood parallel clamp (with metal screws)	400 to 700
C-clamp (depending upon size of clamp)	1,000 to 3,000
Bar clamps	2,000 to 3,000

Figure 19-13
Pressures Applied by Clamping Devices

Duration of Pressure

107 Leave joints under pressure at least until they have developed sufficient strength to withstand internal stresses tending to separate the members and also such stresses as may be placed on the joints during the removal of nails, nailing strips and clamps. Figure 19-14 shows the minimum time in hours that joints must be left under pressure at various temperatures. Before the aircraft can be flown, allow a period of six times the pressure period shown for unstressed joints to elapse.

REPAIR PRINCIPLES AND PROCEDURES

General

108 Repairs fall into two classes; emergency or temporary repairs, and permanent or base repairs. The type of repair to be made will depend largely upon the equipment and time available. Emergency repairs are made as a temporary measure and must be replaced at the earliest opportunity. Permanent repairs are normally made at a base where a wider selection of equipment and tools is available. Time is an important factor, but the quality, strength and permanence of the repair are the

Temperature of air and wood	Stressed or nail strip glued joints		Straight, perfectly mated unstressed joints	
°F	Resin	Casein	Resin	Casein
	Hours	Hours	Hours	Hours
40-49	Not to be used	12	Not to be used	8
50-59	Not to be used	10	Not to be used	7
60-69	Not to be used	8	Not to be used	6
70-79	6	6	4	4
80-89	5	5	3	3
Above 90	4	4	2	2

Figure 19-14 Pressure Time for Glued Joints

prime considerations. Some weight must be added in many cases, but weight beyond that necessary to assure a repair as strong in the direction of stress as the original part should be avoided.

CAUTION

Should any repairs be made which affect weight of control surfaces, adequate check must be made and rebalance effected if necessary. (Refer to Part 18, preceding.)

109 Recommended repairs for typical parts of wooden aircraft only are described here. All of them involve gluing and many of the glue joints are in the finished parts of the aircraft. In these repairs, remove all finish, sealer, old glue and foreign matter from the surfaces by scraping and sanding. Varnish and paint removers are not recommended. Lightly sand the final surface before application of the glue. Avoid abrupt changes in cross-sectional area to eliminate dangerous stress concentration. Do this by tapering splices and making small skin patches round or elliptical snaped instead of rectangular. Round off sharp corners. Make the cross-sectional area of a splice or patch at least equal that of the damaged part. Match the grain direction of the repair part to that of the original.

EMERGENCY REPAIRS

General

110 Emergency repairs must be replaced with permanent repairs as soon as facilities are available.

Skin

111 Most emergency or temporary repairs are made to the skin of the aircraft and the repair is often only a means of covering a hole to keep out rain or snow and to reduce air turbulence. Fabric may be doped on the plywood if the hole is small (with the largest dimension of the trimmed hole not greater

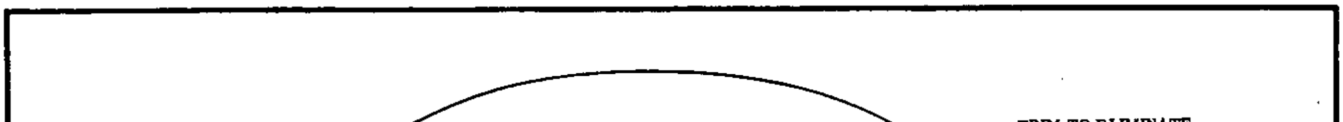


Figure 19-15 Emergency Skin Repair for Small Holes

than 20 times the skin thickness) and not in the leading edge or frontal area of the fuselage where high air pressure exists in flight. Small holes in plywood skin surfaces, not exceeding 40 times the skin thickness in the greatest dimension, may be patched with plywood as shown in Figure 9-15. Trim jagged holes neatly so that stresses are not concentrated at sharp corners and so that splits will not extend into the sound skin near the damage. If the leading edge is damaged, cut away the damage to a neat line, avoiding sharp corners, and cover with any plywood available. Bend the plywood after soaking. If necessary, use the leading edge near the damage as a form. Glue the plywood to the surface and nail along the edges. No attempt need be made to match face grain directions as 45° plywood is difficult to bend under the conditions usually present when an emergency repair is needed.

112 External patches must not terminate forward of the 10% chord point. The forward edge of patches terminating aft of the 10% point must be bevelled as shown. Patches forward of the 10% point are made by wrapping the patch around the leading edge.

Ribs

113 Broken ribs can often be repaired by nailing splices over the break as splints or tacking a piece of thin plywood over one entire side of the broken rib.

PERMANENT REPAIRS TO SKIN

General

114 When removing damaged portions of plywood from the framework, take care not to damage the surface of the frame. First cut or saw plywood on both sides of the framing member, leaving a strip just the width of the framing member. Then remove most of this strip of plywood with a chisel and the remainder by planing, scraping or sanding. Most of the patches described here can be put in entirely from one side and access from the back is not necessary. Where access from both sides may be available, the work may progress somewhat more conveniently by working from the two sides.

115 Much of the outside surface of plywood aircraft is curved. On such areas, plywood used for repairs to the skin must be similarly curved. Curved skins are either of single curvature or of double (compound) curvature. A simple test to determine which type of curvature exists may be made by laying a sheet of heavy paper on the surface in question. If the sheet can be made to fit the surface without wrinkling, the surface is either flat or has single curvature. If the sheet cannot be made to fit the surface without wrinkling, the surface is of double curvature. Repairs to skins of single curvature are formed from flat plywood, either by bending dry or after soaking in hot water.

116 The moulded plywood necessary for a repair to a damaged skin of compound curvature cannot be made from flat plywood unless the area to be repaired is very small or is of exceedingly slight compound curvature. Moulded plywood of the proper curvature must be on hand before the repair can be made.

Repairs to One Ply

117 Damage to one ply only of the plywood skin may often be repaired without removing a portion of the plywood. Fill scratches in the grain direction, or scratches which deviate not more than 1 in 15 the grain direction at any point, with a mixture of resin glue and wood flour or sander dust. Make the mixture of a paste consistency and fill the cracks until a noticeable bead projects above the surface. After the glue mixture has set, sand this bead down flush with the original surface of the wood before refinishing.

118 If edge-glued joints between face veneers are not properly glued or are open due to processing or exposure, the joints may be repaired by the method described in Paragraph 117, preceding, provided that the crack is first cleaned and cut to a 90° vee before working in the glue paste. It is important that the point of the vee-cutter does not scratch or cut the second ply. Adjust the tool to cut only about 2/3 of the way through the face ply.

Repairing Damage to Leading Edge

119 To repair leading edge damage, proceed as follows:

(a) Bend plywood for repair, using leading edge (protected by burlap) as the form.

(b) Prepare backing strips of leading edge curvature by bending on a correctly shaped jig.

(c) Reinforce the skin at ribs and at edges of repair with backing strips.

(d) Install block at rib leading edge when solid wood backing strips are used.

(e) Remove temporary patch and scarf in repair to leading edge using stiffeners. Scarf patch edges and proceed with scarf patch.

(f) Bend plywood over ventilated form of leading edge shape for smaller repairs. Tack a stick over plywood if plywood bulges away from form.

Fabric Patch

120 Do not repair holes nearer than one inch to any frame member or in the leading edge or frontal area of the fuselage using fabric patches. Repair other small holes not exceeding one inch in diameter as follows:

(a) Trim to a smooth outline.

(b) Dope a fabric patch onto the outside of the plywood skin.

(c) Seal the edges of the trimmed hole.

(d) Serrate or fray the edges of the fabric.

Small Surface Patch

121 Holes in plywood skins, after being trimmed to a smooth outline, may be repaired by applying a plywood surface patch. The details of this patch and two methods of gluing are shown in Figure 19-16. In method A, permanent flathead screws are used to apply pressure to the glue line. In method B, round-head screws through a plywood pressure plate are used to serve the same purpose. After the glue has set, the screws and plate are removed. In either case a fabric cover is doped in place over the surface patch before finishing. If fabric is doped on over an old patch directly on wood finish without first removing this finish, blistering of the old finish often results. It is therefore advisable to remove the old finish from the area to be covered by the fabric.

Splayed Patch

122 Small holes with largest dimensions not over 15 times the skin thickness in skins not more than .100 inch in thickness are repaired by using a circular splayed patch as illustrated in Figure 19-17. The term splayed is used to designate that the edges of the patch are tapered but that the slope is steeper than is allowed in scarfing operations. Proceed as follows:

(a) Lay out the size of the patch as shown in Figure 19-17. Centre the dividers as near to the damage as possible or tack a small piece of plywood over the hole for a centre point and draw two circles, the inner one to be the size of the hole and the outer one marking the limits of the taper. The difference between the radii is five times the thickness of the skin. If one leg of the dividers has been sharpened to a chisel edge, the dividers may be used to cut the inner circle completely through.

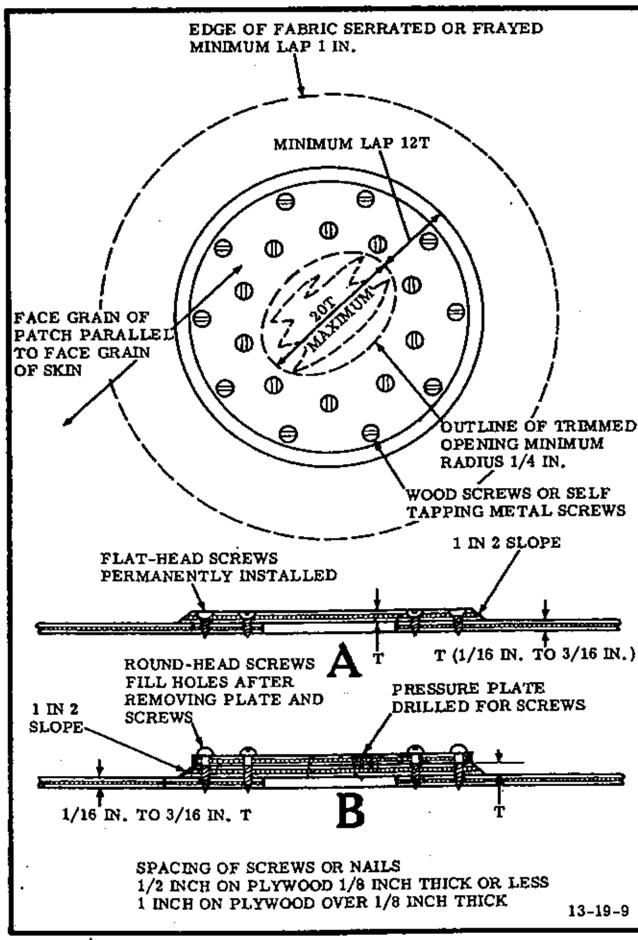


Figure 19-16 Small Surface Patch

(b) Taper the hole evenly to the outer circle with a chisel, knife or rasp.

(c) Prepare a circular tapered patch to fit the prepared hole and glue the patch into place with the face grain direction matching that of the original surface.

(d) Use paper between the patch and a plywood pressure plate cut to the exact size of the patch. This prevents extruded glue from binding patch and plate together. Centre the plate carefully over the patch.

(e) Apply pressure. As there is no reinforcing behind this patch, check that pressure is not great enough to crack the skin. On horizontal surfaces weights or sandbags will be sufficient. On vertical surfaces apply hand clamps lightly but snugly. On patches too far in for the use of standard hand clamps, jaws of greater length may be improvised.

(f) Fill, sand and refinish the patch.

Oval Plug Patch

123 The oval plug patch is used on plywood skins that have been damaged provided that the damage is not larger than can be covered by the patches whose dimensions are given in Figure 19-18. As the oval plug patch is strictly a skin repair, it may be used only for damage that does not involve the supporting structure under the skin. Oval patches must be prepared with the face grain direction carefully oriented. To make an oval plug patch, proceed as follows:

(a) Explore the area about the hole to ensure that it lies at least the width of the oval doubler from a rib or a spar.

(b) Lay a previously prepared oval plug patch over the damage and trace the patch. Saw to the line and trim the hole edges with a knife and sandpaper.

(c) If underside is sealed, remove sealer by scraping. Inspect the underside with a small mirror to be sure that all sealer has been removed.

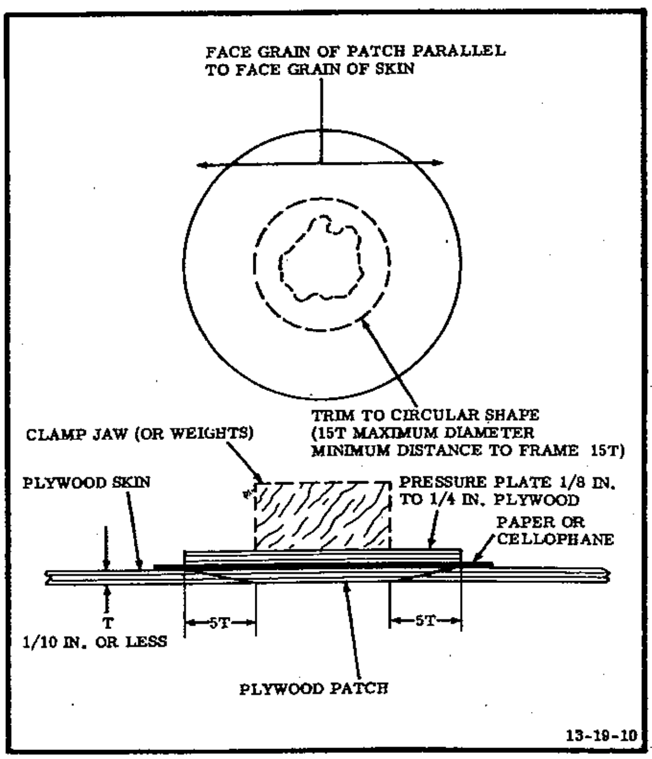


Figure 19-17 Splayed Patch

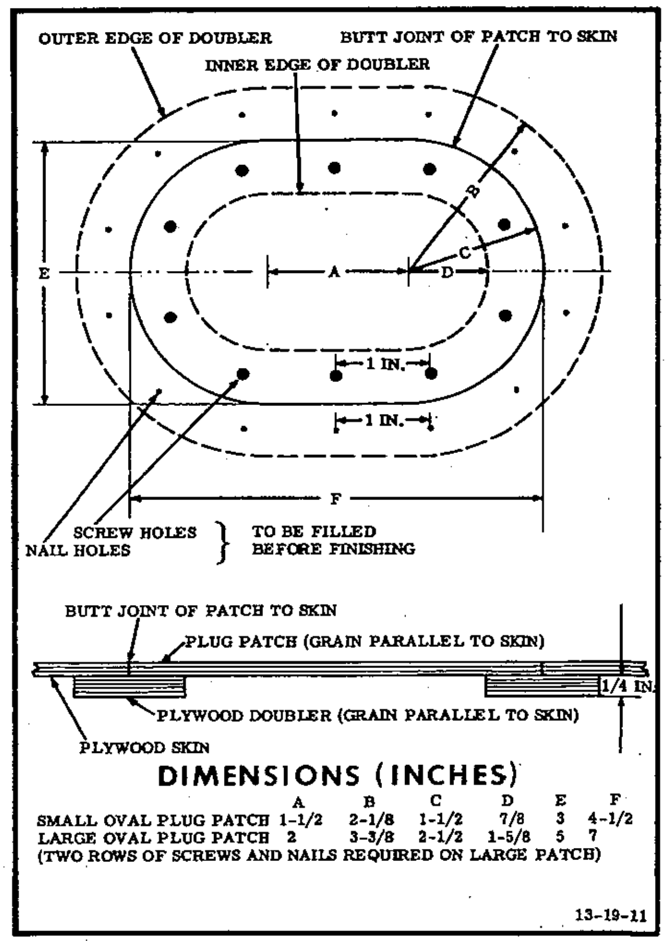


Figure 19-18 Oval Plug Patch Assembly

(d) Mark the exact size of the patch on one surface of the oval doubler and apply glue to the area outside the line. Make the oval doubler of some soft-textured plywood, such as yellow poplar or spruce. Insert doubler through the hole and bring it, glue side up, to the underside of the skin with its pencil outline of the patch matching the edges of the hole. Preform the doubler to the approximate curvature by hot water or steam bending, if the curvature of the surface to be repaired is greater than a rise of 1/8 inch in 6 inches.

(e) Apply nailing strips, outlining the hole, to apply glue pressure between doubler and skin. Use bucking bar to provide support for nailing. When two rows of nails are used, stagger nail spacing.

(f) Apply glue to remaining surface and to an equivalent surface on the patch.

(g) Lay the patch in position over the doubler. Match the face grain direction of the patch to that of the surface to be repaired.

(h) Screw the pressure plate to the patch assembly using a small nail to line up the holes that have been previously made with patch and plate matching. Use No. 4 round-head screws. Leadholes in the plywood doubler are not necessary. Paper or cellophane between plate and patch prevents glue from sealing the plate to the patch. Do not apply clamps or further pressure, as the nailing strips and screws exert ample pressure. Hot sandbags may be laid over the patch to speed the setting of the glue.

(j) After glue has set, unscrew the plate, remove the nailing strips with a pair of pliers (a claw hammer may crack the skin), remove the paper or cellophane and scrape off the extruded glue.

(k) Sandpaper the patch smooth and fill the screw holes and nail holes. The patch is now ready for finishing.

Round Plug Patch

124 The steps in making a round plug patch are identical with those for making the oval plug patch, except for the insertion of the doubler and the orientation of the face grain direction of the patch. In using the round patch where access is from one side only, the round doubler cannot be inserted through the hole unless it has been split. This leaves an area of weakness over the split in the doubler. Rotate the round patch until grain direction matches that of the face grain direction when patch is inserted.

Surface Patch

125 Plywood skins that are damaged between or along framing members may be repaired by surface or overlay patches. Trim damage to a rectangular or triangular shape and round the corners. Make the radius of rounded corners at least five times the skin thickness. Always cover surface patches with fabric before finishing. If fabric is doped on over an old finish without first removing this finish, blistering of the old finish often results. It is therefore advisable to remove the old finish from the area to be covered by the fabric. Overlap the original skin at least one inch, and serrate or fray edges. Do not terminate external patches forward of the 10% chord point. The forward edge of patches terminating aft of the 10% point must be bevelled to four times the skin thickness. Make patches forward of the 10% point by wrapping the patch around the leading edge. Use the following procedure to make a surface patch:

(a) Determine extent of damage and mark trim line.

(b) Cut out the damaged portion.

(c) Remove fabric when plywood skin is fabric covered, but do not cut into plywood.

(d) Put packing strips on unsupported edges, using saddle gussets attached to framing members. Scrape off dope or finish from plywood surface.

(e) Prepare surface patch. Space, drill and countersink screw holes. Apply sealer to inside and replace skin stiffeners if used in original construction.

(f) Apply glue to cleaned skin surface and to patch. Use nailing strips for pressure on supported laps and screws over unsupported portions of laps.

(g) After glue has set, remove nailing strips and sandpaper the patch.

(h) Apply clear dope to patch. Apply serrated or frayed-edge fabric patch and apply clear dope over the fabric. Work out air bubbles at edges with brush.

SCARF PATCH

General

126 A properly prepared and inserted scarf patch is the best repair for damaged plywood skins. It is the preferred type for most skin repairs and must be used when the repair exceeds the size limitations for other types of patches. Do not install scarf patches of the steepest allowable slope (1 in 12) if the radius of curvature of the skin at right angles to the edge of the patch at any point on the outline of the patch is less than 100 times the skin thickness. To determine the radius, use a curved block, with a radius of 100 times the skin thickness, applied to the area of the patch. If the curved block has less curvature than the outside of the skin, the block will rock. A scarf joint cannot be made in the skin at this point. If the curved block fits the skin or rests on both its ends, a scarf joint can be made. This test applies to skins of either single or compound curvature.

127 Patches covering several rib spaces may be installed by using reinforcing strips in each rib spacing covered by the scarf joint. Make scarf patches that require scarf joints at the edge of a spar or other member having an apron strip without removing the overhanging apron strip. If the overhanging edge of the apron strip is damaged, repair both the apron strip and the skin.

128 Scarf cuts in plywood may be made by hand plane, spokeshave, scraper or accurate sandpaper block. Rasped surfaces, except at the corners of scarf patches and sawn surfaces, are not recommended as they are likely to be rough or inaccurate. Use any method which produces accurate, smooth scarfed surfaces.

129 Nail strip gluing is often the only method available for gluing scarf joints in plywood when used in repair work. It is essential that all scarf joints in plywood be backed with plywood or solid wood to provide adequate nail-holding capacity.

Scarf Patch (Back of Skin not Accessible)

130 To make a scarf patch where the back of the skin is not accessible, proceed as follows:

(a) Inspect the damage to determine the extent and to see if damage occurs to ribs or spars. Determine the size of patch to use.

(b) Cut the hole to remove all damaged skin. Use hand tools carefully to avoid splintering. Cut and trim accurately.

(c) Remove sealer from underside of skin where reinforcing is to be attached and inspect with a mirror.

(d) Install backing strips along all edges that are not fully backed by a rib or a spar. To prevent warping of the skin, make backing strips of a soft textured plywood, such as yellow poplar or spruce, rather than solid wood. All junctions between backing strips and ribs or spars must have the end of the backing strip supported by a saddle gusset of plywood.

(e) Nail glue new gusset plate to rib. It may be necessary to remove and replace the old gusset plate by a new saddle gusset or it may be necessary to nail a saddle gusset over the original.

(f) Attach nailing strips to hold backing strips in place while the glue sets. Use bucking bar where necessary to provide support for nailing. Unlike the smaller patches made in a continuous process, further work must wait while the glue holding the backing strips sets.

(g) After the glue attaching the backing strips has set, remove nailing strips. The hole is now firmly supported at all edges.

(h) Scarf the patch and round the corners. This rounding prevents areas of concentrated stress in the completed patch.

(j) Rasp and sand the junctions on the patch where scarfs from adjacent sides meet. This operation on the patch and at the corners of the hole results in a stronger patch than if the corners of both patch and hole were left angular.

(k) Mark the limits of the scarf around the hole and scrape away the finish, as it dulls cutting tools quickly.

(m) Scarf the hole with a spokeshave, small plane or chisel. Round the corners with a fine rasp.

(n) Glue patch in place with face grain direction matching that of the original surface.

(p) Apply nailing strips to all sides of patch and allow glue to set. Use paper or cellophane under the nailing strips.

(q) To speed the glue setting, hot sandbags may be laid over the nailing strips.

(r) Remove nailing strips and scrape away extruded glue. Prepare patch for finishing.

Scarf Patch (Back of Skin Accessible)

131 Major steps in installing a typical scarf patch in a thick plywood fuselage skin that is accessible from the back are as follows:

(a) Trim away damaged areas to framing members. Glue reinforcing strips to framing member and to skin.

(b) Attach diagonal reinforcing to skin and framing members with saddle gussets by gluing.

(c) Scarf the skin and prepare a scarfed patch to fit. Match face grain directions.

(d) Glue the scarfed patch in place, using nailing strips for pressure and using paper or cellophane under the nail strips.

(e) Remove nailing strips and paper or cellophane. Scrape away extruded glue. Prepare patch for refinishing.

Circular Scarf Patch with Double Curvature (Back of Skin Accessible)

132 To prepare a circular scarf patch with double curvature when back of skin is accessible, use the following procedure:

(a) Prepare a block of solid wood to conform to interior curvature and attach by nailing through from the front.

(b) Make a hole the exact size of the inside circle of the scarf patch in the block and centre over the trimmed area of damage.

Type of Patch	Limitations			
	Original skin thickness (T)	Maximum size of trimmed hole	Min. distance between trimmed hole & framing member	Surface Curvature
Fabric	No limitation	1 inch	1 inch	Not in leading edge
Small surface	1/16 to 3/16 inch	20T	No restriction	No limitation
Splayed	Not over 1/10 inch	15T	15T	Limited to flat
Oval plug	No limitation	5 by 7 inches	7/8 inch	Not in leading edge
Round plug	No limitation	6 inches in diameter	7/8 inch	Not in leading edge
Surface	Not over 1/8 inch	One frame space and 50 inch perimeter	No restriction	No limitation
Scarf	No limitation	No limitation	No restriction	No limitation

Figure 19-19 Skin Patch Limitations

(c) Prepare a scarf patch from plywood matched for curvature and face grain direction.

(d) Glue scarfed patch in place, using paper or cellophane between the backing block and the skin.

(e) Lay paper or cellophane over patch and nail on the external pressure ring. Pressure ring has been cut into four segments to fit the double curvature.

(f) Allow backing block to remain until glue has set, then remove backing block.

(g) Remove pressure ring and paper or cellophane. Remove extruded glue, sand the patch and prepare for refinishing.

(h) Clean the back of the patch. Apply sealer if the surrounding interior surface has sealer.

Summary of Limitations for Skin Patches

133 The factors that limit the use of each of the seven types of permanent skin patches to plywood-covered aircraft are shown in Figure 19-19. Of the larger patches, the most desirable is the scarf patch.

PERMANENT REPAIRS TO FRAMEWORK

General

134 The framework includes such items as spars, ribs, wing tip bows, longerons, fuselage frames, leading edge strips, trailing edge strips and any other part that acts as a part of the frame of the aircraft. The scarf joint is the most satisfactory method of making a joint in the grain direction between two solid wood members.

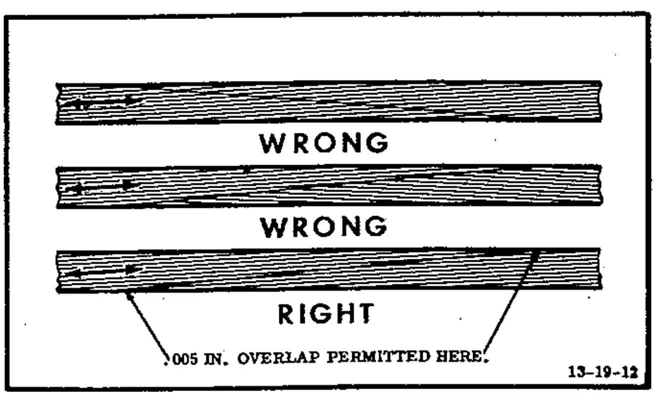


Figure 19-20
Proper Grain Direction for Scarf Joints

135 Cut both parts accurately, because the strength of the joint depends upon maximum contact between the two surfaces being glued. Whenever possible, cut scarf joints on a machine. If one part, however, is attached to the airframe, it must be cut by hand. A hand saw is ordinarily used for the rough cut and a plane or accurate sandpaper block for the final fitting. The proportion of end grain appearing on a scarfed surface may be undesirably increased if the material to be spliced is cross grained, and the scarf is made across rather than in the general direction of the grain. The increased end grain makes gluing more difficult and results in weak joints. When cross grain within the specified acceptable limits is present, make the scarf cut in the general direction of the grain slope. (See Figure 19-20.)

136 Solid spars or spar flanges may be replaced with, or spliced to, laminated spars or vice versa, provided the same species of wood, or one of the permissible substitutes, is used. For this substitution, use material of the same high quality, and match to flat grain or edge grain. Always replace external plywood reinforcements with plywood as in the original structure.

137 In gluing scarf joints the parts must be kept properly aligned and end slippage prevented. A very small amount of overlap (0.005 inch or less) as illustrated in Figure 19-20 is desirable to ensure adequate pressure. Two small nails, one at each end of the scarf, are usually sufficient to prevent end slippage. Remove after gluing. Apply gluing pressure to the scarf joint by means of an adequate number of screw clamps applied over pressure blocks.

Spars

138 A spar may be spliced at any point except under wing attachment fittings, landing gear fittings, engine-mount fittings, or lift and interplane strut fittings. Reinforcing plates must be used as indicated on all scarf repairs to spars. Duplicate all stiffeners on or within the original beam when the beam is repaired. Repair C and double I spars by the method shown for the repair of box spars. Damaged sections of spars may be removed and replaced

by using the methods of splicing shown in Figure 19-21. Whenever the replaced portion is so short that the reinforcing plates of the two splices are less than three times the width of the spar apart, a continuous reinforcing plate must be used over the two splices. Replace short sections of other types of spars by similar methods. Splices in box spars having deep flanges, such as centre section spars, are seldom practical. Repairs to curved portions of curved box spars are not permitted. Repairs to box spars are, therefore, limited to those with relatively shallow flanges or to portions near the wing tips.

Box Spar Webs

139 Small local damage to box spar webs may be repaired by using standard sized plug patches if the edge of the damaged area is far enough from the flanges or filler blocks to allow space for the reinforcing ring. Small circular surface patches may also be used wherever their projection will not interfere with the attachment of other members. Larger damaged areas require replacement of that portion of the web. Make the web splices by scarfing, as shown in Figure 19-21. The splice may be made over an existing filler block if its width is at least 12 times the web thickness. If an existing filler block is too narrow for the splice, it may be made wider by inserting an additional filler block on the side toward the damaged area.

Rib Truss Members

140 Replace damaged rib truss members which are held in individual gussets on both ends. If they are held in continuous gussets, repair by gluing a new member to one side of the damaged member.

Frames

141 Splice frames damaged to the extent that insertion of a new section is required as shown in Figure 19-22. A clean fracture with no material missing and involving no skin damage may be repaired as shown without disturbing the skin. Frames may be repaired at any point except under metal attachment fittings.

Longerons and Stringers

142 Longerons and stringers which are fractured at a frame must be repaired by replacing a short section. This will normally require removal of a portion of the skin. If the longeron is rectangular and has its wider dimension parallel to the skin, make the splice

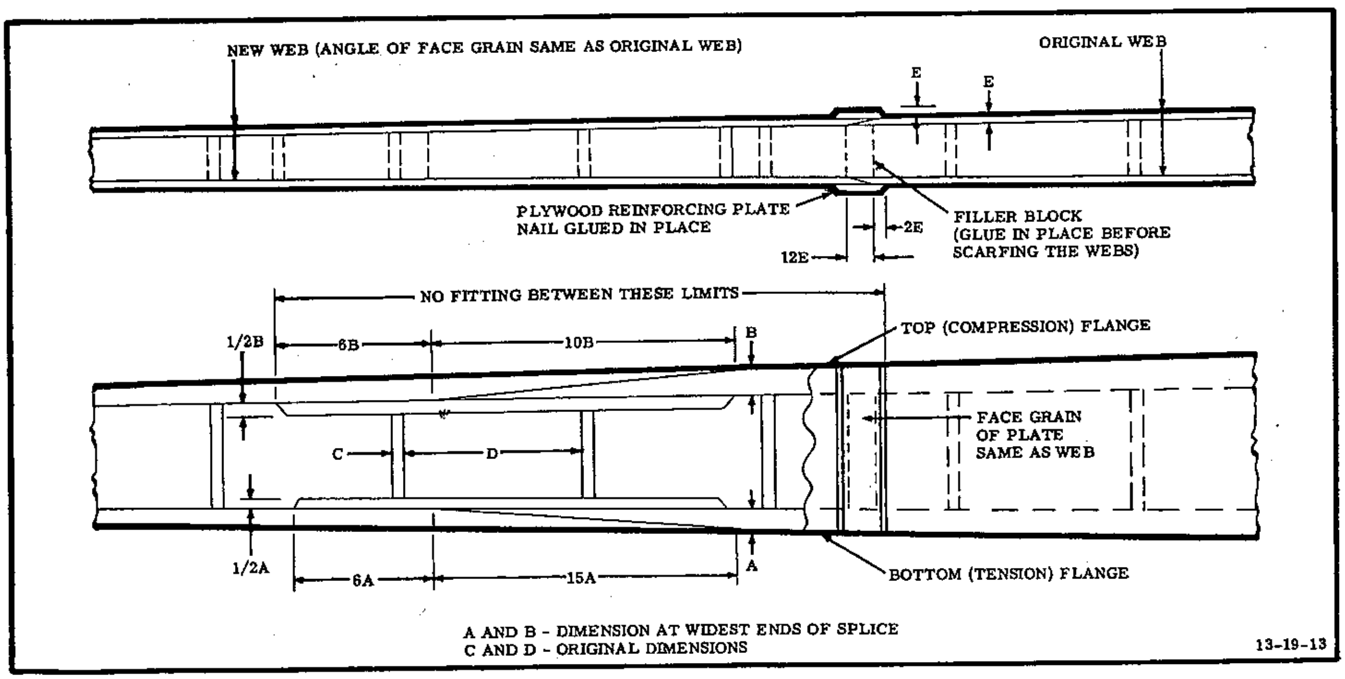


Figure 19-21 Repair to Box Spar

by the method shown in Figure 19-23. A stringer that is merely fractured, with the fracture far enough from a frame to permit, and with the skin undamaged, may be repaired by the method shown in Figure 19-24. This splice does not require removal of the skin. Cut the 1 in 5 slope shown on the reinforcing plates before gluing to the stringer and back by a small wedge during the clamping operation. Longerons which are fractured must be replaced or repaired by scarf splices.

Bulkhead and Rib Webs

143 Stiffening webs in ribs or bulkheads may be repaired or portions replaced by the same method as that recommended for the repair and replacement of webs on box spars. If the web is merely cracked, it may be repaired using reinforcement plates.

Wing Tip Bows

144 Extensive damage to a wing tip bow will require replacement. Make the blank for the replacement bow by laminating thin strips in a jig of the proper curvature. If damage is only slight, the bow may be repaired using reinforcing plates. The reinforcing section can be solid straight grain wood. The replaced portion of wing tip and the reinforcing plates can be made in a laminating jig or can be steam bent. If the part to be replaced is laminated, laminate the reinforcement strip also. Time can be saved by laminating both in the same jig at the same time, omitting the glue between the two pieces.

Stiffeners and Intercostals

145 Short skin stiffeners and short intercostals are usually not repairable and are replaced by new parts. Skin stiffeners which are merely cracked transversely and involve no damage to the skin, may be repaired using reinforcement plates.

Bearing Blocks

146 Do not repair bearing blocks of compreg or hardwood. Replacement will usually mean replacing a part or all of the damaged member.

Fairing Bulkheads

147 Extensive damage to a fairing bulkhead of conventional plywood design calls for replacement of the member. Cracked bulkheads may

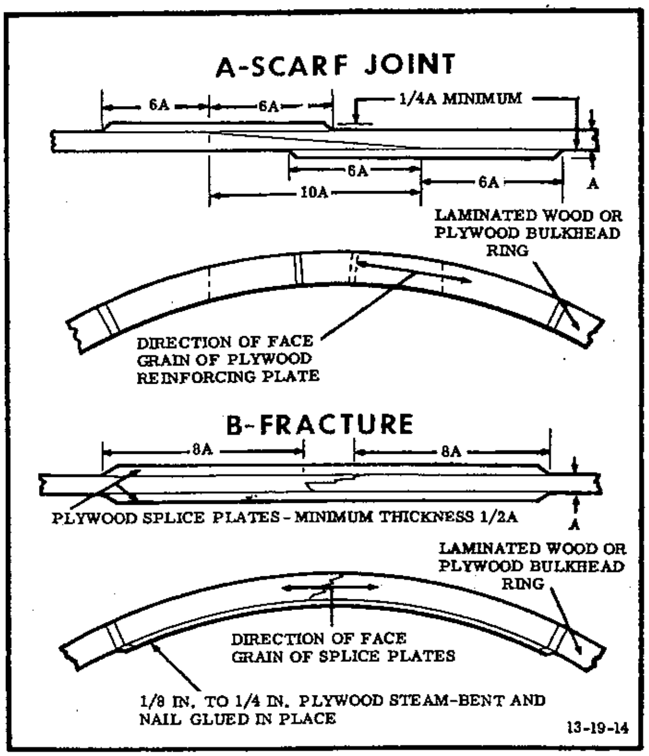


Figure 19-22 Repair to Frames

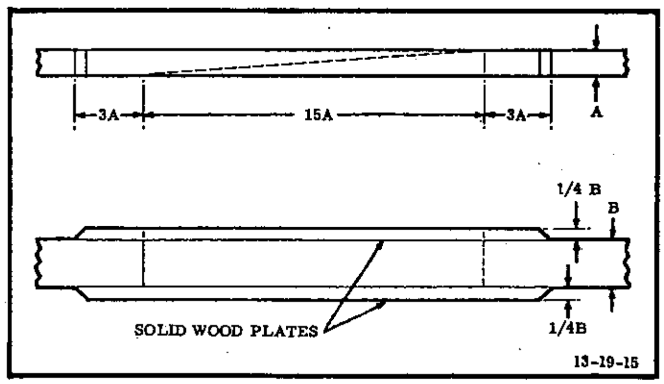


Figure 19-23 Longeron Splice

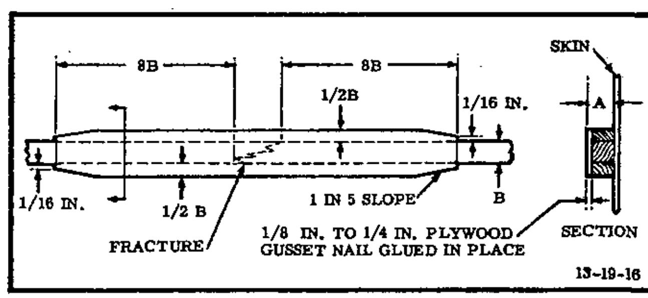


Figure 19-24 Repair of Fractured Stringer

be repaired. Portions of fairing strips of conventional design can be replaced by new sections of the same species and cross section.

Repair of Open Glue Joints

148 Slightly opened glue joints sometimes occur between the plywood skin and the frame. Wherever such open joints in wood-to-wood bonds are accessible, they may be repaired by gluing in place a small triangular wood corner block. If the frame member is curved, make the corner block from similarly curved laminated stock. Repair joints that show slight opening at both edges of a framing member with corner blocks on each side.

Fittings

149 Metal fittings are normally attached to wood frame members by means of bolts. However, some fittings are attached by using special metal-to-wood glues. Metal-to-wood glue bonds that show signs of open joints at any point are not repairable.

NOTE

Do not replace fittings on a member with elongated holes. Rebore the holes and use bushings or replace the member. Generally, it is simpler to replace the member than to rebore and bush the holes. Accurate reboring and bushing of holes is a precise operation requiring special equipment and technique in order to ensure accurate centering and alignment of new holes.

FINISHING

General

150 Any repair to spars, ribs, skin surfaces or other structural parts of the airframe involves finishing as the final step. Repaired skin surfaces require an interior as well as an exterior finish. Interior structural parts require an interior finish only.

Precautions to be Observed before Applying Finish

151 When making repairs, avoid contamination of surfaces with glue squeeze-out at joints and on all surfaces. Always remove excess glue before applying finish. Because paints and glues are incompatible, even a slight amount of glue underneath the finish may cause a premature failure of finish. Refer to Part 20, following for cleaning procedures. If sanding or scraping is employed, avoid removal of the face veneer in excess of 10% of the thickness of the face ply. Remove markings that are made by grease pencils or lumber crayons containing wax. Marks made by ordinary soft graphite pencils and non-bleeding stamp pad inks may be safely finished over. All dust, sander dust, dirt and other solid particles should be cleaned off.

NOTE

Never use lead pencils for marking on hot areas of the aircraft such as jet pipes, exhaust pipes or engines.

Procedures for Finishing Structural Repairs

152 End grain surfaces such as edges of plywood skins and holes in spars and other primary structural members require careful protection. Sand these surfaces smooth.

NOTE

Exposed end grain includes such surfaces as those around vent holes, inspection holes, fittings and exposed scarfed or tapered surfaces such as those of tapered blocking.

153 Finish is likely to crack when applied over flush-driven nails and screws. To avoid this, cement a strip of tape over the row of heads after application of sealer and before the final finish is applied. Fill all holes left from nail-strip gluing or countersunk nails and screws with a wood filler before finishing the surface. It may be necessary to cover the slight depressions left after applying filler with a patching putty if a completely smooth surface is desired.

Repairs to Finishes

154 For repairs to fabric and finishes, refer to Part 18, preceding. When carrying out repairs to plywood components, adhere to the following doping schedules.

(a) Finish to plywood components completely covered with Madapollam (canvas):

(1) Apply two coats of clear dope with a brush and permit to dry.

(2) Cover the surface with Madapollam (canvas).

(3) Brush in a heavy coat of clear dope, ensuring complete saturation of the fabric and good bond with base coat of clear dope.

(4) Apply one spray coat of aluminum pigmented dope.

(5) Apply two or more coats of yellow pigmented dope.

(b) Finish plywood components not completely covered with Madapollam:

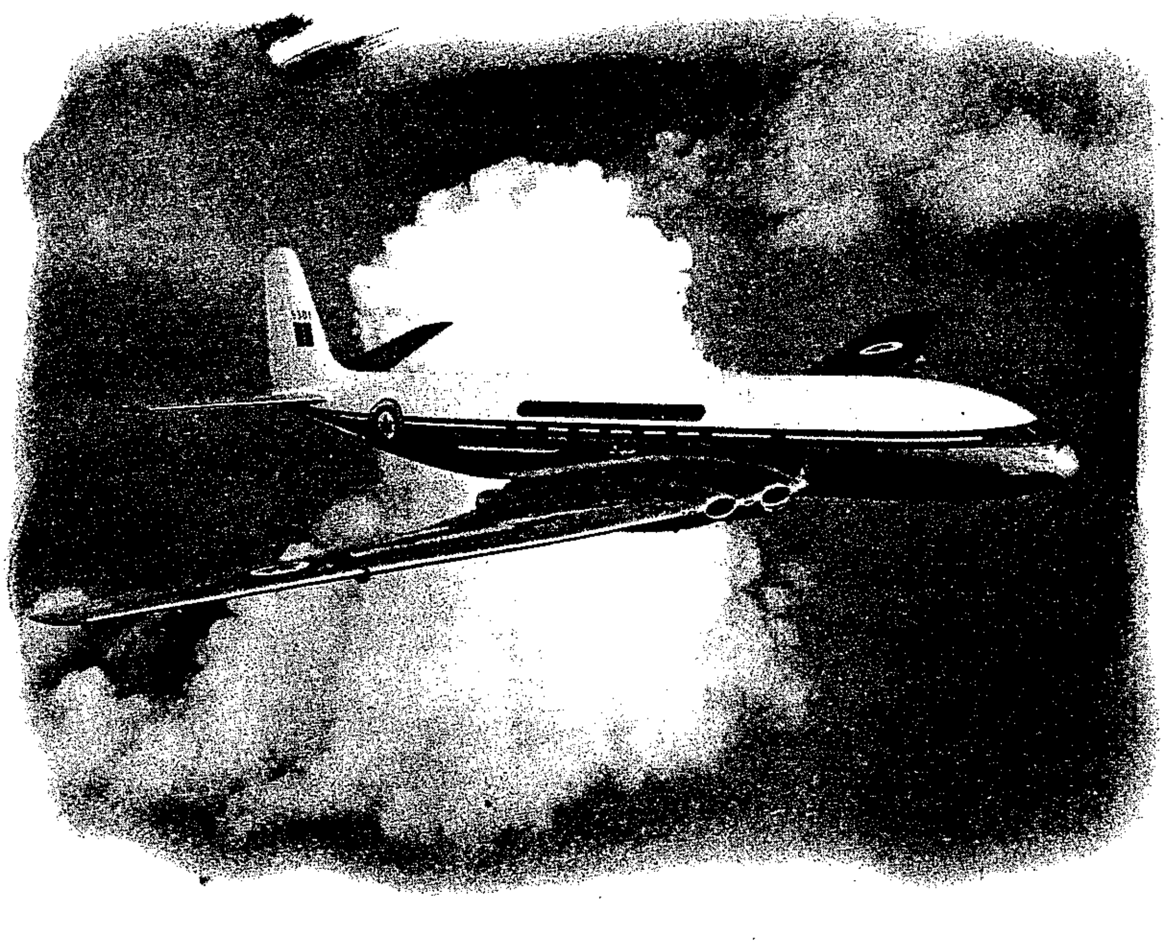
(1) Apply one coat of sealer allowing 15 minutes for penetration. Wipe off and then allow to dry for approximately eight hours.

(2) Apply two coats of clear dope with a brush and permit to dry.

(e) Cover the surface with Madapollam.

PART 20

METAL PROCESSES



PART 20

METAL PROCESSES

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(Continued)

(Continued)

LIST OF ILLUSTRATIONS

PART 20

METAL PROCESSES

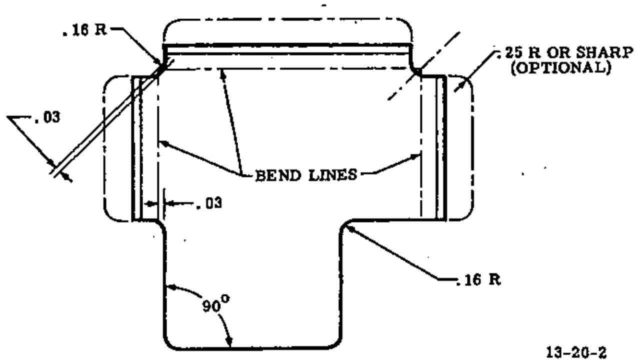
FABRICATION DETAILS

General

1 The following fabrication details are included for the guidance of personnel engaged in structural repairs. All dimensions shown are in inches. Tolerance on dimensions is ± .030 inch unless otherwise stated. These instructions do not supersede any official drawing or repair manual for the aircraft concerned.

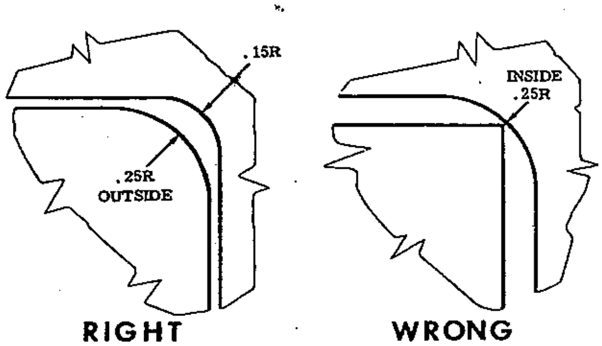
Corner Radii

2 The following are the rules governing corner radii:



13-20-2

(a) Make the inside corner radii .160 inch. When used for bend relief, the .160 inch radius is located on the line bisecting the bend lines and cutting .030 inch into the flat portion of the web.



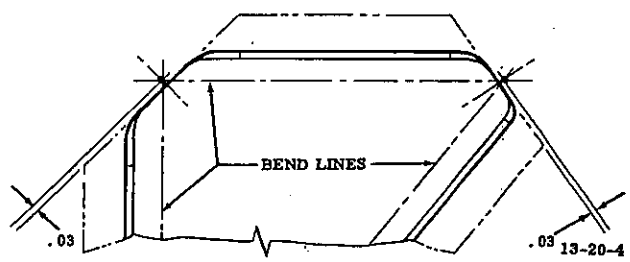
13-20-3

(b) Make outside corners, except butt-jointed exterior skins, (wing, fuselage, etc.), 90° in the flat pattern and .250 inch radius or sharp, (optional). Lap jointed exterior skins may be round cornered.

(c) Make the outside corners of butt-jointed exterior skins sharp unless otherwise dimensioned on drawing, or where mating inside and outside corner radii produce interference.

Diagonal Cuts

3 Diagonal cuts are to be made as follows



13-20-4

(a) Where rivet or bolt spacing will permit, corner bend reliefs may be sheared in straight diagonal cut. Such cuts must be perpendicular to a line bisecting the bendlines and cut .030 inch into the flat portion of the web.

Stiffener and Stringer Cutoffs

4 For explanation of drawing callouts of stiffener and stringer cutoffs, see Figure 20-1.

Extrusion Profiles

5 Advisable tolerance for extrusions which are to have one leg cut away, provided that the resultant projection will not interfere with adjacent parts, is shown in Figure 20-2.

Bend Radii Minimum

6 Bend radii tables, (refer to Part 25, following), are charts of minimum allowable bend radii for simple bends in sheet and plate metal. These are not, in any case, to be construed as superseding the drawing. Bending

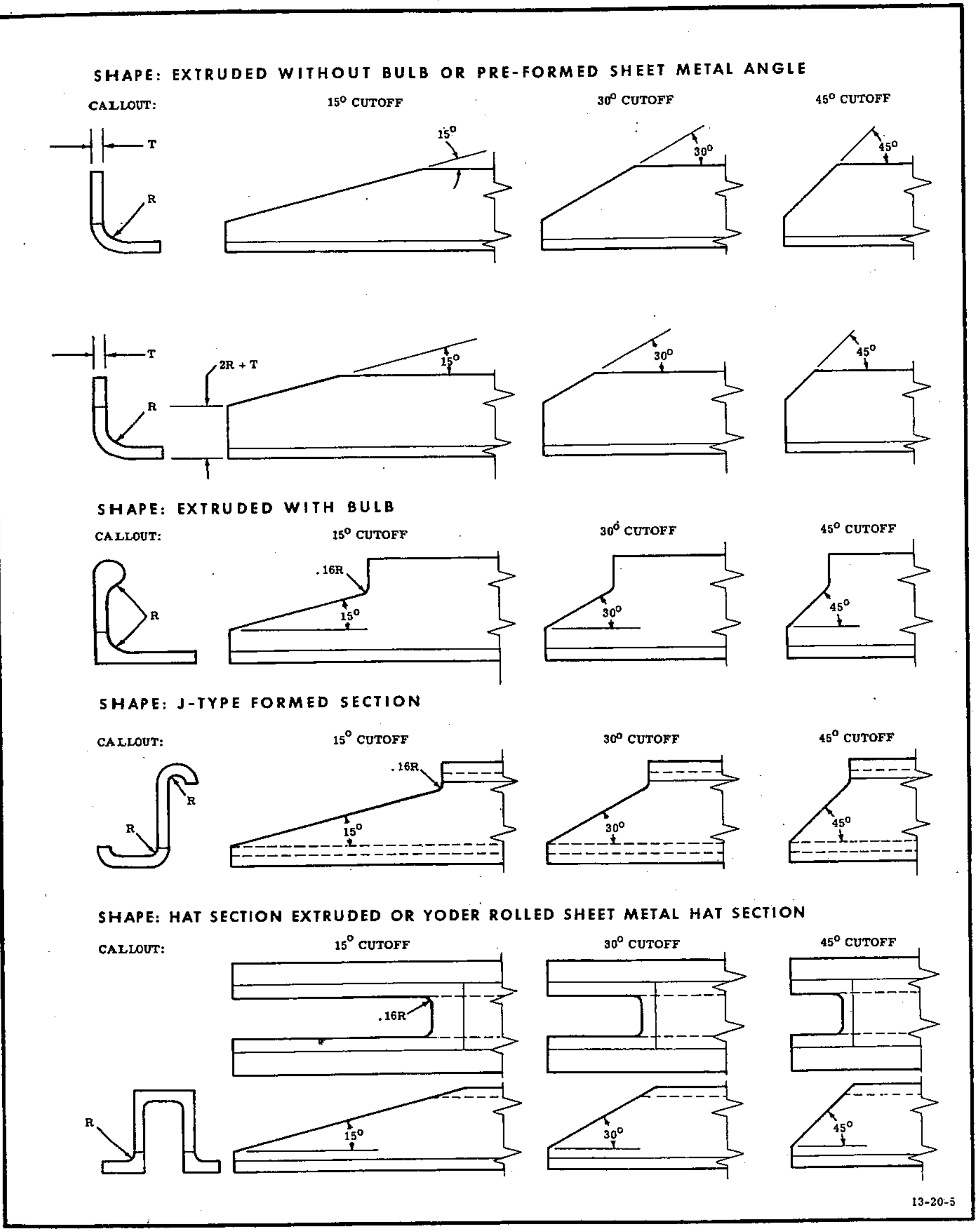


Figure 20-1 Typical Drawing Callouts

must be done to conform with grain direction, (see Figure 20-3), and hot forming limitations.

Joggles

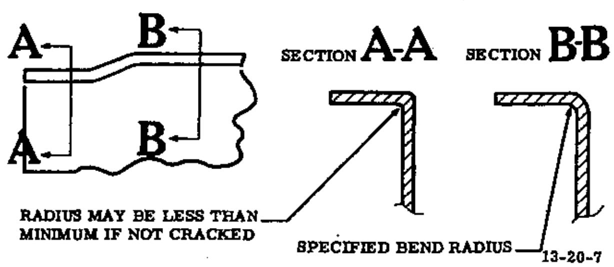
7 Provided no fracture of the metal occurs after joggling, sheet metal parts may have pinched bend radii less than the minimum specified. The bend radius of the flange adjacent to a joggle may be formed as shown to permit more complete forming. The radius must be R1 in the plane as shown. The bend radius at an abrupt change of contour may be similarly rounded off provided no interference with attachments or mating parts occurs at later assembly.

Grain Direction

8 For definition of grain direction for bending and forming operations, see Figure 20-3.

Section Forming (Degreeing)

9 Angular change of flanges of straight aluminum alloy extrusions may be made up to a maximum of 15° open or closed. The angular change may occur away from existing fillets or other non-uniform sections. Where the angle is opened, a concave surface results on the outside of the angle, which should be filed or



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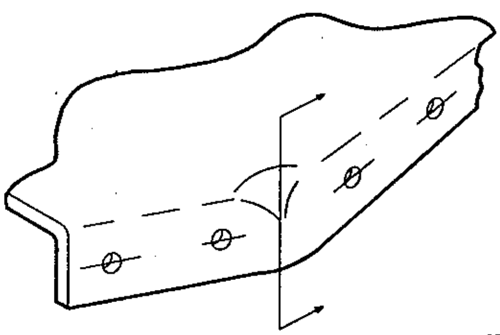

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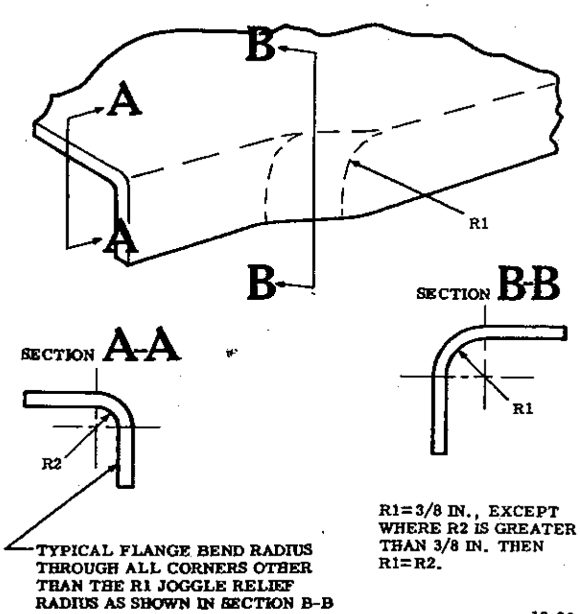

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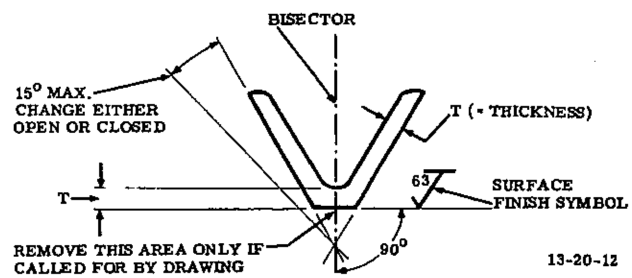

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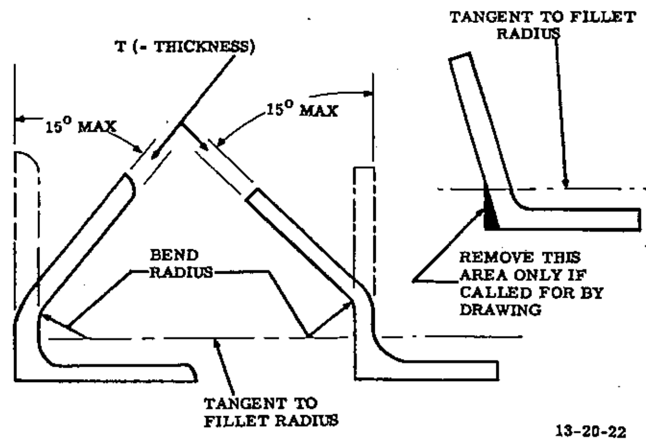

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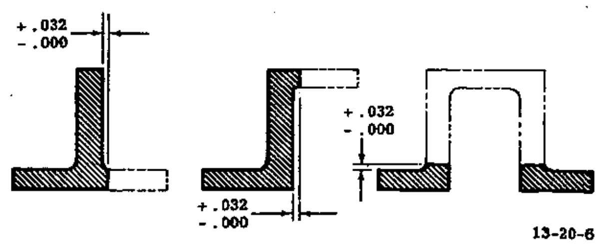


13-20-6

Figure 20-2 Extrusion Profiles

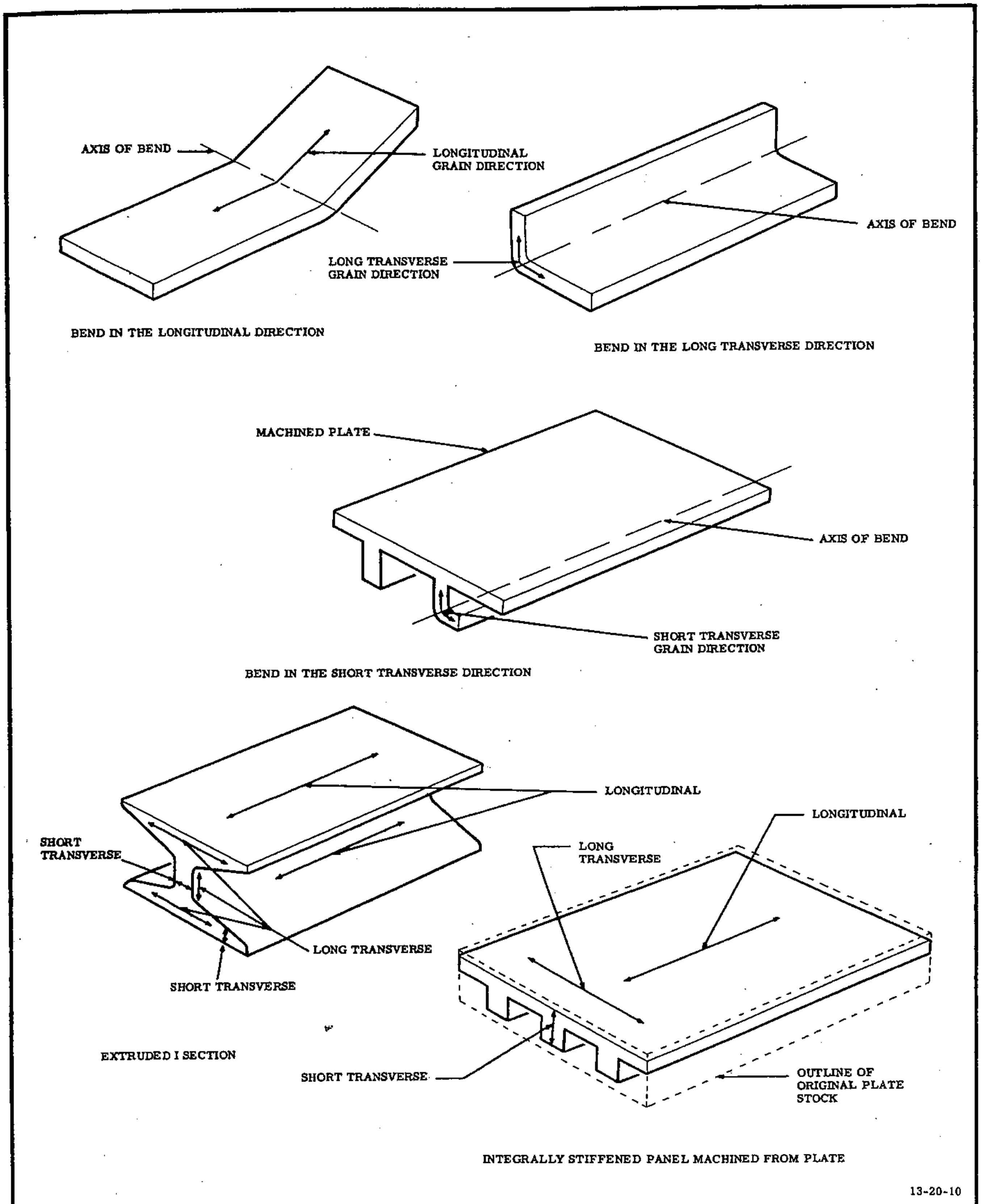


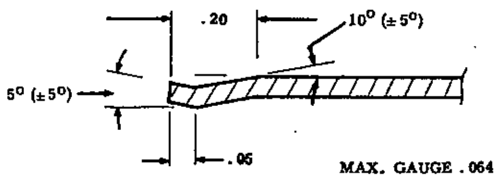
Figure 20-3 Definitions of Grain Direction for Bending and Forming

milled off only if called for by note on the drawing. The angular change may also be made in the original fillet radius of the flange. The material in the heel of the angle should be filed or milled off only if called for by drawing.

Sheet Metal Edge Crimps

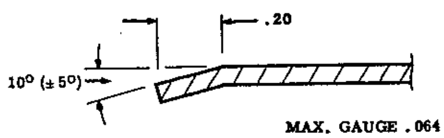
10 The following types of edge crimp are commonly called on drawings:

(a) Type A for doors, skins etc., which are inside the mould line of the airplane, as a stiffening feature to keep such items flat between attachment points.



13-20-13

(b) Type B for fairings and doors which fasten to exterior surface of the airplane.



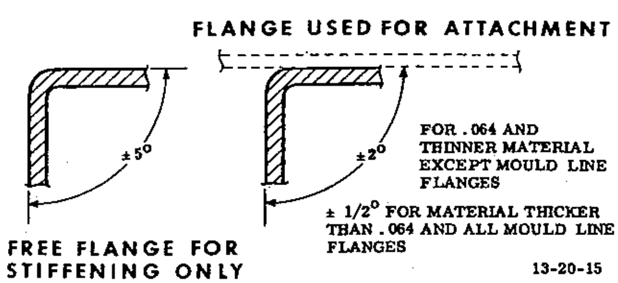
13-20-14

CAUTION

When marking on exhaust stacks, tail pipes or any part of a power plant, do not use pencil. Use only chalk. The use of pencil on metal surfaces that become heated can set up a condition of local case-hardening, a possible starting point for failure.

Tolerance on Flange Angles

11 These tolerances apply to sheet metal

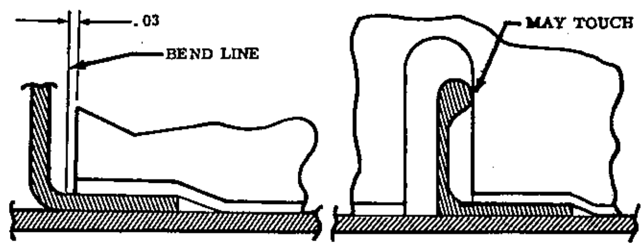


13-20-15

formed parts, unless otherwise specified on the drawing.

Clearance between Adjacent Parts

12 The distance between bend lines and adjacent parts may be .030 inch or more (plus or minus the tolerance specified in Paragraph 1, preceding). No minimum clearance between adjacent parts need be maintained at standard stringer cutouts provided that contact between stringer and frame does not cause distortion of one or the other. This applies to assembly conditions only. For repair purposes, clearances must be .030 inch or more.



13-20-16

Skin Gap Tolerances

13 Unless otherwise noted on assembly drawings, the gap tolerances between adjacent skins at butt joints must be as follows:

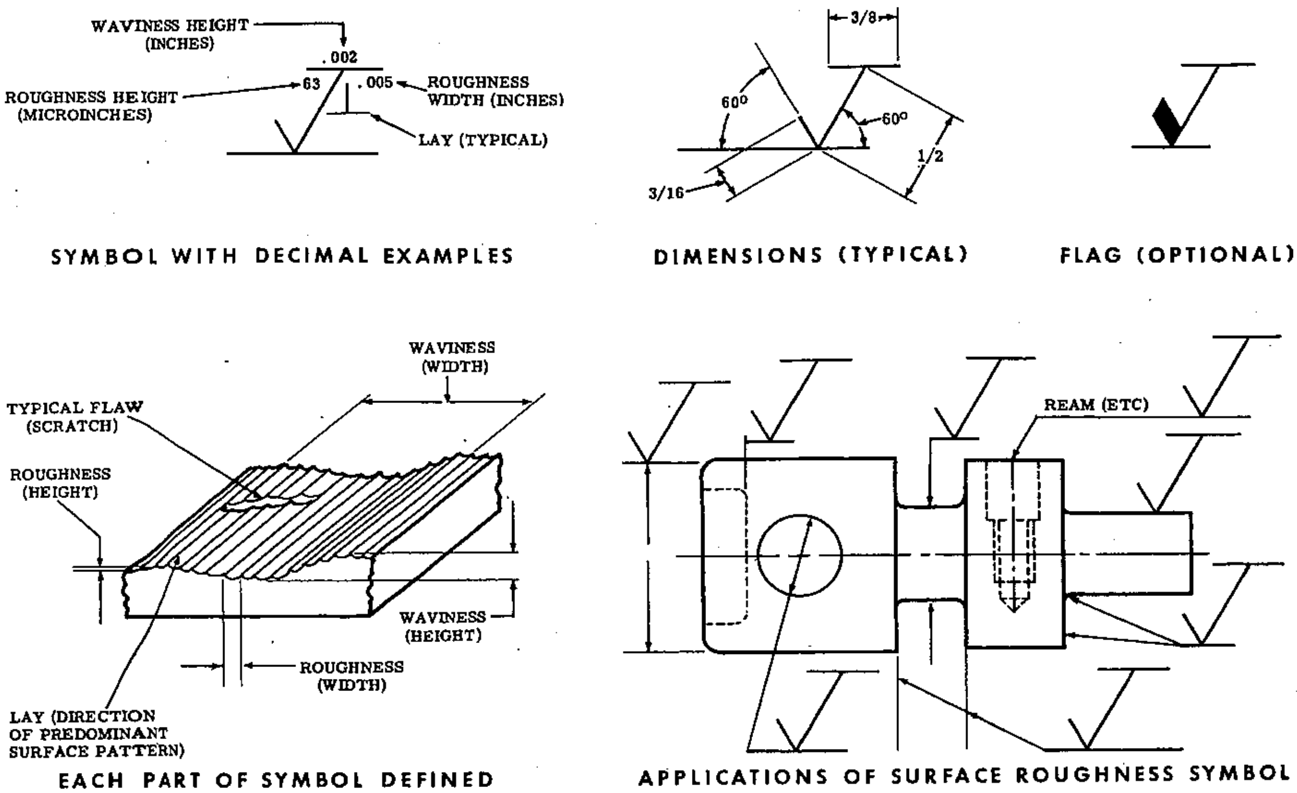
	Max. gap at any point
Fuselage	.090 inch
Wing and nacelle	
Spanwise (or direction generally transverse to airstream)	.090 inch
Chordwise (or direction generally parallel to airstream)	.120 inch
Chordwise for swept wings	.090 inch
Empennage	.060 inch

NOTE

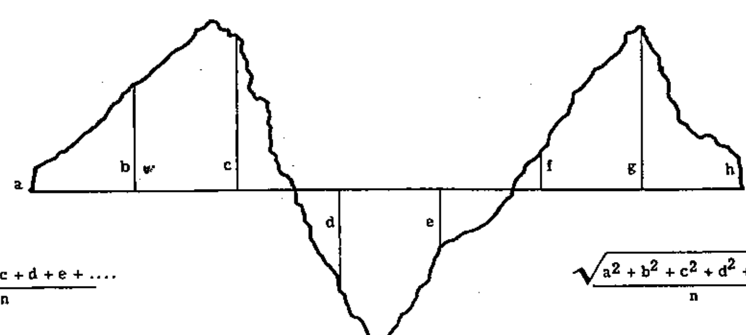
Skins are defined as parts forming the exterior surface of the aircraft.

14 These tolerances do not apply to doors, or to gaps between skin and extruded sections, i.e., skin and extruded trailing edge, etc. Unless otherwise noted on assembly drawings,

SURFACE ROUGHNESS, WAVINESS AND LAY ARE DESIGNATED BY THE USE OF THE FOLLOWING APPROVED SYMBOL:



FOR LIMITING ROUGHNESS OF NON-DESIGNATED SURFACES: XX√ ALL MACHINED SURFACES EXCEPT AS NOTED.
ALL ROUGHNESS HEIGHT RATINGS INDICATE ARITHMETICAL AVERAGE DEVIATION FROM THE MEAN.
THE FOLLOWING ROUGHNESS VALUES IN MICRO INCHES ARE PREFERRED:
2000, 1000, 500, 250, 160, 125, 63, 32, 16, 8, 4, 2, 1.
ALL SINGLE VALUES INDICATE MAXIMUM ACCEPTABLE ROUGHNESS: ANY SMOOTHER SURFACE IS ACCEPTABLE.
IF TWO VALUES ARE GIVEN, THEN BOTH MAXIMUM AND MINIMUM ARE INTENDED.
WHEN THE SYMBOL IS USED IN CONNECTION WITH A DIMENSION IT AFFECTS ALL SURFACES DEFINED BY THE DIMENSION.
AREAS OF TRANSITION, SUCH AS CHAMFERS, FILLETS, ETC., MAY CONFORM TO THE ROUGHEST OF THE ADJACENT AREAS UNLESS OTHERWISE INDICATED.
ROUGHNESS VALUES MUST INDICATE FINISH BEFORE PLATING UNLESS OTHERWISE SPECIFIED.



$$\frac{a+b+c+d+e+\dots}{n}$$

ARITHMETICAL AVERAGE

$$\sqrt{\frac{a^2+b^2+c^2+d^2+e^2+\dots}{n}}$$

ROOT MEAN SQUARE (RMS) AVERAGE

13-20-18

Figure 20-4 Surface Roughness Determination - NAS30 make maximum gap between adjacent interior sheet metal parts (parts forming interior of aircraft) 0.060 inch at butt joints.

SHRINKING (CRIMPING) OF ALUMINUM ALLOY

General

15 Shrinking (crimping) of aluminum alloy may be used as a supplementary fabrication and rework operation, subject to limitations, as follows:

16 The shrinking operation must not gouge, score or reduce the gauge of the material. Light marking is not objectionable providing the exterior appearance of the aircraft is not affected. Similarly, the edge of the shrunken material must not be notched. Where dimensions permit, notches may be removed by filing. Use of emery, files or burnishing, etc. is not permitted on shrunken surfaces. 75S alloy may be shrunk only in the O or W tempers.

SURFACE ROUGHNESS

General

17 Surface roughness is designated in inches and micro-inches, as shown in Figure 20-4. A micro-inch equals one millionth of an inch (.000001 inch). The abbreviation is mu. in. There are two methods of averaging the roughness dimension of an area, the arithmetical average, and the RMS (root mean square). The RMS has been widely used in American industry, but is being replaced by the arithmetical average. The latter is the method endorsed by the National Aircraft Standards Committee and is the method adopted in Britain. For the same set of dimensions, the RMS gives a result about 10% higher than the arithmetical average method.

TEMPIL PRODUCTS

General

18 The use of Tempilstik, Tempil pellets, or Tempilaq (Item 1) produced by Tempil Corporation, is a simple effective means of determining temperature accurately, (within 1% of the stated temperature). If the area is accessible, rub the part gently with the Tempilstik. If the area is inaccessible, apply a thin smear of Tempilaq, or a Tempil Pellet to the part. Temperature signal is the appearance of the first sign of liquid due to melting of the Tempil product.

HOT FORMING OF 26S (14S) 24S and 75S ALUMINUM ALLOYS

General

19 When the design of parts made from 26S, 24S and 75S aluminum alloys is such that forming or straightening in the solution-heat-treated and fully-aged temper is necessary, and when the degree of forming or straightening is such that this cannot be done at room temperature without cracking, then the forming or straightening required may be carried out at an elevated temperature in accordance with the following instructions. Reforming is prohibited, except where specifically approved by engineering authority.

20 The instructions cover the requirements for the hot forming and hot straightening of 26S (14S) 24S and 75S aluminum alloys in the following solution-heat-treated and aged tempers only: (Obsolete temper designations are shown in brackets.)

(a) 26S (14S):-T6 (-T), -T61 (-T), -T62 (-T).

(b) 24S: -T3(-T), -T36(-RT), -T4(-T), -T42 (-T), -T6(-T80), -T62(-T80), -T81(-T8, -T81), -T86(-T86).

(c) 75S: -T6(-T).

Equipment

21 Material to be hot formed or to be hot straightened may be heated by any of the following methods:

(a) In linseed oil baths.

(b) In air furnaces.

(c) Through contact with hot tables.

(d) Through contact with dies and tools having insert heaters or strip heaters.

22 Maintain temperatures in the working zone of oil baths and air furnaces, and on the contact surfaces of hot tables, dies and tools within the temperature limits specified in Paragraph 23, following. To ensure that temperatures are controlled, use thermostatic switches or pyrometers. Manually-operated on-off switches may also be used, provided that Tempilstiks (Item 1) are employed to ensure that the maximum and minimum temp-

erature limits are not exceeded on the contact surfaces.

Procedure

23 Heat the material in or on the equipment specified in Paragraph 21, preceding, to the following temperatures:

(a) 26S (14S): -T6, -T61, -T62 325°(± 25°)F.

(b) 24S: All tempers listed in Paragraph 20 (b) preceding. 300°(± 25°)F.

(c) 75S: -T6 275°(± 25°)F.

24 Time at temperature must not exceed a total of one hour. This time is cumulative; for example, a 24S-T3 part may be heated to a temperature of 300°F for 10 minutes on one occasion, for 20 minutes on a second occasion and for 15 minutes on a third occasion, making the total time at temperature 10+20+15=45 minutes, which is less than the maximum specified. Use Tempilstiks (Item 1) or portable pyrometric equipment to check the surface temperature of all heated material immediately prior to forming or straightening.

HOT FORMING OF MAGNESIUM ALLOY (FS-1, AMC52S, AZ31x) TUBING

General

25 Magnesium alloy tubing which cannot be formed at room temperature may be hot formed using information and equipment as detailed following.

Flaring Equipment

26 Clamping dies of the flaring machine should be heated by electrical elements. Temperatures may be controlled by thermostatic units or Tempilstiks and off-on switches. As an alternative both the end of the tubing and the conically-shaped tool may be heated in hot linseed oil (Item 2) and transferred immediately to the flaring machine.

Bending Equipment

27 Bending blocks etc., may be heated by electrical units. Temperature control may be obtained by thermostatic units or Tempilstiks and off-on switches. The wiping mandrel need not be heated.

Temperature

28 The forming temperature of the tubing should be 450°(± 25)° F.

Procedure for Flaring and Bending

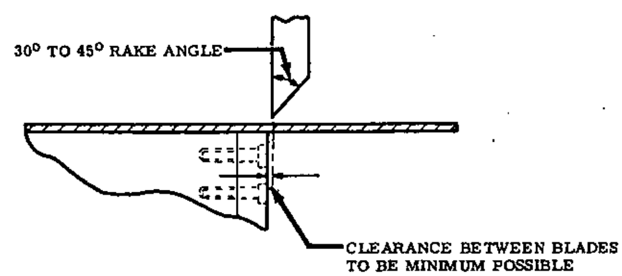
29 Both the flaring and bending operations are carried out in the regular manner. Where hot dies and cold tubing are used, allow sufficient time for the tubing to come up to temperature. Use Tempilstiks frequently. Prior to flaring, cut tube ends square and remove the burr. (Refer to Part 12, preceding.)

30 After flaring, there should be no cracks present nor any scores which may lead to cracks. Bent tubing should be free from cracks, excessive orange-peel and other imperfections.

SHEARING OF MAGNESIUM ALLOY SHEET

General

31 The following instructions govern the shearing of magnesium alloy sheet:



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(a) Sheet .064 inch and less in thickness may be sheared. Clearance between the shear blades must be as small as possible, just short of scoring the blades. A shearing or rake angle of 30° to 45° is recommended on the upper shearing blade.

(b) Sheet over .064 inch in thickness should be either sawn, or sheared oversize then sawn or filed to size in order to remove the cracked or burred edge.

TITANIUM

General

32 Titanium has a dull silver-grey colour similar to that of stainless steel. Several tests may be made to determine whether a part is titanium. Touched on a grinding wheel, titanium gives off white traces ending in brillant white

bursts. Moistened, it leaves grey-white marks when rubbed on glass. Some titanium parts now being used are identified by an etched part number and the word TITANIUM stamped and etched on the part. Titanium is approximately 60% heavier than aluminum and about 40% lighter than stainless steel. It is useful from a strength standpoint to approximately 600° F, while aluminum is useful to approximately 300° F.

33 Titanium is considerably harder than aluminum. Alloys and heat treatments produce hardness equivalent to that of some heat-treated steels. Titanium does not conduct heat as well as aluminum and is subject to hot spots when unevenly heated. It does not expand as much as most other common metals with an increase in temperature. Above 1000° F, oxygen and nitrogen are absorbed in titanium, causing embrittlement. It is therefore not considered suitable for structures encountering this temperature.

34 Titanium starts to melt in the vicinity of 3100° F. In its molten form it combines readily with oxygen and nitrogen and special precautions must be taken to avoid this by using vacuum furnaces. Because of its excellent corrosion resistance, comparable to that of stainless steel, and its resistance to many strong chemicals, titanium is desirable for many uses. Its resistance to sea water and marine atmosphere ranks with that of platinum and is superior to that of stainless steel.

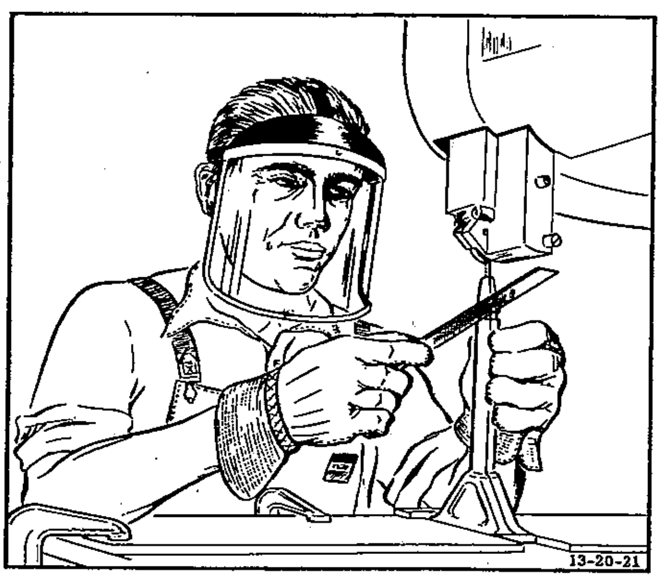


Figure 20-5 Protective Clothing Necessary

35 Hard coatings are formed at all temperatures. These coatings are very thin and virtually invisible at room temperatures, but discolour and thicken at high temperatures. The visible appearance of the hard coatings is as follows:

Room temperature - very thin coatings are formed.

300°F to 400°F - a light-grey adherent coat to formed.

600°F - straw colour.

800°F - purple.

1000°F - purple gone, metal darkened.

1200°F - dulled by slight deposit.

1300°F - light greenish-grey deposit.

36 Titanium is non-magnetic like aluminum and copper. Its electrical resistance is comparable to that of stainless steel.

NOTE

When performing machining operations on titanium, protective clothing should be worn, (see Figure 20-5).

Machining

37 Fundamental studies of chip formation and general behaviour of titanium in machining have led to the following observations:

(a) The low modulus of elasticity of titanium makes it necessary to hold both the work and the tool with exteme rigidity to avoid excessive chatter and vibration. For this reason machine tools used for titanium should be rigidly built and in first class condition.

(b) The chips produced when machining titanium are thinner than steel chips and are generally continuous. There is no built-up edge to the chip when titanium is being machined as there is with steel. This relatively thin chip and lack of built-up edge proves that the cutting force is concentrated on a relatively smaller portion of the tool tip, which results in higher temperatures and higher rates of wear. It has been found that tool tip temperatures are relatively more sensitive to speed and feed rates with carbide-tipped tools than with high-speed steel. In spite of this, it has been found that with proper coolants and tip, tool life, rates of metal removal and power requirements are about the same for Titanium alloys as for 1045 steel.

(c) Typical successful tool designs for various cutting operations are shown in Figure 20-6.

Drilling

38 Hard chrome plating on drills, taps and reamers reduces chip welding. High-speed steel drills with 5% cobalt give longer tool life than the conventional 18-4-1 grades. Drills should be sharp, short, rigid and slightly flatter than those used for stainless steel. Speeds are generally 12 to 15 surface fpm. Feeds vary somewhat in the vicinity of 0.003 to 0.008 inch per revolution. Sufficient power and pressure must be available to keep the drill from riding on the hole. For 1/4 inch diameter holes, 700 rpm may be used as speed guides. For No. 40 holes use 1200 rpm.

39 Assembly drilling may be more troublesome than drilling of detail parts because of the lack of a positive feed when portable drills are used. A practical lubricant for assembly drilling should have paste-like consistency to allow use in vertical or overhead positions. A mixture of beeswax and graphite may be used for this purpose. (See Figure 20-5.)

Tapping

40 Three-flute, interrupted-tooth, spiral-point taps are satisfactory. Hand taps designed for stainless steel may be used. Speed and feed combinations from 12 to 15 surface fpm should be used. Broken tools, such as drills and taps, can be loosened to permit easier removal from titanium parts by submersion of the parts in a saturated solution of ferric ammonium sulphate (Item 3) or nitric acid (Item 4) which does not appreciably affect the titanium.

Reaming

41 Spiral-fluted, high-speed steel reamers have proved satisfactory. Carbide-tipped reamers give good results with a primary clearance of 10° to 15°. Slower speeds of 40 to 70 surface fpm are recommended for the initial reaming. Feeds of 0.005 to 0.020 inch per revolution can be used, increasing with the diameter.

Milling

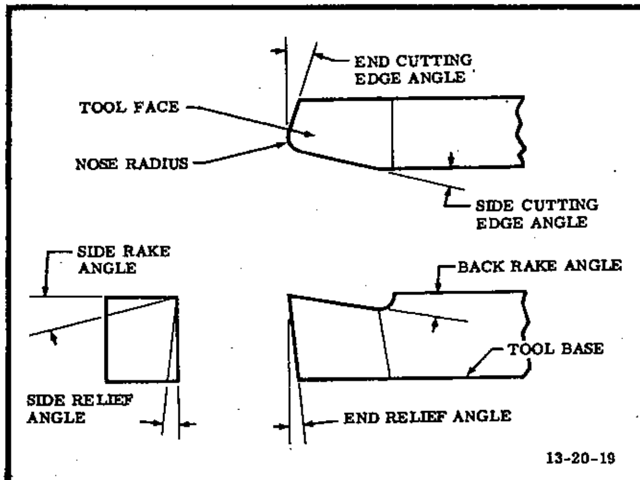
42 For milling, a cutter with a carbide grade similar to Carboloy 883 is recommended at a feed of 0.003 inch per turn in a climb milling operation, i.e., work below centre line of cutter. Dry milling is recommended with a 0° rake angle and a 45° lead angle.

Metal Preparation

43 Titanium blanks may be prepared for forming by shearing, sawing, nibbling or blanking.

Shearing

44 Edge cracking in the plane of the sheet has been observed in shearing operations. This condition can be minimized by the use of sharp blades, by close tolerance between blade and bed, and by hot shearing. Material up to 0.187 inch thick has been sheared on flat bed shears rated for 7-0 gauge mild steel.



Tool	Rake Angle		Relief Angle		Cutting Edge		Nose Radius
	Back	Side	End	Side	End	Side	
HSS - Lathe	0	24	6	6	6	15	.010
Carbide - Lathe	0	6	10	10	5	45	.015
HSS - Shaper	0	28	6	6	6	15	.030

Figure 20-6 Typical Tool Angle Determination

Sawing

45 In sawing, lineal blade speeds of 4500 fpm and higher are used. At these speeds, the cutting action is accomplished mainly by friction, and the number and type of saw teeth is relatively unimportant. Conventional equipment may be used if blades are not permitted to ride and if fairly heavy pressures are applied. A similarity exists in sawing titanium and stainless steel, particularly regarding the tendency for the surface being cut to work-harden. Titanium is more likely to wear and clog the saw blade than stainless steel.

WARNING

Fire precautions are necessary because titanium powder burns similar to magnesium and is explosive when suspended in air.

46 Circular saws, with a hydraulic feed and clamp, operate with an upward cutter rotation and a star wheel chip remover. When bandsaws are used, heavy even pressures are necessary, with the widest band consistent with the contours. Special problems are wear of cutting edge of blade, wandering and seizing of blade, and the tendency of heat to close the saw slot around the saw. When power hacksawing, conventional equipment is satisfactory, provided heavy pressures are applied and the blade is not permitted to ride.

Nibbling

47 Nibbling is satisfactory but leaves an irregular edge which usually requires an additional smoothing operation.

Blanking

48 Blanking dies have been used satisfactorily on material up to 0.071 inch thick. Because of the apparent notch sensitivity of titanium, careful attention must be given to the edge condition of blanks before forming. Removal of burr is a minimum requirement. On the more difficult forming operations, filing or polishing of cut edges may be necessary.

Forming of Sheet

49 The formability of titanium is influenced by the following principal factors:

(a) High yield strength.

(b) Low ductility at room temperature.

(c) Sensitivity to rate of strain.

(d) Directional effects.

(e) Low ratio of uniform strain to necking strain (about half that of annealed stainless steel).

(f) Notch sensitivity.

(g) Non-uniformity of properties.

50 The directional effects resulting from sheet rolling are pronounced in bending titanium. When the axis of bend is perpendicular to the direction of rolling, tighter bend radii can be obtained than where the axis is parallel to the rolling direction. In forming, annealed unalloyed titanium behaves like 1/4 hard stainless steel of the 18 Cr-8 Ni type. Presently available titanium alloys, in the annealed condition, are similar to 1/2 hard 18-8 stainless steel. Only with great difficulty can work-hardened titanium be formed by conventional methods. To obtain maximum formability at a given strength level, the use of suitable alloys rather than work-hardened grades is required.

51 Titanium is sensitive to rates of forming. Slow rates are preferred in order to obtain maximum formability. The spring-back resulting from forming unalloyed titanium (70,000 psi yield strength) is approximately equal to that for 1/4 hard 18-8 stainless steel. In alloy titanium, spring-back is about 25% greater than with 1/2 hard 18-8 stainless steel. Hot forming is advantageous because it produces smaller bend radii, increased elongation and less spring-back and accommodates non-uniformity in material properties. (See Figure 20-7.) Refer to Table of Bend Radii, Part 25, following. Press forming on the hydraulic press is generally more successful than on the mechanical crank type, because of its slower action. Handwork is difficult and undesirable. Heat is required for most hand-forming operations. Heated dollies and furnaces may be used.

Heat Methods

52 When hot working is required, proceed as follows:

(a) Heat the material 800° F to 1000° F, using the upper end of the range when the forming is severe. Air furnaces, electrically heated and controlled within ± 25° F of the operating temperature, are preferred over torch heating generally, and to obtain uniform heating are mandatory for large parts.

(b) Where torch heating is employed, keep the flame on the slightly oxidizing side and check the temperature with Tempilstiks. (Item 1).

(c) Where cracking or difficulty in forming is encountered on parts requiring two or more forming operations, stress relief, as shown in Paragraph 53, following, may also be used as a partial annealing treatment after any of the intermediate forming operations.

(d) Prior to stress relief, all parts must be vapour degreased in accordance with Paragraph 155, following.

Stress Relief

53 After the final forming operations, all formed titanium and titanium alloy parts (except as noted) must be stress relieved as soon as possible and, in any case, not more than two days after the forming operation has been completed. Stress relief is achieved by soaking the parts for 75 minutes at a temperature of 1000° F. Do not stress relieve the following types of parts:

(a) Dimpled sheets after dimpling.

(b) Parts handworked or straightened to remove stress relief warpage.

Forging Titanium

54 Titanium alloys can be forged without undue difficulty once the fundamentals governing the behaviour of titanium are understood and their significance fully appreciated. Titanium, and most of its forgeable alloys, possess a transformation temperature range similar to that of steel. The top of this temperature range is about 1650° F and the bottom about 1200° F. To obtain a fine grained structure necessary for good toughness, forging should commence not too far above 1650° F and should continue down to as near 1200° F as practical. This temperature range will vary with the specific alloy to be forged. Some operators find that forging below 1550° F tends to cause fracture. All are in agreement that excessive temperatures (over 1700° F) should be avoided. As much reduction as possible should be made between each re-heat and the number of reheats should be kept to a minimum. Re-treat temperature for finishing should be within the transformation temperature range.

55 Titanium absorbs oxygen when hot and does this more rapidly as the temperature is increased. This oxygen absorption can create a hard brittle skin on the forging. To keep this oxygen absorption to a minimum it is best to avoid excessive forging temperatures and to limit the soaking time at temperature to an absolute minimum. Salt bath heating might be useful in some cases.

56 Titanium alloys are somewhat sluggish in flow characteristics. They are generally comparable to 75S aluminum and require approximately the same design limitations. Titanium alloys require about the same forging capacity as 75S aluminum.

Joggling

57 Titanium and titanium alloys can be joggled readily at room temperature. Ratios of joggle run-out to depth (ratio of length to offset) can be obtained which compare favourably with the ratio (8 to 1) normally used for 1/2 hard 18-8 stainless steel. Lower ratios (4 or 5 to 1) can be obtained by heating the dies or parts or both.

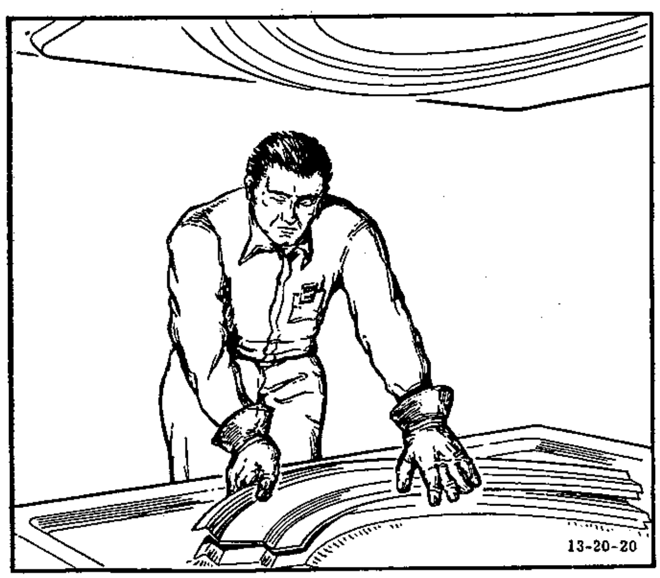


Figure 20-7 Heating of Blanks

Dimpling and Rivetting

58 For dimpling and rivetting procedures, refer to Part 5, preceding.

Welding and Brazing

59 Titanium and titanium alloys can be joined by inert-gas-shielded arc welding, resistance welding and brazing. During welding operations, their ability to absorb gases at high temperatures should be taken into account. Embrittlement during welding may be caused by the combination with these gases or a change in the crystal structure of the metal. Welding titanium to other metals has not generally been successful as yet. Fusion welding of current alloys forms brittle structures which cannot be eliminated except by slow, involved heat treatment. Oxy-acetylene and metal-arc welding are impractical as yet. Chemical cleaning is necessary only where unusual amounts of heat-treat scale are present. The blue or straw-coloured discolouration does not normally cause difficulty. Refer to Paragraphs 64 to 67 following, for cleaning procedures.

Inert-gas-shielded Arc Welding

60 Titanium must be protected from oxygen and nitrogen while being arc welded. Procedures have been developed for manual and automatic welding, both with tungsten and consumable electrodes. A water-cooled copper back-up may be used, but an inert-gas-shield back-up is usually superior. A trailing shield is recommended to provide an inert cover over the hot weld area when welding at high travel speeds with a consumable electrode.

Spot and Seam Welding

61 Satisfactory spot and seam welds can be made in unalloyed titanium, the higher-strength all-alpha alloys, and low-alloy beta alloys, using standard equipment and procedures. Because of the short welding time and the proximity of the sheets being welded, an inert atmosphere is unnecessary. Titanium, in the clean, as-rolled condition, welds readily. Removal of annealing scale and hot forming oxides is necessary. Under most conditions, high-strength welds with moderate ductility can be obtained. A ductility ratio (tensile to shear strength) of about .03 can be expected with unalloyed titanium. Lower ratios are obtained with titanium alloys. Single-phase a.c. spot-welders, such as are used on stainless steel, are suitable for spot-welding titanium. Spot-weld strengths are about the same as those obtained with annealed stainless steel.

Brazing

62 Brazing with a low-melting filler may be particularly advantageous in joining titanium, since exposure to high temperatures in welding is undersirable. Titanium can be brazed with most of the commercial brazing alloys and with pure silver, but the joints produced are generally brittle. Good wetting action can be obtained with induction and furnace brazing in argon without a flux, and with furnace and torch brazing in air with a flux. To minimize the formation of brittle alloy between titanium and the braze metal, a short brazing time is recommended. The joining of other metals to titanium by use of this method is feasible. Pure silver or copper alloy may be applied to titanium with a Heliarc torch, using a very high frequency a.c. welder. Soldering of titanium has not yet been successfully developed for production purposes. Methods of precoating titanium with silver and other materials for soldering are under investigation.

Heat Treating

63 The only heat treatments now feasible for titanium are the stabilizing of forged parts at 1100° F to 1300° F, and stress relieving. (Refer to Paragraph 53, preceding.)

Cleaning and Finishing

64 Light, adherent scale formed on titanium in air below 1300° F can be removed by acid solutions such as:

Nitric Acid (Item 4)	47%
Hydrofluoric Acid (Item 5)	2%
Nitric Acid	10%
Hydrofluoric Acid	2%
Hydrofluoric Acid	10%
Hydrochloric Acid (Item 6)	3%
Hydrofluoric Acid	2%
Sulphuric Acid (Item 7)	10 to 15%

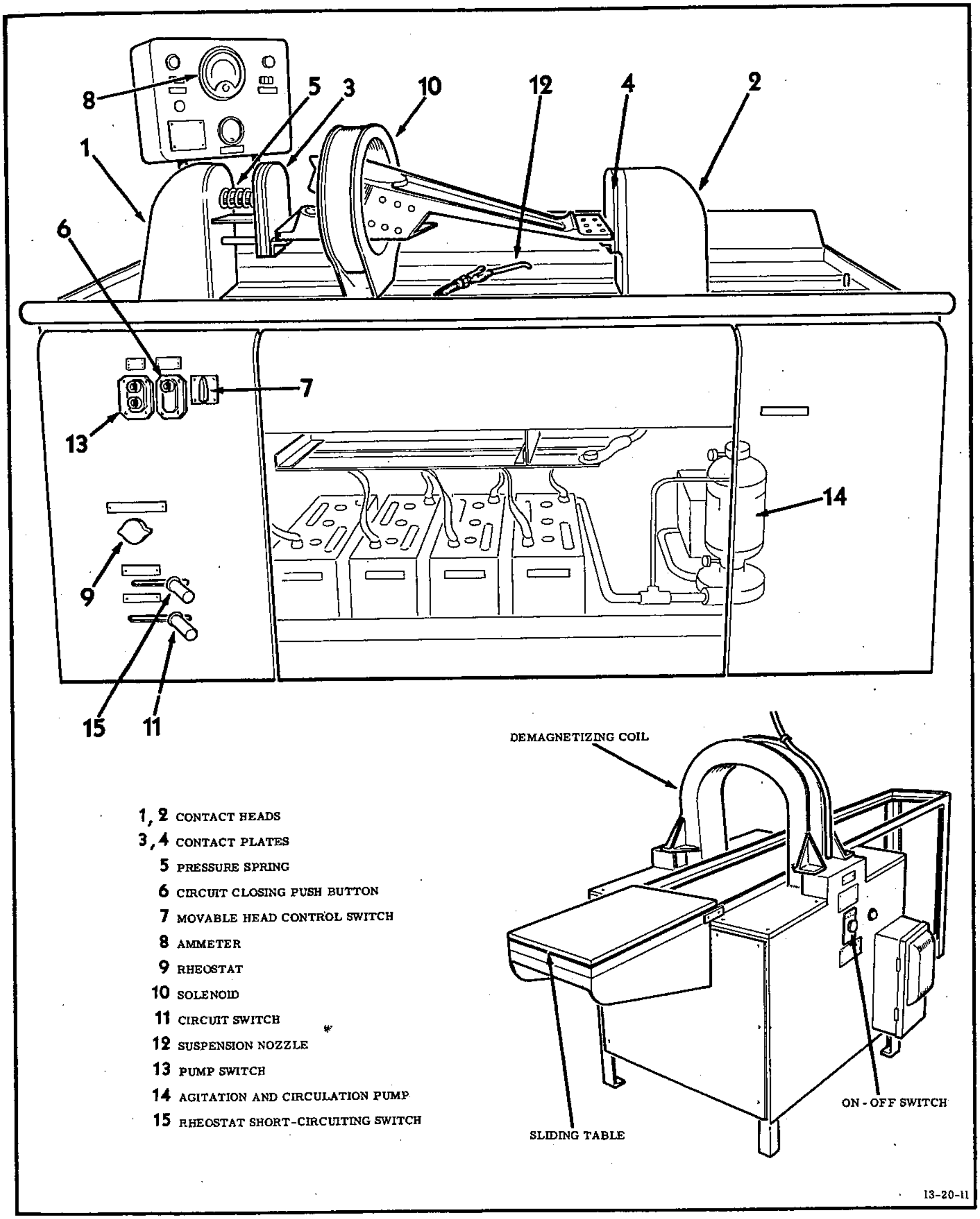


Figure 20-8 Magnaflux Testing Machine

65 The solution mentioned first is preferred because it dissolves less metal and is less likely to cause hydrogen embrittlement. The following conditions are recommended:

Composition: Nitric acid 48(±2)% to

Hydrofluoric acid 2(±1/2)%

Time: 10 to 20 minutes

Temperature: 80°(±10°)F

66 Comparing the various pickling solutions, those containing the least nitric acid offer the greatest danger of hydrogen embrittlement of the titanium being pickled. Heavy scale formed at temperatures above 1300° F is removed best by molten sodium hydride salt baths at 700° F. Bath temperature must be controlled carefully, because titanium reacts violently with molten salt baths at temperatures above 1000° F. Hot hydrofluoric acid solutions, (5% at 170° to 200° F), will also remove heavy scale but may remove too much titanium metal.

67 Abrasive cleaning is usually restricted to forgings, bars and heavy plate. Shot and grit may be embedded in soft unalloyed titanium and subsequent salt bath or acid pickling is recommended to remove such particles less they cause surface defects. To prevent iron pickup, wire brushing should also be used with caution. When grit-blasting is required, use artificial garnet-type silica-free fused aluminum oxide grit (Item 8, 9 or 10).

68 Grit may be re-used, provided that it has not become contaminated with more than 10%, by weight, of metal. Air pressure must not exceed 50 psi.

Defect Inspection

69 Inspection for defects must be carried out by one of the following methods, special attention being given to edges, holes, etc:

(a) Fluorescent penetrant (Zyglo). (Refer to Paragraphs 105 to 112, following.)

(b) Dye penetrant (Dy-Chek). (Refer to Paragraph 113, following.)

MAGNETIC PARTICLE INSPECTION-MAGNAFLUX

General

70 Magnetic particle inspection is a non-destructive test on magnetizable metals for the detection of defects, such as cracks, seams, laps and inclusions. This test is used particularly for all vital and highly-stressed aircraft parts as a major process inspection and as a required overhaul inspection for the detection of incipient service failures.

Magnetic Test

71 In this test, a magnetic field is induced in the test piece by passing a direct current either through the piece or through a conductor which passes into or through a hole in the piece, or through a coil around the piece. Any interruption on the induced field by a defect in the piece produces a magnetic gap or leakage field attracting iron powder which is applied to the piece. The first method induces a circular field, the second a longitudinal field. The powder can be dusted on the part in dry form, or suspended in a light oil and flowed over the the specimen by means of a hose. The liquid suspension may also be used as a bath into which the part is dipped. Thus the iron particles are given mobility for response to the magnetic gap or leakage field, where they align themselves along the defect.

Inspection Machines

72 The magnetizing apparatus, (see Figure 20-8), is constructed to provide uniform controlled operation. The magnetic flux is produced by direct current from generators, storage batteries or rectifiers. The apparatus is capable of inducing, in the piece under inspection, a magnetic flux of suitable intensity in the desired direction by either the longitudinal or circular method. For the longitudinal method, the magnetic flux is induced in the piece by placing the piece in a magnetic field between the poles of electromagnets, or in a solenoid or coil carrying suitable currents. For the circular method, the magnetic flux is induced in the piece by means of a low-voltage, high-amperage current passed through the piece, or through a conductor which passes into or through a hole in the piece. A demagnetizing apparatus, (see Figure 20-8), is required, consisting of suitable units such as

an open coil or box-type demagnetizer or other means, and having the necessary capacity for the satisfactory demagnetization of all types of pieces inspected.

Magnetic Field Indicator

73 A magnaflux field indicator, (manufactured by Williams & Wilson Ltd. Montreal), is required for checking for residual magnetism after demagnetization.

Preparation of Parts Prior to Inspection

74 Prior to inspection by the magnetic particle process, prepare parts as follows:

(a) Remove grease and oil by wiping with a cloth dampened in cleaner (Item 14) or by rinsing in cleaner.

(b) Grit or sand blast rough forgings, if this will facilitate inspection.

(c) Grit blast or wire brush welded assemblies to remove scale and weld spatter.

(d) Prime parts where it is necessary to provide a light coloured background for indications.

(e) Seal off portions of part and assemblies which might be damaged by the magnetic fluid, or which are so shaped that accumulations of the magnetic substance could not be removed. Use hard grease or wood plugs for sealing.

Make-up of Magnetic Fluid

75 Black or red magnetic fluid for the process is made by mixing black Magnaflux No. 7 (Item 15), or red Magnaflux No. 9 paste (Item 16), with kerosene (Item 17) to provide 1.2 to 1.8 ounces, by weight, of magnetic solids per Imperial gallon of fluid applied to parts.

Inspection

76 For all routine work, inspect by the non-fluorescent process (Magnaflux). Carry out inspection by the wet continuous method. Wet implies that a fluid containing magnetic particles is applied to the part by immersion or hose stream. Continuous (as opposed to residual) implies that the current is applied while the part is immersed in the magnetic fluid or just after the hose stream has been removed and the part is thoroughly covered with the magnetic fluid. For the non-fluorescent process with the wet continuous method, use black magnetic fluid for light-coloured parts, and red magnetic fluid for dark-coloured parts. Where the wet continuous method would not give as sensitive an indication as desired, or where there is danger of the magnetic fluid becoming entrapped without complete removal, carry out inspection by the non-fluorescent process with the dry continuous method. Dry implies dry magnetic iron oxide powder is applied to the part by sprinkling. Apply the magnetizing currents shown in the following table during the inspection process:

For the longitudinal method on all parts.	1800 amperes where the magnetizing coil contains 5 turns.
	2250 amperes where the magnetizing coil contains 4 turns.
For the circular method on solid and hollow cylindrical parts.	1000 amperes per inch of outside diameter.
For the circular method on other than cylindrical parts.	1000 amperes per inch of the maximum cross section diagonal (see Note) perpendicular to the direction of current flow.

NOTE

For parts having varying cross-sections, the term maximum cross-sectional diagonal implies that the longest diagonal is considered for each section. The maximum of these longest diagonals is used as a basic for determining the current.

77 Complete inspection must consist of the following:

(a) The production of indications by one or more magnetizing operations in a longitudinal and/or circular direction. The operations must be so conducted that the lines of force produced lie approximately at 90° to any defect which may exist.

(b) An examination of the indications produced in accordance with Paragraphs 86 to 91, following.

Machine Operations (Circular Magnetization)

78 Clamp the part between the contact heads by moving the adjustable head toward the fixed head until its spring pressure regulator automatically stops the motion.

(a) Place the knife switch in the position marked CONTACT PLATES.

(b) Set the magnetizing circuit rheostat for the required current value.

(c) Use hose to flow the magnetic particle fluid, (refer to Paragraph 75, preceding), over the whole surface of the part. The appearance of the fluid is a visual check on the degree of agitation or concentration of the particles in the fluid.

(d) Cut off application of fluid and at the same instant, press the main contactor delivering the magnetizing current shot to the part.

Inspection

79 Inspect the part for magnetic particle indications. Use the auxiliary light and magnifying glass if necessary.

Demagnetization

80 Demagnetize parts between successive magnetizing operations when necessary to obtain proper indication of defects.

Machine Operation
(Longitudinal Magnetization)

81 Throw the knife switch to the magnetizing coil and position the coil with respect to the part. The current circuit now goes through the coil and the longitudinal magnetic field induced in the part is axial for detection of defects transverse to the part axis. Set the magnetizing circuit rheostat to supply the current necessary for longitudinal magnetization and repeat procedure in Paragraphs 78 (c) and (d), 79 and 80.

Magnaglo

82 Use the fluorescent process (Magnaglo) only where the non-fluorescent process is difficult or impracticable (e.g. on internal bores, on areas where a non-fluorescent particle is hard to see, etc.). Conduct this test in a suitable darkened booth or similarly darkened area with a black light source, provided for the fluorescent process, consisting of a No. H-100-SP4 100-watt black light and Magnaflux No. ZB-3901 filter, (both supplied by Williams & Wilson Ltd., Montreal).

83 Magnetic fluid for the fluorescent process is made up by mixing Magnaglo No. 10 paste (Item 18) with kerosene, (Item 17) to provide 0.12 to 0.48 ounces, by weight, of magnetic solids per Imperial gallon of fluid applied to parts.

Demagnetization

84 After inspection (i.e., after the final magnetizing operation), demagnetize parts completely by means of the equipment provided. Parts may also be demagnetized between successive magnetizing operations, if this improves indications. After final demagnetization, use a Magnaflux field indicator to verify that proper demagnetization has been achieved. Always demagnetize all parts tested.

Cleaning after Inspection

85 After inspection and demagnetization, clean parts thoroughly with cleaner (Item 14) to remove all magnetic fluid or powder. Remove hard grease or wood plugs used for sealing. Clean off the residual grease with cleaner.

Interpretation of Indications

86 All indications resulting from magnetic particle inspection are not defects, or injurious to the functioning of the part inspected. Under certain conditions, grain-flow lines, superficial tool marks, work-hardened areas, etc., are revealed. Therefore, interpretation of indications requires experience and judgement.

Structural Parts

87 Examine suspected structural parts to determine the nature of the flaws. Defects which are confined to the surface, such as laps or gouges, may be removed by grinding, provided that machined surfaces are not damaged nor structural strength impaired. After grinding, the parts must be re-inspected. Rejected parts which cannot be salvaged in this manner must be reduced to produce.

Rejectable Defects on Bolts and Screws

88 The following defects on bolts and screws are cause for rejection:

(a) Seams, inclusions, nicks or gouges deeper than .010 inch on the head.

(b) Cracks in the fillet from head to shank. Longitudinal seams only, up to .005 inch deep, are acceptable in this area.

(c) Transverse indications in the shanks, threads or fillet.

(d) Cracks resulting from heat treatment.

(e) Grinding cracks on the shank or threads.

89 Nearly all failures of bolts and screws occur in the areas shown in Figure 20-9. Indications in these areas should be given the most careful examination, whereas indications outside these areas are of lesser importance.

Rejectable Defects on Nuts

90 Longitudinal cracks in nuts, which are deeper than .005 inch on the outside or inside and penetrate into either end face, are cause for rejection.

Non-rejectable Defects on all Parts

91 The following false indications and minor defects are not cause for rejection of parts:

(a) False indications, such as magnetic writing (this indication appears as a characteristic scrawl) which may be accidentally produced by rubbing one part against another, thus producing magnetic leakages on the surface of either part. If in doubt, parts should be demagnetized and re-inspected. The indication should not then reappear.

(b) Leakage of flux at the ends of longitudinally magnetized pieces or at abrupt changes of section.

(c) Indications of cold work or hard and soft spots.

(d) Normal machine or die marks.

(e) Inclusions, (refer to Paragraph 92, following).

(f) Minor nicks, scratches or pits.

(g) Minor longitudinal indications in the shank or threads of bolts or screws or on the outside of nuts.

(h) Minor transverse indications on nuts.

(j) Unimportant flaws in nut anchoring ears or small forming tears in lock retaining ears of Boots type nuts.

INCLUSIONS

General

92 Inclusions are foreign materials formed by impurities in the metal during processing. They exist in the form of fine, reasonably straight lines and lie in the direction of rolling in bar stock, or in the direction of grain flow in forgings. Inclusions can be very short or relatively long and, as found by magnetic inspection, may lie below the surface of the part.

Method of Distinguishing

93 To distinguish between a crack and an inclusion, use the sharp edge of a pocket knife blade. The blade will be snagged by a crack. However, the blade test is not always positive and where doubt exists, use the Zyglo method, (refer to Paragraphs 105 to 112 following), or the Dy-Check method (refer to Paragraph 113, following).

Disposition

94 Parts containing inclusions may be considered acceptable for use on the following basis:

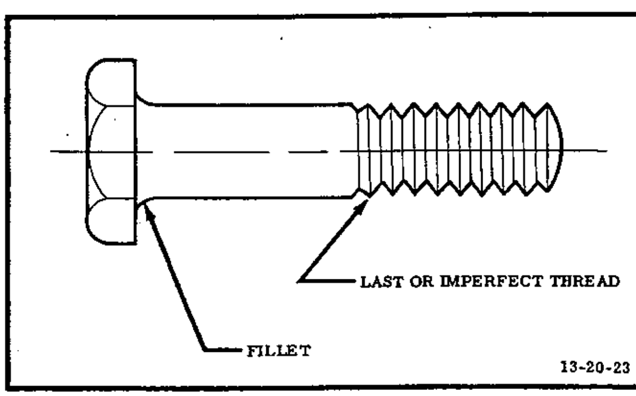


Figure 20-9 Critical Areas in Bolts and Screws

(a) There is no restriction in the number of inclusions in any one part, nor in the length of any one inclusion.

(b) Inclusions which are not in the same line, running in the direction of rolling or forging, must not be closer to one another than 1/2 inch when there is an overlap nor closer than 1/4 inch when there is no overlap, (see Figure 20-10).

(c) Inclusions must be fine or sharp line-like in width.

(d) Parts containing one or more inclusions running into fillets, corners, holes, changes in section, etc. are not acceptable.

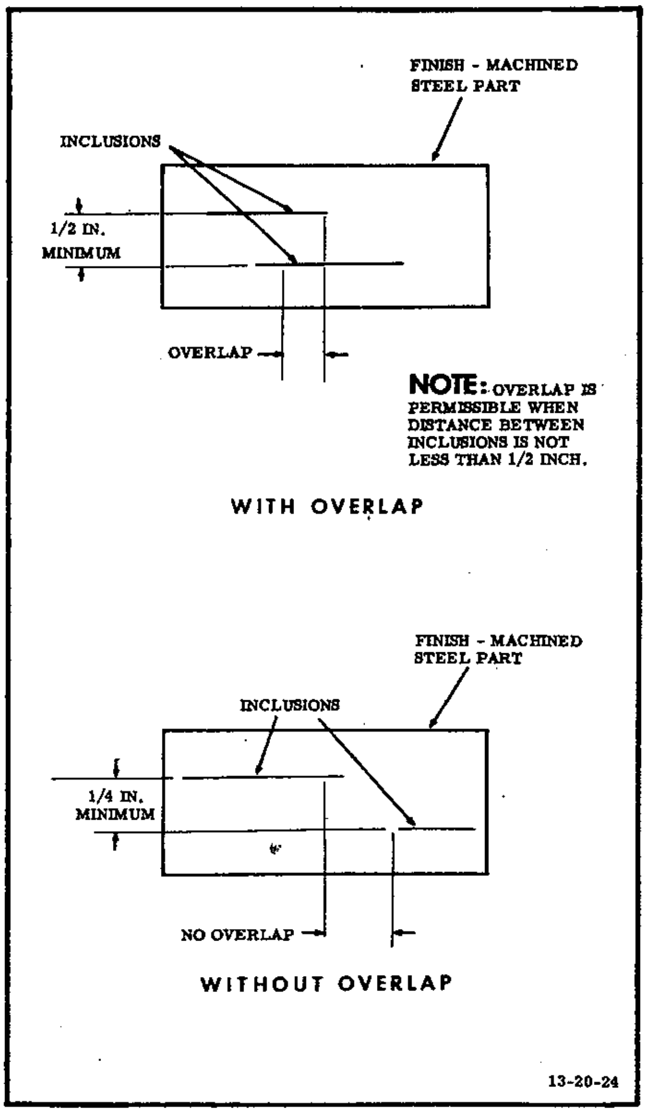


Figure 20-10 Acceptability of Inclusions

(e) Unless a sub-surface defect is suspected of being a crack for some special reason, it should be considered an inclusion.

B-1955 MAGNETIC INSPECTOR

General

95 The model B-1955 magnetic inspector is similar to the Magnaflux in operation and provides a means of inspection and demagnetization in the same portable unit. It is provided with two handles, an adapter with two spring-type battery clips for attachment to a d.c. supply, iron oxide paste (Item 19) mixed with cleaner (Item 14), an applicator for the solution, a magnifying glass and a compass for determining complete demagnetization after inspection.

Preparation of Parts

96 Clean parts thoroughly and remove scratches or corrosion pits by polishing prior to inspection.

Preparation of Solution

97 Mix iron oxide paste (Item 19) provided, with one gallon of cleaner (Item 14). Ensure the mixture is thoroughly agitated before filling the applicator.

Alternating-current Operation

CAUTION

Before connecting the equipment to the a.c. supply, ensure that the aircraft or its component is properly grounded, and that the magnetic inspector is grounded to the part to be tested.

98 Plug in a.c. supply, either 110 or 220 volts, and place part to be inspected in bore of the magnetic inspector. If part is greater than 5 inches in diameter, place it beside the magnetic inspector.

NOTE

The magnetic inspector should not be left switched on for more than 5 minutes or a thermal cut-out switch, incorporated in the unit, will automatically open the circuit to prevent overheating, and hold it open until the unit has cooled.

99 With current on, apply solution to area to be inspected, (refer to Paragraph 97, preceding). The area of greatest flux density is the area closest to but not within the bore of the coil. Area to be inspected must be within area of greatest flux intensity. Move magnetic inspector or part as required. A surface defect will be outlined by a build-up of the iron oxide solution defining the defect, and can then be further examined with the magnifying glass.

Demagnetization

100 After inspection, demagnetize the part as follows:

(a) With power on, draw the part slowly and completely through the field to a point where no magnetic attraction can be felt. If part is too large, or fixed, move the magnetic inspector from the part.

(b) Check for residual magnetism, using compass. Repeat previous operation if magnetism remains.

(c) Switch power off.

(d) Disconnect unit from outlet.

(e) Remove ground wire.

Direct-current Operation

101 The d.c. method of inspection is desirable for checking small parts that can be passed through the coil. In this method the part is magnetized for as long as required and then removed from the magnetic inspector for inspection. Grounding the unit is unnecessary when using d.c.

102 Attach extension cord to 24-28 volt d.c. supply. Insert part in the field of the magnetic inspector. Switch on for a few seconds, switch off and remove part. Ensure adequate magnetization using compass. Apply iron oxide solution and examine part. Repeat above procedure changing axis of part in flux of magnetic inspector.

Demagnetization

103 Repeat procedure in Paragraph 102, preceding, using a.c. power.

Post-inspection Procedure

104 Clean parts thoroughly, using cleaner (Item 14). Dry, using clean cloths (Item 20). Inhibit against corrosion, (refer to Part 23, following), and blank off openings until ready for re-assembly.

FLUORESCENT PENETRANT INSPECTION (ZYGLO)

General

105 Fluorescent penetrant inspection is a method of examining materials and parts whereby surface defects too small to be easily seen by regular inspection methods are rendered readily detectable. Fine cracks, porosity, laps and seams open to the surface are examples of such defects. The following instructions describe the requirements, necessary materials and the procedure to be followed for the fluorescent penetrant inspection of parts and materials. Carry out inspection after all machining and heat-treating operations are completed, but before chemical or other surface coating operations.

Limitation

106 The fluorescent penetrant method of inspection cannot be used on:

(a) Wood or other porous materials.

(b) New parts that have not been in service and the surfaces of which are painted, alodized, anodized, chromodized, chrome pickled, dichromated, etched or otherwise subjected to strong acids or alkalis.

(c) Parts which have been buffed, shot peened or burnished. These operations cause a folding of the surface metal over the defects thereby blocking the entrance of the penetrant.

(d) Parts having large defects such as gouges and large nicks. The penetrant is washed out from large surface defects and these defects are accordingly not detected under black light.

Preparation of Penetrant Tank

107 Fill tank to the working level with the fluorescent penetrant (Item 12). Do not allow the penetrant to become contaminated with water.

Preparation of Developer Tank

108 Fill tank to working level with water. Add three pounds of developer powder (Item 13) for each 10 Imperial gallons of water and stir until a smooth mixture is obtained. Immediately after the initial make-up and once-weekly thereafter, check the bath consistency by pouring a streak of the suspension on a glossy black surface, drying in dryer, and comparing with the standard panel procured from Magnaflux Corporation. Adjust the bath consistency by adding developer powder (Item 13) until the test streak matches the standard of four gallons per pound.

NOTE

For small batches or single parts, developer and penetrant may be brushed or sprayed on.

Preparation of Parts for Zylglo Inspection

109 Parts must be clean. Remove dirt and oil by vapour degreasing, solvent or mild alkaline cleaner. Refer to Paragraphs 155 to 158, following. Scale may be removed by grit blasting. Dry parts completely. Since slight preheating of the part or material increases the sensitivity of the process, the parts may be heated to a maximum of 140° F, if necessary.

Inspection Procedure

110 The inspection procedure is as follows:

(a) Completely immerse the parts in penetrant (Item 12) and set on rack to drain. Immersion plus drain time must conform to time shown:

PART	MINIMUM TIME (minutes)
Metal castings	30
Forgings	45
Extrusions, bar, tubing sheet	60
Weld joints	30
Non-metals	30

(b) With a water hose, spray rinse the parts free from surface penetrant (Item 12) until the black light does not develop fluorescence on the parts. Use a hood or tent to blank off outside sources of light when using black light equipment.

(c) After extended draining time, rinsing is facilitated by re-immersing the parts in penetrant and washing immediately with water.

(d) Partially dry the parts by blowing with compressed air.

(e) Immerse the parts in agitated developer tank.

(f) Place in dryer heated to a maximum temperature of 200° F. Do not leave parts in dryer longer than necessary since this will cause gradual evaporation of the penetrant from the defects. Do not exceed fifteen minutes in the dryer at 200° F.

(g) Examine under black light.

(h) After examination, remove the developer from the surface of the parts by rinsing in water.

Interpretation of Indications

111 Interpretation of indications is as follows:

(a) False indications: These are caused by flow marks, rough areas or by faulty rinsing following application of the penetrant. False indications may be wiped off without reappearing and generally do not show the brilliance of true indications.

(b) True Indications: Cracks, seams, laps and cold shuts show up as lines. Porosity is revealed by round glowing spots. Since the larger the defect the greater the volume of penetrant that seeps out during development, the extent of the defect can be estimated from the area of fluorescence at the defect. For estimating the extent of the defect, it is also helpful to examine under white light where the penetrant on the surface can be seen as a brown stain.

(c) Defects in finished parts: Reject defective parts unless the defects can be removed within the dimensional tolerances. A retest is necessary before the part may be accepted.

(d) Defects in raw stock: The following defects may be ignored:

(1) Defects confined to areas which will be completely removed in machining.

(2) Scattered shallow porosity.

(3) Shallow cold shuts and laps.

(e) The following defects are cause for immediate rejection:

(1) Cracks penetrating through in areas which will not be removed in subsequent machining.

(2) Through porosity in castings required to be pressure tight.

Oil-Chalk for Cracks

112 For information regarding procedures and equipment required to conduct this test, refer to EO 105-1-2B.

Dye Penetrant (Dy-Chek) Method

113 Use the following procedure for the detection of cracks, seams, laps and cold shuts by the dye penetrant (Item 11) (Dy-Chek) method.

(a) Thoroughly clean the surface to be inspected, removing all oil, grease, dirt, rust, paint, etc., (refer to Paragraphs 155 to 157 following).

(b) On the clean and dry surface, apply a coat of dye penetrant by spraying or with a brush.

(c) Let the part stand for five to ten minutes or longer if small tight cracks are suspected.

(d) Remove the dye penetrant completely with remover (Item 21) and follow with a wash with cloths dampened with water.

(e) Thoroughly mix the developer (Item 22). Keep mixed while in use.

(f) On the clean and dry surface, apply a thin coat of developer by spraying or with a brush.

(g) Let the part stand until the developer dries to a smooth white finish.

(h) Observe the surface after allowing about three minutes for all indications to develop.

(j) A crack will show as a red line; a very tight crack will show as a series of red dots close together in a line. Scattered red dots with no particular pattern indicate porosity.

(k) Remove the developer completely by wiping with a clean dry cloth.

(m) If required, re-finish the part to the original paint scheme.

TINNING AND SOLDERING

General

114 The following materials and procedure must be used in tinning and soldering steel, corrosion resistant alloys, copper and copper alloys.

(a) Use solder (Item 23) in wire or in bar form with or without rosin core, as required.

(b) Use a high melting point solder (Item 24) when soldering ethylene glycol radiators and other parts subject to higher temperatures than lead and tin solders would stand. It may be obtained in wire, bar and granulated form.

(c) For tinning and soldering in a pot, liquid fluxes are most suitable. With a soldering iron or acetylene torch, paste type fluxes are used most successfully since greater fluidity and adherence are secured. Fluxes (Items 25, 26 and 27) are recommended for general use.

Preparation of Work

115 All materials must be absolutely clean. This is the most important and necessary operation in all soldering and tinning. Paint, oil and grease, etc. are removed as outlined in Paragraphs 155 to 158, following.

Tinning Procedures

116 Treat areas to be tinned as follows:

(a) Dip area to be tinned into liquid soldering flux. Use flux, (Item 26) for brass, bronze, and copper; and flux (Item 27) for carbon steel, low alloy steel and corrosion resistant alloys. Flux (Item 27) contains acid, and special care must be taken in the rinsing operation.

(b) Transfer to molten solder pot and hold there until the temperature of the molten solder has been reached.

(c) Remove from solder pot and shake or knock off excess solder.

(d) Rinse thoroughly in frequently changed water, preferably hot. It is desirable that parts be immersed for at least 15 minutes. Brush or wipe to remove clinging flux. Where red flux has been used, a 10% soda ash (Item 28) solution must be used as a neutralizing bath, followed by a clean water rinse and drying. The importance of proper rinsing cannot be too strongly emphasized as residual flux will be a source of future corrosion.

Tinning Details

117 When tinning, note the following details:

(a) Threaded fittings: Immerse in flux and solder just far enough to cover threads.

(b) Preventing tinning in localized areas: Where it is desirable not to have an area tinned, masking may be effected by the application of chalk, (Item 29) talc (Item 30) or soda ash (Item 28) to the surface. A small amount of petroleum oil may be added to the powders as a binder if desired. Subsequent to tinning, solvents and hot water washing must be used to remove any residual powder or oil.

Soldering Procedures

118 The soldering procedure is as follows:

(a) Surfaces to be joined must be free from dust or dirt films.

(b) Preheat, if convenient, to about 200° F.

(c) Apply a small amount of flux to each surface, using approved fluxes as specified in Paragraph 114, preceding. On previously tinned surfaces, keep flux to minimum.

(d) Place together surfaces to be joined. The separation must not exceed .010 inch unless authorized by engineering authority. Highest strength joints are secured when the separation is between .001 inch and .005 inch.

(e) Heat the joint, using soldering iron or torch.

(f) When the joint is hot, place a small amount of solder at the edge. With proper heating and fluxing, the solder should melt and be drawn quickly into the space between the surfaces by capillary action. Such action is termed sweating or sweat soldering. Only enough solder should be added to just fill the space. It is the solder between the surfaces which gives strength to the joint, not the solder on the outside or piled around the edge. Excess solder may be removed while still in the semi-liquid (plastic) stage by wiping with a cloth.

(g) Allow the solder to solidify.

(h) After solidification and cooling, clean the joint thoroughly by wiping, using cleaner (Item 14).

Soldering Special Details

119 For the soldering of special details proceed as follows:

(a) Sealing of hydraulic assemblies: Where drawings call for hydraulic parts to be joined and sealed by sweat soldering, the following requirements must be observed:

(1) Perform operations quickly to prevent corrosion on all unplated parts.

(2) Tin all surfaces to be joined prior to assembly, (refer to Paragraphs 116 and 117, preceding).

(b) Where threaded areas or press fits are joined proceed as follows:

(1) Preheat the parts to melt the solder on the tinned surfaces.

(2) Assemble the parts, tighten threaded joints fully and seal by the addition of sufficient solder to fill the joints. Do not add an excess. Sufficient torch heat must be applied during the above operations to keep the solder in a molten state but do not overheat.

(3) Flux the joint edge, using paste flux to ensure perfect sealing.

(4) Allow parts to cool. Clean thoroughly.

Soldering Electrical Parts

120 For assembly of electrical parts, use rosin core solder (Item 23) only. Both the

liquid and paste fluxes contain chemicals, the corrosive action of which is accelerated by electricity. After soldering, remove traces of rosin by wiping with carbon tetrachloride (Item 31). Refer to Part 9, preceding, for further soldering details.

Soldering Oxygen Tubing

121 Refer to Part 12, preceding, for instructions regarding the soldering of oxygen high pressure tubing.

Cable Soldering

122 Only soft solder (Item 23) and liquid soldering flux (Item 26) may be used for control cable soldering. For cable soldering procedures, refer to Part 10, preceding.

SILVER BRAZING (TORCH)

General

123 All parts to be silver brazed must be cleaned and prepared as outlined in the following paragraphs.

Cleaning

124 All parts to be brazed must be cleaned prior to assembly. (Refer to Paragraphs 155 to 158, following.)

125 Dip copper alloys(brass and bronze) in a solution containing 45% sulphuric acid (Item 7), 7% nitric acid (Item 4) and 48% water by volume. As a final operation, all parts must be cleaned with carbon tetrachloride (Item 31) or in trichlorethylene (Item 32) vapour immediately prior to assembly.

Procedure for Brazing

126 Preparation of parts for brazing is as follows:

(a) Prior to assembly apply flux (Item 33) to all surfaces to be joined.

(b) Assemble parts so that the clearance between the mating surface is within the limits specified on the drawing. Never use interference fits. Staking, pinning, rivetting, tack spot welding or tack arc welding may be used when permitted on the drawing.

(c) Apply sufficient silver brazing alloy (Item 34) in close proximity to one edge of each joint to completely fill the largest clearance encountered on the drawing. For joints having one end inaccessible to visual inspection, apply filler metal at the blind end. For joints having all edges accessible to visual inspection, apply filler metal (Item 34) manually during torch brazing.

Brazing

127 Braze parts as follows:

(a) Heat the joint above the melting and flowing temperature of the brazing alloy but not hotter than is required to make an acceptable joint and in no case hotter than 1600° F.

(b) After brazing, air cool parts to 400° F or less.

(c) Remove flux from brazed parts, as soon as possible after brazing, by immersing the parts in water at 160° to 212° F, for 40 minutes minimum, followed by rinsing in clean running water.

(d) Never heat silver brazed parts above 800° F after brazing.

NOTE

All brazed joints must have a bond visibly complete at all edges and not recessed more than 10% of the joint depth.

ALUMINUM BRAZING

General

128 Aluminum brazing may be used as a method of joining 2S, 3S, 52S, or 61S aluminum alloy wrought materials and 43, 355 and 356 aluminum alloy castings. Joint types are restricted to corner, fillet, sleeve or inverted flange. Straight butt or flange types are not permitted.

Cleaning

129 Clean all parts thoroughly. Remove oil, grease, dirt and paint as detailed in Paragraphs 155 to 158, following.

Fluxing

130 Prepare flux (Item 35) by mixing the dry powder with water to form a thin paste. Apply by brushing in sufficient quantity to cover the area to be joined. Where desired, flux may be applied to the brazing wire (Item 36).

Brazing Operations

131 Heat the parts with an oxy-hydrogen or oxy-acetylene torch, using a tip of sufficient size to bring the work rapidly up to heat. Use sufficient heat and filler metal (Item 36) to ensure full penetration in all joints.

CAUTION

Avoid underheating or overheating as either of these will result in undercutting or excessive pitting of the material.

Flux Removal

132 Immediately after brazing, remove flux from the parts as follows:

(a) Immerse for 10 minutes in a 10% solution by weight of sulphuric acid (Item 7). Operate at room temperature.

(b) Remove parts from the acid and rinse thoroughly in clean hot or cold water.

(c) Ensure that parts are completely dry. Compressed air or hot air may be used if desired.

Inspection after Brazing

133 Ensure that brazed rivets are surrounded by a smooth uniform fillet and that sheet material surrounding the rivet is not grooved or pitted. Full penetration and smooth fillets must be evidenced in all points, with no pitting.

CLEANING OF METALS

General

134 The following instructions, including material and equipment used for the cleaning of metals, are to be followed for most satisfactory results. The metals covered include aluminum and magnesium alloys, copper and copper alloys, and ferrous alloys.

ALUMINUM AND MAGNESIUM ALLOYS

Mild Alkaline Cleaner

135 The cleaner (Item 37) is an approved type containing a suitable wetting agent and specifically designed for the cleaning of aluminum and magnesium alloys in agitated, heated tanks. It has a detergent effect strong enough to render prior treatment unnecessary unless the parts are coated with oil and grease. The solution is alkaline in reaction and is inhibited against attack on aluminum and magnesium. Oil, grease, etc., must not be allowed to gather on the surface of the solutions. Remove by skimming, overflow or other suitable methods. This method of cleaning is limited to detail parts unless, in assemblies, complete drainage, rinsing and drying can be obtained in pockets, joints etc. Otherwise, vapour degreasing must be used. Refer to Paragraphs 155 to 157, following.

Equipment

136 Use cleaning tanks made of steel, cement or earthenware. Heating coils must be provided. Provision must be made for agitation of the solution by compressed air or other means.

Procedure for Cleaning

137 The concentration of the alkaline cleaner (Item 37) should be 7-1/2 ounces per Imperial gallon. The temperature should be 180° F minimum. Immerse the parts in the solution in such a manner as to permit free circulation at the surfaces being cleaned. Leave immersed long enough to clean the parts completely. Rinse immediately in cold water, then hot water and allow to dry.

Mechanical Cleaning

138 Use mechanical cleaning only as a last resort to remove light or heavy corrosion. Remove corrosion by using approved polishing compounds (Item 38) and buffing wheels or cloths. Treat magnesium surfaces, cleaned by any of the above methods, with a chrome pickle solution as specified in Part 23, following. Treat aluminum surfaces, where possible, with a 10% chromic acid solution (Item 39) except in those areas where anodizing or chromodizing has purposely been omitted (i.e. integral fuel tank areas, etc.).

Etching

139 Etching may be used for the removal of corrosion from detail parts made of aluminum or magnesium alloys. This method may also be used on assemblies if it is assured that all traces of the etching solution can be removed. Use a shallow wooden tank or an earthenware crock to hold the hydrofluoric acid - gum tragacanth solution, which can be applied with an ordinary paint brush. Motor-driven mixers of the paint mixing type are preferred for stirring the solution.

Preparation

140 For brushing, prepare the solution as follows to make approximately one Imperial gallon:

(a) Add five ounces, by weight, of gum tragacanth (Item 40) to one pint of denatured alcohol (Item 41) and stir to a smooth consistency.

(b) To one Imperial gallon of boiling water, slowly add the gum - alcohol solution, stirring constantly, until a smooth paste is produced. This usually required about fifteen minutes.

(c) Cool the paste to room temperature and then transfer to the tank specified in Paragraph 139, preceding.

(d) Add one-half pint of hydrofluoric acid (Item 5) slowly and with constant stirring.

CAUTION

Use oversize containers to avoid foaming over when adding the gum - alcohol solution to the boiling water.

Operation

141 Brush on copious amounts of solution. Avoid processing too large an area at one time. Keep the solution in motion on the aluminum by constant brushing. Rinse thoroughly in clean, cool water and dry by air blast.

NOTE

Solution must be fresh at all times. If any unused hydrofluoric acid - gum solution remains after 24 hours, discard.

REMOVAL OF AIRCRAFT FINISHES

General

142 Materials used for paint removal are corrosive, toxic and flammable. Safety precautions for doping, painting and paint removal, must be followed during use of these materials, (refer to EO 00-25-19). Paint removers can be made from various chemicals and the composition of a particular remover will determine the severity of its attack on material other than paint. Some strippers will dissolve aluminum, stain metals, craze plastics, rot rubber, weaken adhesives and damage wood and fabric. Materials used for the stripping of aircraft finishes are therefore chosen to provide fast efficient removal within safety limits for the aircraft.

Cleaning prior to Paint Removal

143 The action of paint remover is impaired by the presence of oil, grease, mud and other foreign materials on the surfaces. For the same reason, soap films must be thoroughly rinsed from the surfaces. Prior to paint removal, clean surfaces with liquid soap, (refer to EO 50-10-1B). The use of emulsion cleaner for aircraft (EO 50-10A-2A) is to be avoided prior to paint removal, since this material leaves a residual oily film which interferes with the action of the remover. After washing and rinsing, the surfaces must be allowed to dry thoroughly. The action of paint remover, is completely stopped in the presence of a film of water.

Protection of Surfaces from Paint Remover

144 Removable parts which consist wholly or in part of plastic, rubber, wood, fabric or non-metallic material must be removed prior to paint stripping. Fixed parts which are subject to damage by paint remover should be masked with wax or by means of other adequate cover. These parts include:

(a) Plastic surfaces (windows, canopies).

(b) Rubber surfaces (de-icer boots, tires).

(c) Fabric surfaces (rudder, ailerons, elevators).

(d) Loop antenna and housing.

145 Instructional stencilling, decals, transfers, warning signs, etc. must be protected by masking or replaced after the stripping operation.

Method of Masking

146 Paper customarily used for masking purposes is ineffective protection against paint remover. For masking use wax (Item 47), as follows:

(a) Using masking tape (Item 48) outline the area to be masked.

(b) Melt the wax (Item 47) and brush a thick coat over the area. The application temperature of wax should be approximately (150° F). Higher temperatures may deform plastic.

(c) Remove masking tape.

(d) After the paint remover has been flushed from the surface, both wax and loosened paint can be removed by a stream of water under pressure.

NOTE

Paint removers, thinners and solvents can seriously deteriorate runways and flooring made from asphalt or similar type material. Choose a work area which will not be damaged by these materials.

Paint Removal Procedure for Metal Surfaces

147 Agitate paint remover (Item 46) thoroughly to break up and disperse lumps of wax which may have separated from the mixture. Remaining lumps may be removed by straining through a 16 mesh screen.

148 The remover may be streamed or brushed on the surfaces. For flow-on application, the material may be fed from a simple pressurized fluid tank to a non-atomizing spray nozzle. An atomized spray must not be used since the volatile solvent will be lost. Paint remover is applied as a wet coat, starting from the highest point on vertical or sloping surfaces and working progressively downwards. Maintain a wet coat throughout by additional applications of remover.

149 The stripping action is usually complete within fifteen minutes. Various films behave as follows:

(a) Enamel surfaces will wrinkle and lift within 5 to 15 minutes.

(b) Lacquer surfaces usually do not wrinkle but are softened by solvent action of the remover in 8 to 10 minutes. Test the lacquer film for slippage and remove it from the metal when loose.

(c) Wash down zinc chromate surfaces, without top coat applied, as soon as possible after loosening of the primer is observed, otherwise the primer may set up on the metal and become very difficult to remove. After rinsing and drying, any primer still remaining on the metal may be re-treated with paint remover.

150 Flush off the stripped paint, using warm water at 100° F under 150 pounds pressure. Cold water at hydrant pressure may be used. Start at the bottom of the surface and work upwards, keeping the water off the unwashed portions. Re-application of paint remover may be required in order to soften and remove completely abnormally thick layers of paint. After flushing, the surfaces must be allowed to dry thoroughly before paint remover is re-applied.

151 Complete the removal of paint and paint stripper from crevices and around rivets by brushing with a stiff fibre brush wetted with a mixture of three parts water to one part ethyl acetate (Item 49). Do not use a wire brush. Wipe dry immediately with a clean cloth (Item 20). Blow out all seams on the stripped surfaces and clean out any paint remover which may have run down inside the fuselage. Rinse and inspect any equipment contacted by the paint remover and replace damaged parts where necessary. Dispose of stripped paint in accordance with regulations governing the disposal of combustible waste.

NOTE

Paint remover (Item 46), or other strippers containing ethylene or methylene dichloride may not be used to remove paint from metal surfaces containing metal to metal bonded joints. Use of such materials seriously weakens the shear strength of the joints. Paint removal from these surfaces is to be accomplished only by use of strippers approved for this specific use or by use of thinners.

Removing Paint from Fabric Surfaces

152 Thinner (Item 50) is to be used for removal of the finish from fabric covered surfaces prior to refinishing. Paint remover is not to be used because it will deposit a residue in the fabric which will cause early failure of the refinished surface. The fabric is to be kept wet with thinner until the coating is softened and removed by scraping with a rounded putty knife or similar dull instrument.

Removing Paint from Wood Surfaces

153 If simple sanding to remove irregularities and to roughen the surfaces is inadequate, paint remover (Item 46) may be used. Avoid prolonged contact of the stripper with the bare wood, since the wood will absorb some of the wax and make good refinishing difficult. The loosened paint is scraped away with a dull instrument and the remaining paint and stripper is to be removed from the wood surfaces with thinner (Item 50). Water must not be used to rinse off the remover since water will cause wood to swell. After the solvents have evaporated, the surface must be sanded with fine sandpaper prior to refinishing.

CAUTION

Ground aircraft. Keep away all sources of sparks and flame. Protect eyes and skin. Rinse contacted areas at once with water. Avoid applying paint remover in the hot sun. Avoid soaking parts in paint remover. Keep masked areas and markings free from remover. Keep paint remover one inch or further away from the edge of plexiglas. Do not use caustic cleaning compounds, metal scrapers, wire brushes or emery cloth for paint removal from aluminum or magnesium surfaces. Read and follow EO 00-25-19.

Cold Cleaners

154 The following cold cleaners are approved for use on aircraft exteriors:

(a) Mulsirex (Item 42) and Mulsine (Item 43) are to be used following the manufacturers instructions.

(b) Steam aero brightening agent (Item 44) is approved for all cleaning of aluminum alloys following paint stripping operation. The compound must be dissolved in boiling water, using three-quarters of an ounce of the compound to one Imperial gallon of water. Spray the mixture on with steam gun cleaning equipment.

Vapour Degreasing Equipment

155 The following equipment must be available for vapour degreasing:

(a) An approved type tank equipped with heating and condensing coils.

(b) Thermostatic controls to maintain the outlet water temperature in the condensing system at 95° to 105° F, and the temperature of the heating system at 188° to 195° F.

(c) Stabilized trichlorethylene (Item 32).

Vapour Degreasing of Tubes and Ducts

156 Place tubes and ducts into the degreaser, individually or in bundles, as nearly vertical as possible. Flush clean, hot (160° F minimum) degreaser fluid through each unit until the parts are clean. The volume of liquid used must be sufficient to ensure that the complete internal area is in contact with liquid throughout the flushing operation. Allow complete drainage to take place. Ensure that degreasing fluid (Item 32) does not remain trapped in bends, etc. After this treatment, seal parts until ready for installation in the aircraft.

Vapour Degreasing of other Equipment

157 Load parts into the degreaser so that the greatest surface area is exposed to the vapour. Contact with the vapour must continue until condensation on the parts ceases. Parts must be lowered into and raised out of the degreaser not faster than 7 to 11 feet per minute.

CAUTION

Avoid inhaling trichlorethylene vapour. Smoking or the presence of flames in the vicinity of the degreaser is prohibited.

Organic Solvents

158 When vapour degreasing or alkaline degreasing is not practical, trichlorethylene (Item 32), carbon tetrachloride (Item 31)

naphtha (Item 51) or other suitable organic solvents may be used with a clean cloth to remove oil and grease.

Cleaning Exterior of Aircraft

159 To clean the exterior of the aircraft, proceed as follows:

(a) Remove excess sealing compounds, grease, etc., using solvent such as lacquer thinner (Item 52) or ethyl acetate (Item 49).

(b) Clean the aircraft by spraying with an approved brightener, (Items 42, 43 and 44) and scrub thoroughly with a bristle brush.

(c) Rinse with water, preferably warm.

COPPER AND COPPER ALLOYS

General

160 Clean copper and copper alloys by one of the methods described in the following paragraphs.

Mechanical Cleaning

161 Use light sand-blasting, wire brushing or similar mechanical methods to remove light oxide and tarnish from copper and copper alloys. Use organic solvents, (refer to Paragraph 158, preceding), to remove oil and grease.

Sulphuric Acid Cleaning

162 Clean parts which are heavily scaled as a result of brazing or soldering in a 10% sulphuric acid solution for 20 to 30 minutes at room temperature. Rinse with hot water and dry in an oven at 200 to 250° F, or with compressed air.

FERROUS ALLOYS

General

163 Ferrous alloys are cleaned by any one of the methods outlined in the following paragraphs.

Mechanical Cleaning

164 Remove heavy scale, oxide film or rust by sandblasting or wire brushing until parts are clean. Sand-blast lightly, using a non-metallic grit (Item 10). Non-metallic grit must not contain more than 10% by weight of iron contamination when used on stainless steel parts. Stainless steel parts require passivation after sandblasting. Thin gauge sheets and parts to be resistance welded must not be sandblasted.

Degreasing

165 Degrease excessively greasy parts before sand-blasting by using Royalite (Item 56). This material is designed for the cleaning of ferrous alloys in agitated heated tanks. Use a concentration of 6 ounces per Imperial gallon at a temperature of 180° F minimum and vapour degrease as specified in Paragraph 156 or 157, preceding. Organic solvents may also be used, as specified.

Removal of Scale, Oxide Film and Rust from Non-stainless Steels

166 Non-stainless parts which cannot be conveniently cleaned by the grit blast methods specified in Paragraph 164, preceding, shall be pickled as specified herein. If required, degrease parts according to Paragraph 165, preceding, before pickling. Use a lead lined or other suitable tank to hold the acid solution.

Operations

167 Pickle heavily scaled parts in a mixture of two parts sulphuric acid (Item 7), one part hydrochloric acid (Item 6) and ten parts tap water at a temperature of 160° to 180° F. Use a pickling solution containing an approved wetting agent (Item 55) and an inhibitor (Item 54). After pickling, rinse parts thoroughly in agitated clean water.

Wetting Agent

168 Ridosal (Item 55) wetting agent is approved for the above solution. One Imperial pint of Ridosal should be added for every thousand gallons of solution.

Inhibiting Agent

169 Rodine (Item 54) is approved for inhibiting non-stainless steel pickling solutions. The amount added should be .5% by volume of the total amount of concentrated acid used.

Relief of Hydrogen Embrittlement

170 Refer to Part 23, following, for instructions regarding the relief of hydrogen embrittlement.

Pickling of Stainless Steels

171 Pickling may be performed only on thin gauge stainless steel parts where blast cleaning would cause distortion. Otherwise, blast cleaning is to be used throughout.

Equipment

172 Use a tank lined with a suitable acid resistant material such as bitumastic, Koroseal etc.

Procedure

173 Immerse parts or assemblies in solution of 12% nitric acid (Item 4) and 6% hydrofluoric acid (Item 5), by volume, at room temperature until free from rust or scale. Rinse parts thoroughly in clean, agitated water, then dry in an air blast and passivate, (refer to Paragraph 175, following).

Pickling of Formed Stainless Steel Parts

174 Pickle lead or Kirksite-die formed parts (a passivating solution may be used) before any subsequent heating operation is performed. The pickling need only take place until the evolution of gas bubbles ceases.

Passivation

175 As a final operation, assemblies for exhaust systems, such as stacks, collector rings, preheaters, supports for rings, etc., must be immersed in a 50% solution of nitric acid (Item 4) at room temperature for a period of two hours. As an alternative a 20% nitric acid solution at 130° (±5°) F for 40 minutes may be used.

Electro-cleaning

176 Use electro-cleaning whenever specified.

Equipment

177 Use a steel tank provided with iron heating coils and with nickel plated steel cathode bars approximately four inches wide suspended from nickel-plated copper conductor bars placed along the two long sides of the tank. Place the anode conductor bar, from which the parts to be cleaned are suspended, midway between the cathode conductor bars. Provide adequate transverse ventilation for this tank.

Operation

178 Clean the degreased parts in an electro-cleaner of the following composition:

(a) Sodium carbonate (Item 28), 5 ounces per Imperial gallon of water.

(b) Trisodium phosphate (Item 57), 5 ounces per Imperial gallon of water.

(c) Sodium hydroxide (Item 58), 1/2 ounce per Imperial gallon of water.

179 In the electro-cleaning process, make the parts the anode for 3 to 5 minutes at a current density of approximately 50 amperes per square foot. At this current density, a vigorous evolution of hydrogen gas occurs. To secure proper cleaning action ensure that the temperature of the solution is 195° F or more. Rinse parts in warm water immediately after cleaning.

NOTE

> Magnet C cleaner (Item 59) is an approved substitute for the electro cleaner specified above. It should be used on the basis of 12 ounces per Imperial gallon.

Relief of Hydrogen Embrittlement

180 Refer to Part 23, following, for instructions regarding the relief of hydrogen embrittlement after electro-cleaning.

Cleaning of Springs

181 Prior to plating, grit-blast scaled springs, using a fine grit (Item 10) and an air pressure of 40 to 50 psi, or clean by vapour degreasing. Other methods require approval of engineering authority.

HEAT-RESISTANT ALLOYS (OTHER THAN STAINLESS STEELS)

General

182 Clean heat-resistant alloys, such as Hastelloy CN-155, Inconel, etc. as described in the following paragraphs.

Degreasing

183 Degrease by either of the methods described in Paragraphs 156 and 157, preceding.

Removal of Scale and Welding Flux

184 Remove scale and welding flux by pickling in a solution of 50% (by volume) concentrated nitric acid (Item 4) and 10% (by volume), of concentrated hydrofluoric acid (Item 5), at room temperature for 5 to 30 minutes, until all scale and flux are removed. The removal may be accelerated by scrubbing parts with a brush. Rinse parts thoroughly in clean, agitated (hot or cold) water, and follow by completely drying in an air blast. For selective pickling, degrease the areas to be protected as described in Paragraphs 156 and 157, preceding, and follow by coating with Unichrome stop-off lacquer (Item 60).

ELECTROFILM DRY LUBRICANT

General

185 Use the following procedure for the application of Electrofilm dry lubricant to parts when called for by drawing. This procedure does not cover the Electrofilm process for electrical resistance heating compounds.

Preparation of Parts

186 Prior to the application of the Electrofilm compound, parts must be treated as follows:

(a) Non-stainless steel and cadmium plated parts: Phosphate treat in accordance with Part 23, following.

(b) Stainless steel, chromium and nickel plated parts, copper and copper alloys: Grit-blast very lightly using Blastite (Item 10), Arrowblast (Item 9) or equivalent aluminum oxide grit with a No. 100 grit size. Passivate stainless steel parts after blasting in accordance with Paragraph 175, preceding.

(c) Aluminum and aluminum alloys: Anodize in accordance with Part 23, following, except that the rinsing after anodizing must be done in cold water instead of hot water.

(d) Magnesium alloys - Apply dichromate treatment (Dow No. 7) in accordance with Part 23, following.

Thermosetting Plastics

187 Grit-blast very lightly at an air pressure of 40 to 50 psi using aluminum oxide grit (Item 9 and 10) with a No. 100 grit size. After any of the above treatments, do not hold parts longer than 24 hours prior to the application of the dry lubricant. Handle in such a manner that the parts do not become contaminated with grease or dirt.

Application of Electrofilm Compound

188 Dilute the compound (Item 61) with solvent (Item 62) or para-dioxane (Item 63) on the basis of 4 parts solvent to 1 part of compound, measured by volume. Mix thoroughly and then strain to remove any particles which do not become dispersed.

189 Using a Binks gun (Model 15), a Binks nozzle (Type D76S) or equivalent and an air pressure of 20 to 30 psi, spray the parts to give a coating thickness of .0003 to .0005 inch. When the fit of the parts is very close, as indicated by drawing, a smaller coating thickness may be applied. The compound should come out of the nozzle in the form of a very fine mist. Agitate the mixture in the spray gun constantly to prevent separation from taking place. Air agitation may be used. Always spray in a spray booth due to the toxic nature of some of the compounds.

190 Where it is impractical to use a spray gun, coat parts by immersion in a mixture diluted in accordance with Paragraph 188, preceding. Remove any drops or tears which develop after the compound is allowed to drain. Spray where possible.

191 When required, mask parts in the same manner as for painting processes. The masking tape should be removed prior to baking.

Curing of Electrofilm Compound

192 Cure the electrofilm compound as follows:

(a) For copper and copper alloys, and steel parts both plated and unplated, bake at 400° (±25°)F for forty-five minutes.

(b) For aluminum, aluminum alloy and magnesium alloy parts, bake at 300°(±25°)F for one and one-quarter hours.

(c) For thermosetting plastics, bake at 250°(±25°)F for two hours.

Quality Requirements

193 After the preparatory treatment described in Paragraphs 186 and 187, preceding, the parts must be clean and uniform in appearance. Non-stainless steel parts, plated and unplated, must not appear too grainy after the phosphate treatment. After spraying the compound and prior to and after baking, the coating must be uniform in appearance, free from tears, voids, etc. After baking, the coating is to be resistant to finger-nail scratching.

194 The cured coating must pass the following adhesion test:

(a) Firmly apply the adhesive surface of fresh tape (Item 64) to the coated surface to be tested and remove the tape in one abrupt motion.

(b) The adhesion of the coating is considered satisfactory if no flakes or large particles of the film adhere to the tape. A faint uniform covering of powdery material adhering to the tape shall not be cause for rejection.

195 No additional finish is required for those surfaces of the parts which have been coated with Electrofilm.

ANTI-CHAFING MIXTURE

General

196 The procedure to be followed and materials used for the lubrication of such parts as engine cowling chafing pads in order to reduce wear due to chafing and abrasion is detailed in the following paragraphs.

Preparation

197 Make up the lubricating mixture by mixing 1 part of powdered graphite (Item 53) with 2 parts of fresh Bostik C cement (Item 65) to give a paste of suitable consistency for brush application.

Procedure

198 Apply the lubricating mixture with a paint brush and allow to dry before assembling the parts. When removal of the anti-chafing compound is required, benzol may be used.

APPLICATION OF NON-PEELABLE PLASTIC COATING TO AIRCRAFT EXTERIORS

General

199 Use the following procedure for the application of non-peelable plastic coating to the exterior of the aircraft.

(a) Thoroughly clean and polish the aircraft with approved cleaner (Item 45).

(b) To obtain best results, remove any residual cleaning compound from around rivets heads, skin laps, etc.

(c) Degrease small areas at a time, using brush-wash thinners (Item 68) and clean cloths.

(d) Spray plastic coatings (Item 66 or 67) at a temperature of 70°F, using 45 to 55 psi air pressure, keeping the nozzle about one foot away from the surface being coated. One return pass of the spray gun will normally assure complete coverage.

(e) When necessary, reduce the plastic solution to spraying consistency by the addition of thinners recommended by the supplier.

(f) The sprayed coating should be smooth, free from orange peel and about 0.0005 inch thick.

NOTE

This plastic coating will retard corrosion but will not prevent it indefinitely. Stored or parked aircraft should be examined periodically. The treatment prescribed is for unprimed and unpainted aluminum, aluminum alloy and steel but not for fabric surfaces.

(g) When it is desired to remove the film, use brush-wash thinners (Item 68) and cloths (Item 20).

PREPARATION OF EXTERIOR SURFACES OF AIRCRAFT FOR LOCAL PAINTING

General

200 The procedure to be followed in the cleaning of exterior surfaces of aircraft prior to the application of paint, lacquer, insignia or exterior markings when the rest of the aircraft is to be left bare, is to be found in the following paragraphs.

Cleaning of Exterior Surfaces

201 Remove any paint, lacquer, primer, etc. Remove any superficial corrosion with cleaner, (Item 45) then proceed as follows:

(a) Apply the compound, over an area approximately two feet square, with a clean cloth that has been dipped in water and wrung out.

(b) Rub vigorously with a crosswise motion until corrosion is removed.

(c) Remove excess cleaner with clean, dry cloth (Item 20). Change the wiping cloth frequently.

202 For large areas, spray the surface with a mixture of 1 part of Mulsirex (Item 43) to 7-1/2 parts of cleaner (Item 14). Allow to stand for approximately twenty minutes and then wash down with a steam jet. Etch the metal surface with phosphoric acid treatment as specified in EO 05-1-2AH. Proceed as follows:

(a) Treat assemblies containing magnesium parts with extreme caution. The etchant readily attacks magnesium and must not be allowed to contact any magnesium parts.

(b) Apply the etching solution with a swab or brush and allow to remain on the surface for one to two minutes. Keep the etchant out of seams and faying surfaces.

(c) The etching action usually causes a white frosting of the surface, and the etchant should be kept off areas not to be painted. For insignia and exterior markings, etch the complete area on which the insignia or markings are to be applied. Ensure that the surface etched is no larger than required. The frosting can be removed by polishing when necessary. The etchant also has a solvent action on primer and paint and should not be allowed to contact primed or painted surfaces.

(d) Scrub the surfaces lightly and rinse thoroughly with water.

CAUTION

Ensure that any etchant in seams and faying surfaces is completely removed.

(e) Dry surfaces thoroughly. Use an air hose to blow water out of all joints, seams, etc.

(f) Wear rubber gloves when using the etchant (Item 69). If acid gets on the skin, immediately wash with water. Refer to EO 00-25-25 for safety precautions.

(g) Spray the surface with zinc chromate primer (Item 70). (Refer to Part 23, following).

(h) Apply paint, lacquer, insignia or exterior markings in accordance with the exterior finish drawing for the particular aircraft.

APPLICATION OF DECAL (SCOTCHCAL) ON EXTERIOR SURFACES OF AIRCRAFT

General

203 For the application of adhesive backed vinyl film decals to the exterior surfaces of aircraft, refer to the following paragraphs.

Surface Preparation

204 Clean painted surfaces by wiping with clean cloths and toluene (Item 68), then wipe the surface dry with clean dry cloths. For unpainted aluminum surface, degrease by wiping with clean cloths and thinner (Item 72) then wipe dry with clean, dry cloths. Etch the area to which the decal is to be applied with phosphoric acid treatment as specified in EO 05-1-2AH. Rinse thoroughly by wiping with clean cloths moistened with water and wipe dry. Blow water out of all seams and joints with compressed air.

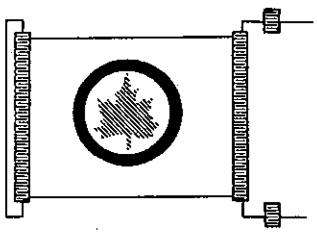
Application of Decals (Small)

205 For procedure for the application of small decals, see Figure 20-11.

Application of Decals (Large)

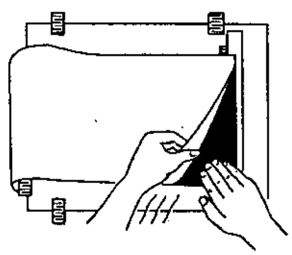
206 Position decal (Item 75) on aircraft surface with emblem facing out as it would normally appear in use. Hold the decal in place temporarily by small pieces of adhesive tape (Item 64). At this stage the protective backing paper is left intact on the decal.

207 Cut a piece of application tape (Item 76) about 4 to 5 inches longer and wider than the decal. Affix this piece of tape about 5 to 6 inches below the bottom edge of the positioned decal. Hold the free end out taut and away from the surface and bring the tape into contact with the decal by means of the plastic applicator. Use parallel, overlapping, upward strokes with the applicator. As the tape is pressed down near the top portion of the decal, remove the temporary pieces of adhesive tape and press down the remaining tape.



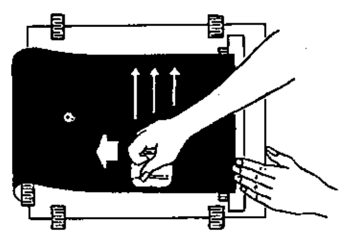
STEPS

1 POSITION EMBLEM ON SURFACE AND SECURE IN PLACE WITH MASKING TAPE AT ONE EDGE. TAPE A STRIP OF CARDBOARD OR WOOD TO OPPOSITE EDGE TO SERVE AS A STIFFENER.

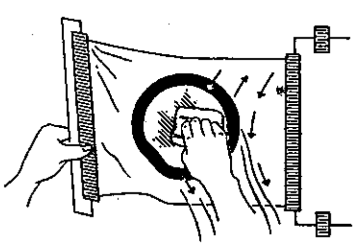


2 USING MASKING TAPE AS A HINGE, FOLD EMBLEM BACK ONTO A PIECE OF HEAVY PAPER OR CARDBOARD.

REMOVE THE PAPER LINER FROM FILM.



3 DIP FELT SQUEEGEE IN PAN OF ACTIVATOR. BLOT EXCESS LIQUID ONTO AN ABSORBENT CLOTH. DRAW SQUEEGEE ACROSS ADHESIVE SURFACE. USE PARALLEL OVERLAPPING STROKES, WORKING FROM OUTSIDE EDGE TOWARDS HINGE. ACTIVATOR MUST BE APPLIED EVENLY TO PREVENT PUCKERING. BE SURE TO ACTIVATE 1/2 INCH BEYOND ALL EDGES TO ASSURE COMPLETE ACTIVATION.



4 BRING ACTIVATED SECTION BACK TO ORIGINAL POSITION. HOLD UNDER SLIGHT TENSION AND KEEP SLIGHTLY AWAY FROM SURFACE.

USING THE PLASTIC APPLICATOR, RUB EMBLEM ONTO SURFACE WITH OVERLAPPING, FAN-LIKE STROKES, STARTING AT HINGE. IF RUBBER ROLLER IS USED, START AT HINGE AND USE PARALLEL, OVERLAPPING STROKES. ACTIVATED SECTION SHOULD NOT TOUCH SURFACE UNTIL PLASTIC APPLICATOR OR ROLLER PRESSES IT DOWN.

GO OVER ALL EDGES FIRMLY TO ASSURE GOOD EDGE CONTACT.

13-20-63

Figure 20-11 Application of Scotchcal Decals

208 Butt the edge of a stiff board, of wood or laminated plastic, against the lower edge of the application tape. Using the lower edge of the tape as a hinge, peel back the upper portion on which the decal is secured and place on the board, holding the board in a horizontal position.

209 Prepare to activate the adhesive film, using activator (Item 77) as follows:

(a) Remove the protective backing paper from the decal. This paper liner is easily stripped off after separating a corner or edge of the film from the backing paper with the finger nail or a razor blade.

(b) Dip a felt squeegee into a pan of A-2 activator. Blot squeegee two to three times on a clean absorbent cloth to remove excess activator. Excessive amounts of activator may cause damage to vinyl film of decal.

(c) Apply the activator to the exposed adhesive film, using parallel or radial overlapping strokes depending on the shape of the decal. Make certain that all decal edges are activated by applying activator 1/2 inch beyond the decal.

(d) Bring activated section back to its original position by holding the application tape taut and using the plastic applicator as described in Paragraph 207, preceding. The activated section must not touch the surface until the applicator presses it down. Go over all edges firmly to ensure good edge contact.

(e) After a few minutes remove the application tape by pulling it away from decal.

(f) Examine the decal surface carefully. Remove any blisters by puncturing with a pin and smoothing out the blister with the applicator. Go over the decal edges with applicator to ensure good edge contact.

Removal of Decal

210 Remove the decal by rubbing with a cloth saturated with methyl ethyl ketone (Item 78). Where decals have to be removed from painted surfaces, ensure that the methyl ethyl ketone is not spread beyond the area of the decal. After the decal has been removed, examine the painted surface carefully to determine whether the solvent has removed any of the paint. If the paint film has deteriorated in any way it must be stripped and the affected area repainted.

Inspection

211 Reject and replace decals which, after application, exhibit any of the following defects:

(a) Tears or wrinkles.

(b) Air blisters which cannot be smoothed out.

(c) Poor adhesion or inadequate edge contact.

(d) Damage to vinyl film due to excessive use of activator.

PREPARATION OF EXTERIOR SURFACE OF AIRCRAFT PRIOR TO CAMOUFLAGING

General

212 The procedure to be followed for the preparation of the exterior surface of the aircraft prior to camouflaging or other overall painting is to be found in the following paragraphs.

Cleaning of Exterior Surface

213 To clean surfaces which have previously been coated with zinc chromate primer or other finishes, strip in accordance with Paragraphs 147 to 151, preceding, until they are completely free of primer or paint. Then proceed as follows:

(a) Clean by spraying with one of the cold cleaners (Item 42 or 43) and rinse thoroughly with hot water until the exterior metal surfaces are free from oil, grease, dirt, waxy substances, etc.

(b) Wipe surfaces with clean cloths and thinner (Items 50 or 52).

214 Prepare and apply the etch primer (Item 73) as follows:

(a) The etch primer is supplied as a two component product which should be mixed in the ratio of four parts resin component to one part acid component. The ingredients must be measured accurately.

(b) Mix the components of etch primer at a temperature below 90°F. Limit the quantity to be mixed to the amount which will be used within four hours. Discard any primer not used within four hours.

(c) Both acid and resin components must be thoroughly agitated before mixing. Add acid component to resin to obtain maximum adhesion from etch primer.

(d) Slowly add one part by volume of the acid component, with constant stirring, to four parts by volume of the resin component. The acid component must be added slowly to prevent immediate jelling of the mixture. Never add the resin component to the acid component.

(e) When thoroughly mixed, reduce the etch primer with thinner (Item 72) to a viscosity of 28 to 30 seconds on a Zahn No. 2 cup. Mix one part of acid component with four parts of resin component and thin the resulting mixture with 1-1/2 to 2 additional parts of thinner (Item 72).

NOTE

It is extremely important that the surfaces of the parts be perfectly clean before the application of the etch primer.

(f) Apply one wet coat of etch primer. Do not attempt to obtain thin films by holding the spray gun at an exaggerated distance from the work or to get full hiding, as poor adhesion will result in both cases.

(g) Allow etch primer to air-dry for the minimum time specified in Figure 20-12 before the application of zinc chromate primer (Item 70).

(h) Apply one two-way coat zinc chromate primer in the conventional manner and allow to air dry for the minimum time specified in Figure 20-12. For spraying, the zinc chromate primer is thinned with toluene (Item 68) to a viscosity of 24 to 26 seconds on a Zahn No. 2 cup. Approximately two gallons of toluene will be required for each gallon of zinc chromate paste.

(j) Sand the primed surfaces, using fine emery paper. After sanding, the surface of the primer must be smooth.

(k) Remove dust from the sanding operation by blowing with an air hose followed by cleaning with tack-rags. Prepare tack-rags by immersing clean cheese cloth in spar varnish (Item 74) which has been diluted with cleaner (Item 14) and allowed to dry until just tacky.

(m) Apply camouflage enamel in accordance with the applicable finish drawing. Apply a mist coat of the enamel followed after 10 or 15 minutes, with a normal wet coat. For spraying, thin the enamels to a viscosity of 28 - 30 seconds on a Zahn No. 2 cup.

Retouching

215 The following are the instructions for retouching at various stages:

NOTE

Materials such as plastics, rubber, etc., must be masked before retouching. On completed aircraft, remove the canopy during paint removal.

(a) When it is necessary to refinish a bare spot, taper the edges of the old finish adjacent to the bare spot by sanding. Spot the etch primer in over the bare area and feather slightly over the old finish to as small a distance as possible.

(b) When it is necessary to refinish a local area of the etch primer (Item 73), remove the

Primer	Hours	
	Min.	Max.
Drying time for etch primer	1/4	4
Drying time for zinc chromate primer applied over etch primer	1/2	24

NOTE

Where parts coated with zinc chromate primer cannot be given a finish coat within the maximum time specified, the surface of the primer must be cleaned with solvent (Item 14), before the enamel is applied.

Figure 20-12 Primer Drying Time

finish in the area desired and recoat. No intermediate chemical film or etch treatment is necessary.

(c) When it is necessary to refinish a local area after the etch primer and zinc chromate primer have both been applied, remove the finish and replace the etch primer. Exercise care to prevent overspray on surrounding areas. After removal of any such overspray, apply the zinc chromate primer as usual.

CHROMODIZING

General

216 Chromodizing is a process used to improve the adherance of paint to clad material. It is used as a base for zinc chromate and other paints. The following instructions are to be used when chromodizing is required as part of the finishing process.

Chromic Acid Tanks

217 Chromic acid tanks must be made of mild steel or other approved materials and must contain heating coils to maintain the temperature of the solution at 120° to 140°F. Clamp, racks, wire and other fixtures used for suspending parts in the chromic acid tank must be made of aluminum.

Rinse Tanks

218 Rinse tanks must be provided for hot water and for cold water. The hot water must be maintained at 180° to 212°F. The tanks must be of the recirculating type, able to maintain a constant supply of clean water and must be fitted with skimming troughs.

Preparation and Maintenance of Chromic Acid Solution

219 Prepare the chromic acid solution as follows:

(a)	Chromic acid (Item 39)	52.5 pounds
(b)	Nacconal NR wetting agent (Item 71)	1 pound
(c)	Water	100 Imperial gallons.

220 When making up the initial solution or adding chemicals to the existing solution, agitate the tank by compressed air until it is certain that the solution has become uniform. Where chromic acid is to be added, dissolve the acid crystals in a bucket of water, add to the tank and agitate.

Cleaning of Parts Prior to Chromodizing

221 Clean by vapour degreasing or with alkaline cleaner, followed by rinsing in cold water, in accordance with Paragraphs 135 or 155, preceding. When the latter method is used, no water breaks are to be present after rinsing.

Chromodizing

222 Immerse parts in the chromic acid solution for 5 (±1) minutes and rinse, first in cold water then in hot water.

Material Specifications

223 For table showing item numbers, materials, specifications and manufacturer, see Figure 20-13.

Item No.	Material	RCAF Ref.	Specification	Manufacturer
1	Tempil Products	33C/647, 648, 649		Tempil Corp., 132 W 22nd., St., New York City, New York.
2	Oil, Linseed	33A/348, 344	1-GP-41	
3	Ferric Ammonium Sulphate			
4	Acid, Nitric	33C/2		
5	Acid, Hydrofluoric			Technical Grade
6	Acid, Hydrochloric	33C/1		
7	Acid, Sulphuric	33C/4	15-GP-8a	
8	Alundun X No.100			Norton Co., Chippawa, Ontario.
9	Arrowblast No.100			Norton Co., Chippawa, Ontario.
10	Blastite, Aluminum oxide grit			Canadian Carborundum Co., Niagara Falls, Ontario.
11	Penetrant, Dy-chek	33C/749, 750, 751 752		B.W. Deane & Co., 3620 Namur, Montreal.
12	Penetrant, Zyglo ZL-1			Magnaflux Corp., 5931 Northwest Highway, Chicago.
13	Developer, Zyglo ZP-3			Magnuflux Corp., 5931 Northwest Highway, Chicago.
14	Cleaner	33C/182	3-GP-8	
15	Magnaflux No. 7 Black	33C/629		Magnaflux Corp., 5931 Northwest Highway, Chicago.

Figure 20-13 (Sheet 1 of 5) Table of Material Specifications

TAIL PIPE ALUMINIZATION RE-IDENTIFICATION

General

224 Following a blade failure in the compressor section of an axial flow engine, aluminum spatter will form in the tail cone and tail pipe. To change the colour of this spatter so that future failures can be detected the solution as specified below is to be applied to the affected parts.

Preparation

225 Slowly add to one gallon of water 4 oz of Alodine 1200; (Item 79). When completely dissolved add to this solution 1/2 pint of alodine 1200 toner; (Item 80). To accurately measure and weight ingredients for less than 1 gallon of solution it is recommended that the facilities of a station hospital laboratory be used.

NOTE

This operation is to be done slowly to ensure ingredients are completely compounded.

Storage

226 Acid resistant polyethylene or stainless steel type 321/347 tight sealing containers (local procurement) are to be used for storage of this solution. During actual application the solution may be contained in glass vessels. The solution is not to be used if it has remained in the glass container for more than eight hours. To facilitate storage it is recommended that only one quart of solution be prepared at one time.

Application

227 Application is as follows:

(a) Remove tail pipe from aircraft.

(b) Ensure area to be treated is clean and free from grease and oil. Degrease by scrubbing with a clean cloth dipped in trichlorethylene or carbon tetrachloride.

(c) Rotate tail pipe so that affected area is at the bottom.

(d) Apply the solution to the affected area by means of a nylon brush or a swab made from a piece of clean cloth tied to a suitable stick and keep in a thoroughly wetted condition allowing the solution to act on the spatter until a coating with a golden brown colour appears. The colour may appear in from one to five minutes depending on the temperature of the part, and the freshness of the solution.

(e) Neutralize the solution by washing the treated area thoroughly with clean water and dry by means of a dry cloth and air blast. Before discarding the swab, wash thoroughly.

228 This method of treatment is not to be used for removing the aluminization from tail pipes undergoing repair or overhaul. Care is to be taken to ensure that powder or solution does not come in contact with aluminum alloy parts.

CAUTION

Safety precautions as per EO 00-80-4/26 paragraphs 27 to 47 are to be observed.

Item No.	Material	RCAF Ref	Specification	Manufacturer
16	Magnaflux No. 9 Red	33C/628		Magnaflux Corp., 5931 Northwest Highway, Chicago.
17	Kerosene	34A/217	3-GP-3	
18	Paste, Magnaglo No. 10			Magnaflux Corp., 5931 Northwest Highway, Chicago.
19	Paste, Iron oxide			Magnaflux Corp., 5931 Northwest Highway, Chicago.
20	Cloths	32B/14	Unit 9-1-1	
21	Remover, Dy-Chek	33C/750		B.W.Deane & Co., 3620 Namur, Montreal.
22	Developer, Dy-Chek	33C/752		B.W.Deane & Co., 3620 Namur, Montreal.
23	Solder, 50-50	30B/400	QQ-S-571 Comp. Sn50	
24	Solder, High melting point	30B/NIC		
25	Flux, Soldering, Paste	33C/		Canada Metal Co., 721 Eastern Ave., Toronto.
26	Flux, Soldering, Liquid Blue	33C/		Canada Metal Co., 721 Eastern Ave., Toronto.
27	Flux, Soldering, Liquid Red	33C/		Canada Metal Co., 721 Eastern Ave., Toronto.
28	Sodium Carbonate, Anhydrous	33C/687	15-GP-5a	
29	Chalk, French	33C/11	MAT-2-1	
30	Talc	33C/11	MAT-2-1	
31	Carbon tetrachloride	33C/102	O-C-141	

Figure 20-13 (Sheet 2 of 5) Table of Material Specifications

Item No.	Material	RCAF Ref	Specification	Manufacturer
32	Trichlorethylene	33C/163	MIL-T-7003	
33	Flux		AAF11316	
34	Brazing Alloy, Silver	30B/616	QQ-S-561 Grade 4	
35	Flux, Alcoa No.33			Aluminum Co. of Canada, 1700 Sun Life Bldg., Montreal.
36	Filler Metal, Alcoa No. 716			
37	Alclean			Canadian Hanson & Van Winkle, 15 Morrow Ave., Toronto.
38	Compound, Polishing, Aluminum	33C/689	MIL-P-6888	
39	Acid, Chromic	33C/494	O-C-303	
40	Gum Tragacanth			P.N. Soden Co. Ltd., 2143 St. Patrick, Montreal.
41	Alcohol, Denatured	34A/216	3-GP-530	
42	Mulsirex			B.W. Deane & Co., 3620 Namur, Montreal.
43	Mulsine			B.W. Deane & Co., 3620 Namur, Montreal.
44	Brightening Agent, Steam Aero			B.W. Deane & Co., 3620 Namur, Montreal.
45	Cleaner	33C/690	MIL-C-25179	
46	Remover, Paint	33A/456	1-GP-78	
47	Wax, Paraffin	33C/93		
48	Tape, Masking	32G/99, 100, 101	UV-T-106A	

Figure 20-13 (Sheet 3 of 5) Table of Material Specifications

53,036-0

Item No.	Material	RCAF Ref	Specification	Manufacturer
49	Ethyl Acetate	33C/294	C31-302	
50	Thinner, Cellulose Nitrate Finishes	33A/466	1-GP-506	
51	Benzol or Naphtha	33C/653, 34A/218	TT-N-95 3-GP- 27a	
52	Thinner, Lacquer	33A/98	1-GP-4a	
53	Graphite, Powdered	34A/208	MIL-G-6711	
54	Inhibiting Agent, Rodine No. 82			American Chemical Paint Co., Walkerville, Ont.
55	Wetting Agent, Ridosal No. 591			American Chemical Paint Co., Walkerville, Ont.
56	Roylite No. 134-A			Canadian Hanson & Van Winkle, 15 Morrow Ave., Toronto.
57	Trisodium Phosphate	33C/688	2-GP-31	Commercial Grade
58	Sodium Hydroxide	33C/672	15-GP-7a	Commercial Grade
59	Cleaner, Magnet C			Canadian Hanson & Van Winkle, 15 Morrow Ave., Toronto.
60	Lacquer, Unichrome Stop-off No. 323			Canadian Hanson & Van Winkle, 15 Morrow Ave., Toronto.
61	Compound, Lube-Lok No. 4856			Electro-film, 7116 Laurel Canyon Blvd., N. Hollywood.
62	Solvent, Lube-Lok No.4000			Electro-film 7116 Laurel Canyon Blvd., N. Hollywood
63	Para-Dioxane			Technical grade
64	Tape, Adhesive, Pressure Sensitive, Water Resistant	33G/5,6	43-GP-3a Grade B Type2	

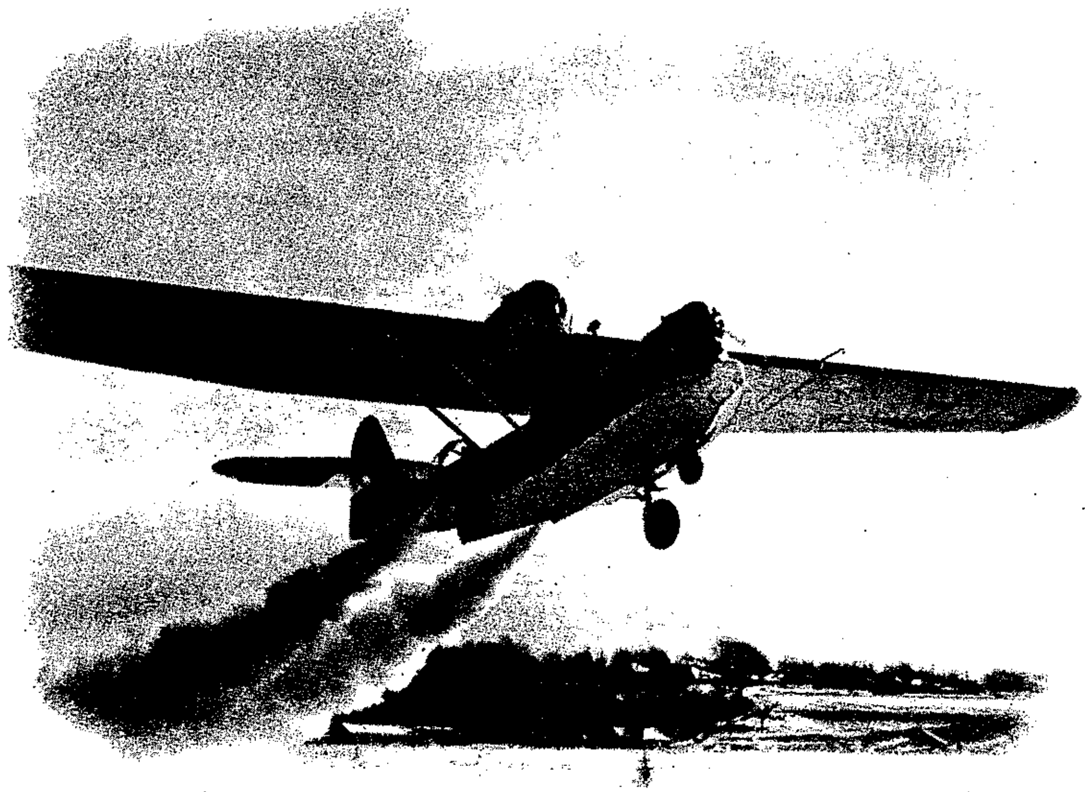
Figure 20-13 (Sheet 4 of 5) Table of Material Specifications

Item No.	Material	RCAF Ref	Specification	Manufacturer
65	Cement, Bostik C	33C/590		BB Chemical Co., Box 1447, Montreal.
66	Spray, Plastic Krylon No. 200			Simpson Machinery Ltd., 2180 Wilson, Montreal, Quebec.
67	Coating, Plastic, Clear Gloss	33A/		International Paints, 6700 Park Ave., Montreal.
68	Thinner, Toluol	33A/467	TT-T-548A	
69	Etchant, W.O. No. 1, [illegible] DELETED	33C/3[illegible]	[illegible]	Montreal.
70	Primer, Zinc Chromate	33A/462	MIL-P-6889A	
71	Wetting Agent, Powder, Nacconal NR	33C/728		
72	Thinner, Etch primer	33A/505	MIL-C-15328A	
73	Coating, Pretreatment, Etch primer		MIL-C-15328A	
74	Varnish, Spar	33A/475	TT-V-119	
75	Decal		MIL-D-8634	Minn. Mining & Mfg., London, Ontario.
76	Tape, Application, No Mar No. 323	32B/		Minn. Mining & Mfg., London, Ontario.
77	Activator, Adhesive A-2			Minn. Mining & Mfg., London, Ontario.
78	Methyl Ethyl Ketone	33C/520	TT-M-261	
79	Alodine 1200	33C/769		American Chemical Paint Co.
80	Alodine 1200 toner	33C/770		American Chemical Paint Co.

Figure 20-13 (Sheet 5 of 5) Table of Material Specifications

PART 21

FLOAT AND HULL REPAIR



PART 21

FLOAT AND HULL REPAIR

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PART 21

FLOAT AND HULL REPAIR

FLOAT AND HULL REPAIR

General

1 Repairs to floats and hulls must be performed as soon as damage is found so as to decrease the corrosive action of liquid inside the damaged component. Instructions for making hull repairs are generally applicable to floats. The following instructions apply to all types of repairs:

(a) All sheet replacement must be of the same or one higher gauge and of the same material and heat treated condition as the original. Refer to relevant Parts List or Structural Repair Manual for material specifications.

(b) Joints must be sealed using approved sealer as instructed in Paragraphs 12 and 13, following.

(c) Mark off or lay out rivet patterns with a soft pencil, never with a scriber or scratch awl.

(d) Use rivets of the same type as those being replaced, using the original spacing pattern. For enlarged or deformed rivet holes, use the next larger size rivet. Refer to Part 5, following, for rivetting instructions.

(e) After repair, observe anti-corrosion precautions detailed in Part 23, following, for the type of material.

(f) Surface finish procedure must conform to instructions issued in the relevant Description and Maintenance Instructions Manual for the aircraft.

(g) Perform a leakage test after each repair, (refer to Paragraph 22, following).

Nomenclature Used

2 See Figure 21-1 for terminology used in repairs to floats and hulls.

Corrosion Protection

3 After repair, the surface must be refinished to conform to the original finish scheme for the aircraft. Refer to the relevant Structural Repair Manual for the aircraft for the proper finishing procedure. For suitable aerodynamically smooth finish for use on aluminum surfaces proceed as follows:

(a) Apply primer (Item 1) not to exceed .0007 inch thickness.

(b) Apply two coats of surfacer (Item 2), wet-sanded smooth, using No. 360 sandpaper (Item 3).

(c) Apply one wet two-way coat of glossy lacquer (Item 4) and wet-sand with No. 400 sandpaper (Item 5).

(d) Use rubbing compound (Item 6) to remove scratches, orange peel and other lacquer defects.

(e) Apply polishing wax (Item 7) and polish by hand or with a mechanical buffer.

Primer

4 Zinc chromate primer (Item 1), is used because it combines low specific gravity with excellent corrosion-inhibitive qualities, and may be used on a wide variety of materials. It is yellow-green in colour and dries within five minutes when properly applied. Single coat thickness must be .00025 to .00035 inch. The total dry film thickness of primer on surfaces to be topcoated must not exceed .0007 inch. Apply by brush or spray.

Surfacer

5 Sanding surfacer (Item 2) is applied over primed surfaces prior to glossy lacquer or enamel topcoats in order to obtain aerodynamically smooth surfaces. The surfacer is thinned as specified on the container, using thinner (Item 8), applied in thin coats and

sanded to a total thickness of approximately 006 inch.

Topcoats

6 Topcoating materials to be used depend on the previous finish scheme for the aircraft. Lacquer (Item 4) is recommended for flying boat hull bottoms where fouling does not occur. Where fouling occurs, use anti-fouling paint (Item 9).

Protective Coatings after Repair

7 Treat aluminum alloy, from which the anodic film has been removed, with chromic acid (Item 10), then prime and paint with one coat of aluminized lacquer (Item 4) and one additional coat of lacquer to match the adjacent parts. Treat steel parts, from which the cadmium plating has been removed and which cannot be readily replated, with two coats of primer, one coat of aluminized lacquer (Item 4), and one coat to match the adjacent parts.

Finish of Repaired Areas

8 Finish replaced or repaired portions strictly in accordance with the detailed finish specification given in the relevant Description and Maintenance Instruction Manual.

Treatment of Slight Corrosion

9 Slight corrosion is not sufficient to threaten the structural strength of the particular member. Recommended procedure for dealing with cases of slight corrosion is as follows:

(a) Remove paint from an area sufficiently large to determine the full extent of corrosion and destruction of the anodic film.

(b) Scrape away corrosion with rough canvas or carpet material soaked in toluene (Item 11) or equivalent solvent. Exercise care to minimize marring of adjacent anodic film. It is important that corrosive matter be completely eliminated, as remaining traces will spread after repainting.

(c) If surface is pitted, level out indentations by application of aluminum metal spray. (Refer to Part 23, following.)

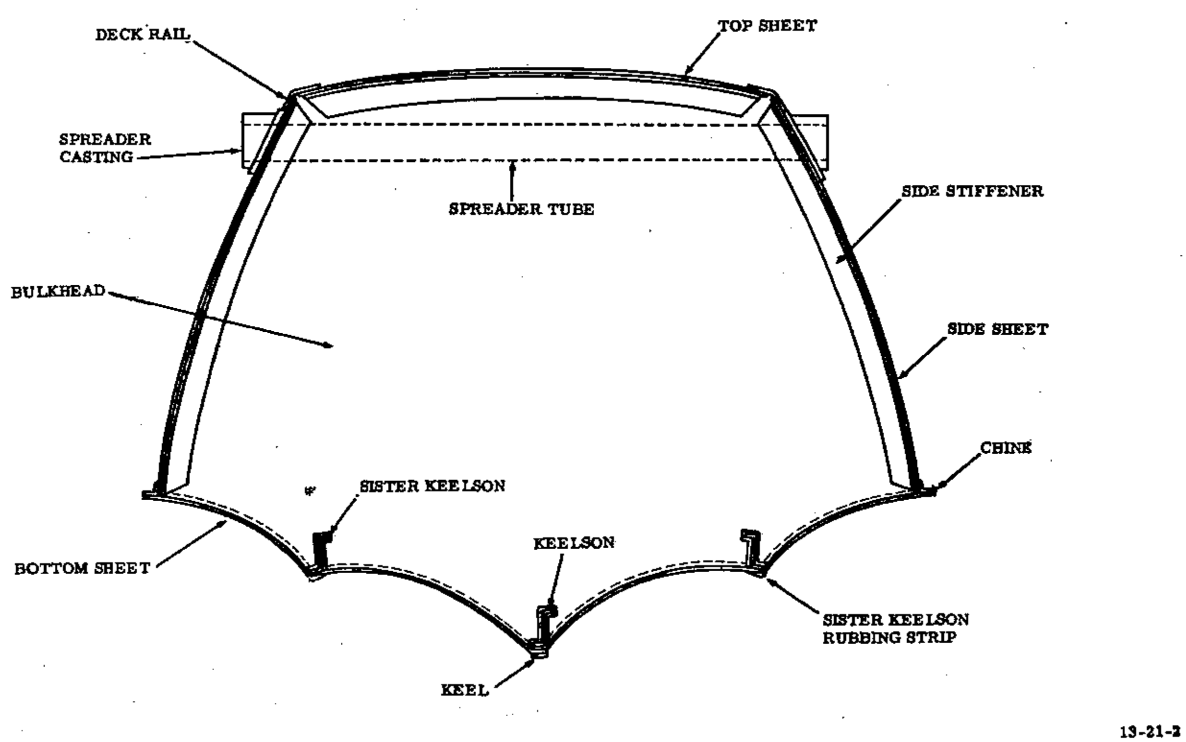


Figure 21-1 Location of Major Structural Members

(d) Brush or wipe the cleaned area with a 10% solution of chromic acid (Item 10).

(e) Apply a light coat of zinc chromate primer (Item 1) and an appropriate finish in accordance with the detailed finish specification given in the relevant Description and Maintenance Instructions Manual.

Treatment of Severe Corrosion

10 Where corrosion is so far advanced that the structural strength of the member is impaired, the following general procedure is recommended:

(a) Remove sufficient paint to ascertain the full extent of corrosion.

(b) Support the surrounding structure (refer to Paragraph 11, following), and cut out corroded area.

(c) Apply patch as required following instructions given in Paragraph 28, following. Refer to Part 5, preceding, for rivetting procedure.

(d) Finish according to detailed finish instructions found in relevant Description and Maintenance Instructions for the aircraft.

Support of Structure During Repair

11 The structure must be suitably supported to prevent distortion during repair when any member is removed. Use a jury strut so that damaged member may be removed without disturbing the rigidity of the surrounding structure, or to relieve the load on the damaged member if the repair is to be made in place. Extensive damage to the keelson will necessitate the ends of the hull or float being adequately supported when aircraft is on either beaching gear or cradle.

Sealing Materials

12 The following approved sealing materials are used in making watertight joints in aluminum alloy. These tapes are not affected by primers, lacquers or other protective coatings, and need not be removed along contact surfaces before jointing.

(a) Neoprene tape (Item 12), made of lightweight cotton fabric impregnated and coated on both sides with neoprene, or plain neoprene tape (Item 13) without the fabric base.

(b) P.A.W. sealing tape (Item 14), a plain neoprene tape coated with a dry type rubber cement containing a corrosion inhibitor.

Application

13 The method of applying P.A.W. tape is as follows:

(a) Moisten one surface of the tape with gasoline (Item 15) or kerosene (Item 16) to the point where the adhesive becomes quite soft.

(b) Allow the solvent to evaporate until the adhesive becomes tacky.

(c) Apply the tape to one contact surface and allow to set.

(d) Soften the adhesive on the remaining surface of the tape as above and apply the second metal surface.

(e) Complete the joint.

14 If, after softening the adhesive, the joint is not completed, it may be re-softened by application of solvent as often as necessary without detrimental effect. After completing the joint, excessive adhesive is removed with kerosene or gasoline. Where it is necessary to pie-cut or butt the tape, or in corners etc., where it is difficult to ensure a seal by the use of tape alone, neoprene cement (Item 17) must be used as an added precaution.

CAUTION

Do not expose P.A.W. sealing tape to light, as this tends to form a film on surface preventing thorough softening. The adhesive is soluble in gasoline and must not be used for joints which come into contact with gasoline or oil.

15 Kerosene as a solvent gives a slower set than gasoline and a still slower set may be obtained by the use of a mixture of kerosene and lubricating oil.

16 The application of plain neoprene tape (Item 13) is similar except that neoprene cement (Item 17) must be applied to the tape as it is used, when necessary.

Approved Substitute Tapes

17 Cotton or canvas tape soaked in marine glue (Item 18) is approved as a seal. Rubber cement may be used but marine glue is preferable. Contact surfaces should be coated with bitumastic where possible before jointing. Friction tape must not be used for jointing purposes as it is not thick enough.

Use of Bostik Cement

18 To seal smaller patches secured with Parker-Kalon screws, bolts or rivets, use Bostik Cement (Item 19). This material is satisfactory for joints in float plating which have stiff reinforcing and where no local buckling takes place. It must not be used on continuous joints which are required to be consistently watertight and which require periodic assembly, or for joints that have no stiff reinforcing.

CAUTION

Never use Bostik Cement where the joint may be subject to gasoline or oil.

Application of Bostik Cement

19 The method of application is as follows:

(a) Thoroughly clean the metal in way of the joints and apply a thin coating of Bostik Cement (Item 20) to each surface.

(b) Allow this coat to become tacky (about 10 minutes) and then apply a coat of Bostik Cement (Item 19).

(c) Complete the joint immediately following the second application.

(d) Bolts, rivets or Parker-Kalon screws used to fasten joints are to be dipped in Bostik Cement (Item 19) before driving.

(e) The cement requires from 24 to 48 hours to dry thoroughly when it has the consistency of heavy rubber. It is removable with gasoline.

(f) With very light gauge sheet, larger quantities of Bostik Cement (Item 19) are necessary to fill all spaces due to slight bulges.

CAUTION

Do not weld any part of the floats, since it destroys the strength of the heat-treated metal as well as the Alclad finish.

Stopping Leaks in Floats

20 Inspect for and repair leaks as follows:

(a) Slight seepage of water from one compartment to another is ordinarily permissible unless the float plane must be left out at moorings unattended for long periods. An appreciable trickle of water between bulkheads, such as a cupful in ten minutes, should be stopped, as should any leak whatever through the outside skin. Correct minor seam leaks by the application of sealing compound, (see Paragraphs 18 and 19, preceding), after the excess of old seam filler has been removed.

(b) Correct major leaks by tightening the rivets locally, or, if this is not sufficient, remove the rivets, clean out the seam, seal with new sealing compound and put in new rivets. Tighten existing rivets by backing up the rivet with a heavy piece of iron against the inside and hammering on the outside.

Hand-hole Covers

21 A frequent source of leakage is found in the hand-hole covers, particularly if the aircraft is carelessly nosed up on a steep beach so that the rear deck is under water. To prevent seepage, the vent hole drilled in the covers to prevent the floats from blowing out during a rapid climb must be kept plugged with heavy grease (Item 21). On floats without hand-hole covers, this hole is located in the access plates. The rubber gasket will also get worn in time and require replacement, and care must be taken to ensure it will retain proper fit. Sometimes the metal cover itself does not fit snugly down onto the deck. Test by removing the gasket and screwing down the cover to see that even contact is made. If it does not fit tightly, either the thread of the screw is at fault or else the flange in the deck is too wide and should be filed away so as to enlarge the hole.

NOTE

Do not tighten hand-hole cover knobs with wrenches; a cover which cannot be made tight by hand is improperly fitted. The use of a wrench may force the spiders up under the deck with sufficient force to permanently deform it.

Leakage Test for Floats

22 After every overhaul a leakage test should be made with the aircraft on land. Block up the floats before filling with water to prevent undue strain caused by the weight of water inside. Properly fitted forms located under the bulkheads and spaced about four feet apart, with additional supports for the keel in between, are suggested as the best arrangement. If this is impractical, see that the keel forward of the step is flat on the floor. Place several supports under the keel at the bow and stern and block up at a number of points along the chine as well.

23 To test the floats, fill alternate compartments with water and, after noting any leaks between bulkheads, fill all compartments and inspect for outside leaks. Unless the floats are very well braced, it is advisable to fill all compartments only partly, gradually adding water to every compartment until all are filled to the top. Mark leaks with an indelible pencil. A special float pump is usually provided with each aircraft for pumping out the water. Follow similar procedure for hulls. Because of the large volume of water involved, careful and adequate blocking of the hull is essential.

Winter Storage

24 If floats have been used in salt water, wash them thoroughly with a hose, both inside and out, to remove all salt deposits. Store upside down on boxes or horses, clear of the floor in a dry, well ventilated room. Set the hand-hole covers off centre, to allow for ample ventilation and to prevent internal sweating. If floats are not equipped with hand-hole covers, the access plates must be opened. Protect all bare steel parts with grease, (refer to Part 23, following).

SKIN REPAIRS - HULLS

General

25 A careful inspection must be made to determine the classification of the damage according to one of the following definitions: Negligible; repairable by patching or insertion; necessitating replacement.

Negligible Damage

26 Dents in the hull or float skins, located at least fifty times the plate thickness from structural members such as stringers, frames, or bulkheads, need not be repaired if they are free from sharply defined edges, scoring or abrasions. A smooth dent not exceeding a depth of 3/8 inches and extending over an area not including a structural member is regarded as negligible.

Bulkheads and Frames

27 Deformation of flanges, stiffeners, or beads is never considered negligible, and must be repaired. Dents in the web, if not exceeding a depth of 1/8 inch and free from sharply defined edges, scoring or abrasions, need not be repaired. Minor damage such as dented flanges, etc., must be straightened, and, if necessary, a reinforcement part added. Care must be taken on watertight bulkheads that all repairs are watertight. If plating is damaged near stringers, frames, or bulkheads, it is possible that rivets in the vicinity may be strained.

NOTE

In general, hammer repairs as little as possible and only where absolutely necessary, because cold working changes the molecular structure of aluminum alloy, weakening it and making it more subject to corrosion.

Partial Replacement of Skin by Patching

28 The distorted skin must first be restored to shape using a mallet and wooden back-up block. (See Figure 21-2.) Examine the structure in the vicinity, since straightening may have caused cracks to develop or rivets to be strained. Drill a 1/8 inch diameter hole at each extremity of cracks to prevent further extension.

29 The patch plate must be prepared from material of the same gauge and specification as the plate being repaired. Where possible, the repair patch plate should be fitted on the outside of the hull, especially when the plating

is badly cracked, since this will minimize possible corrosion.

NOTE

Do not patch a dented piece of metal until it has been hammered back into shape.

30. The damaged area may be cut out and patched as shown in Figure 21-3. When cutting out the damaged portion, remove only the minimum amount necessary for efficient repair. The proximity of frames or stringers must be considered and their lines of rivets picked up. In general, if the edge of the hole being patched is within 1-1/2 inches of an existing line of rivets, extend the patch to pick them up. Should a beltframe member or stringer cross the area to be covered by a patch, the joint with the plating must be included in the repair and the rivets removed and renewed.

31 After drilling at all new rivet positions, place the plate over the opening, drill through at opposite corners and bolt in place temporarily. Drill the skin through the remaining holes in the patch. If patches are required on a part of the hull with a pronounced curve, preform to shape so that they lie in position without being forced by the rivets. Do all marking off or laying out of rivet holes with a soft pencil. Do not use a scriber or any other sharp pointed tool. Before rivetting, cover overlapping surfaces with fabric impregnated with neoprene or an equivalent waterseal to ensure watertightness. (Refer to Paragraphs 12 and 13, preceding.)

32 If the stringers and/or beltframes are damaged in the adjacent areas, always repair these members before proceeding to rivet the patch plate to the skin.

CAUTION

As irregularities in the bottom skin forward of the step are likely to affect planing characteristics, the use of several small patches in this region must be avoided. Under such circumstances, replace the entire panel.

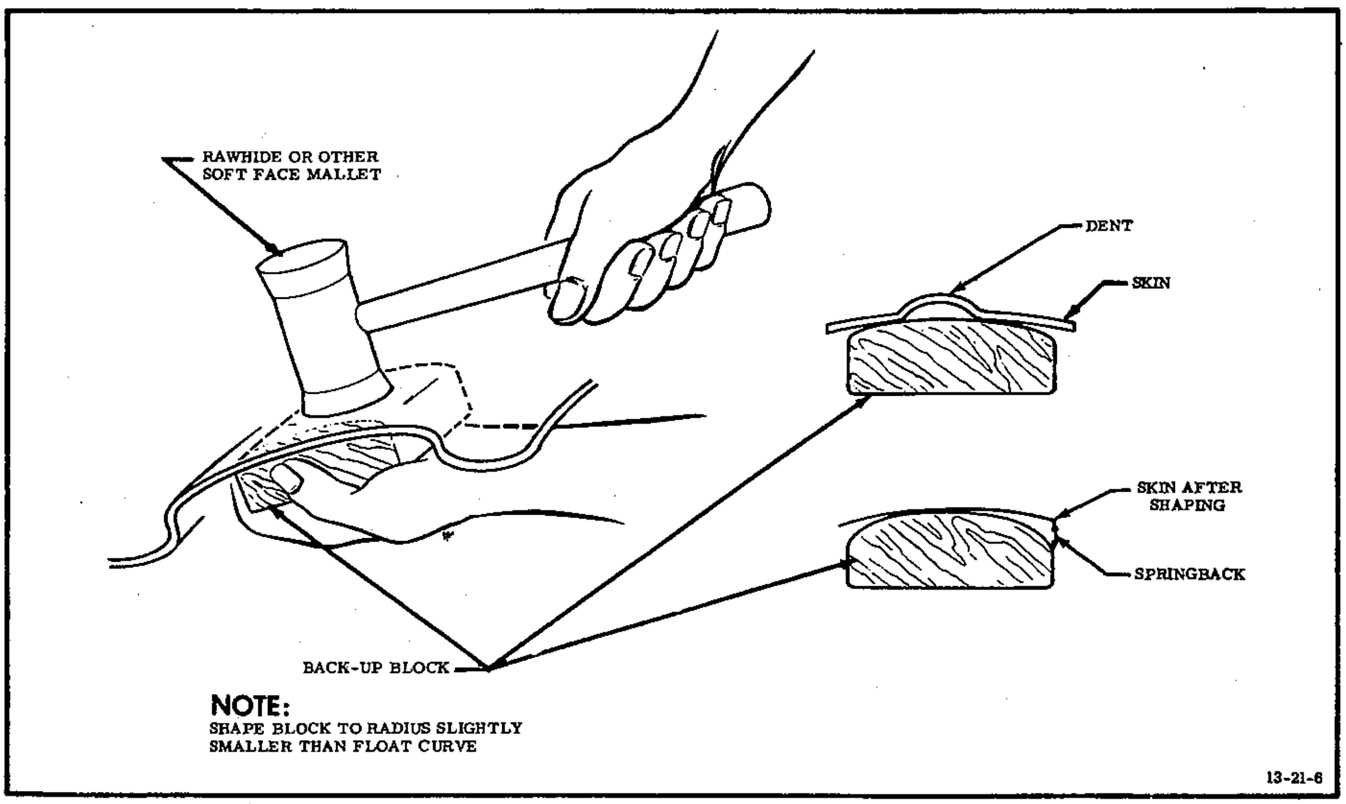
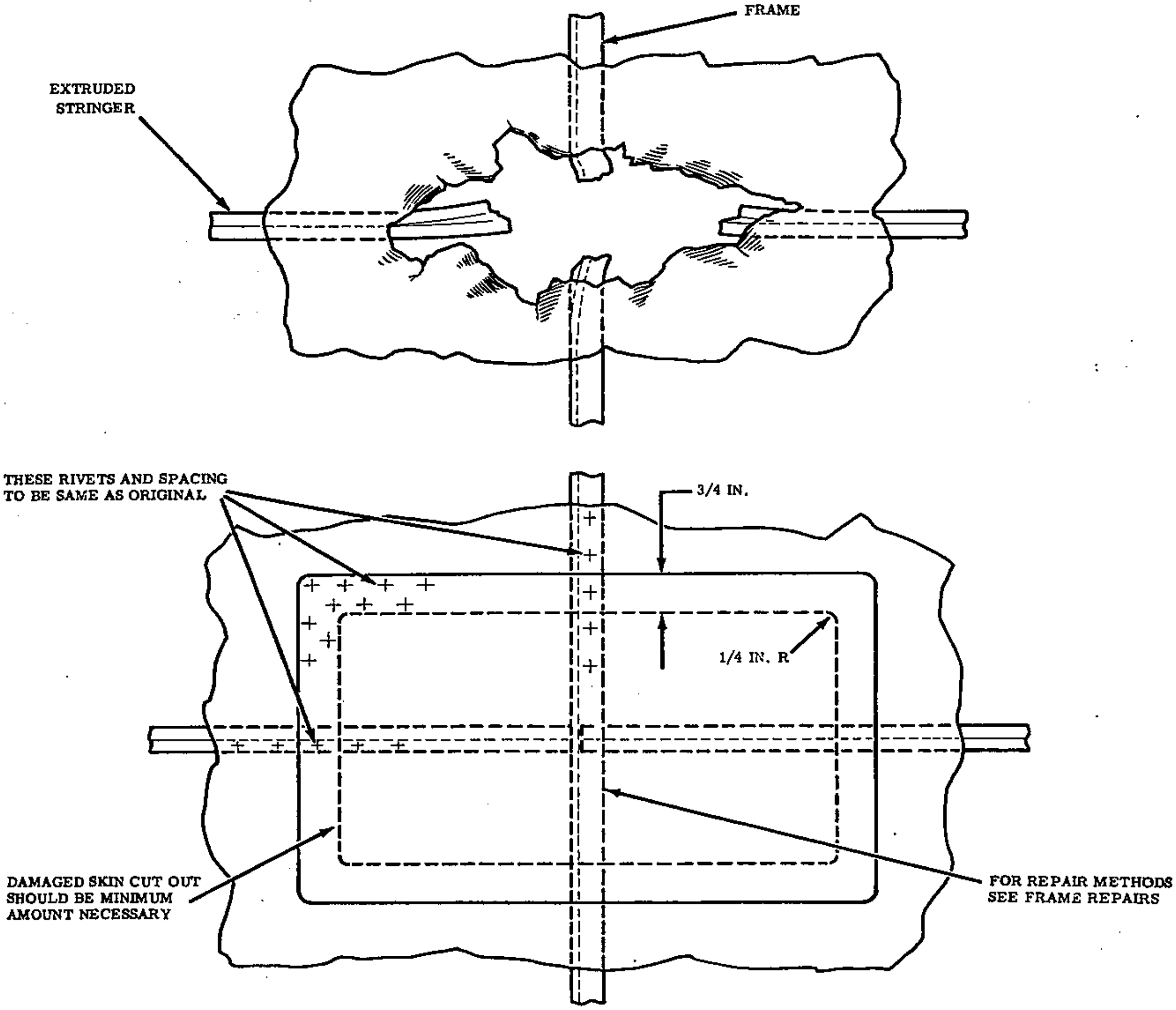


Figure 21-2 Method of Removing Dents



STEPS

1 TRIM OUT DAMAGED SKIN TO FORM A SYMMETRICALLY SHAPED OPENING HAVING A 1/4 INCH MINIMUM RADIUS AT EACH CORNER IF OPENING IS ANGULAR.

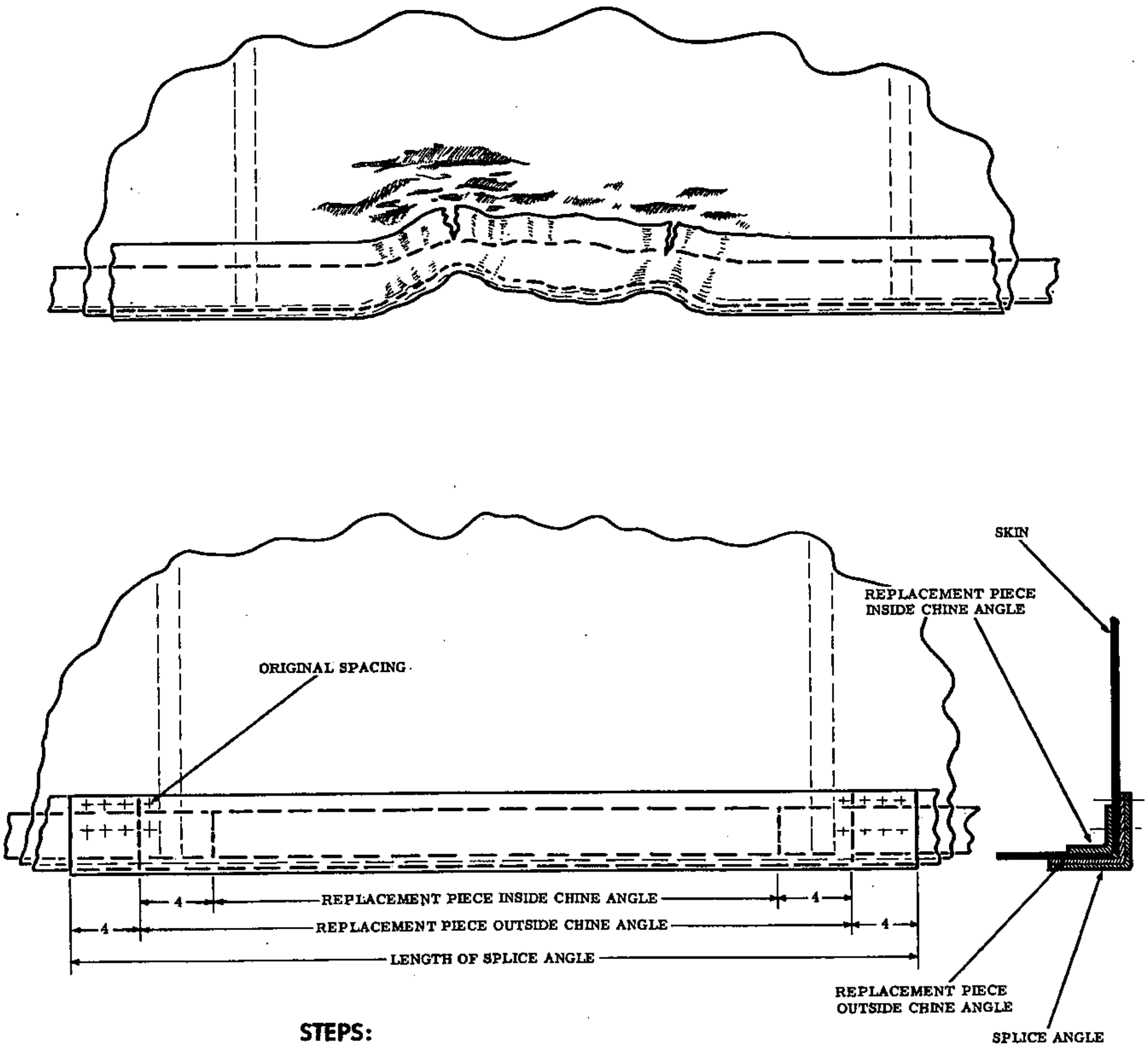
2 CUT A PATCH OF SHEET ONE GAUGE HEAVIER THAN SKIN, AND LARGE ENOUGH TO COVER OPENING, ALLOWING A 3/4 INCH OVERLAP AROUND ALL EDGES.

3 LAYOUT, CENTERPUNCH, AND DRILL, TWO ROWS OF HOLES THROUGH PATCH AND SKIN AS INSTRUCTED IN PART 5.

4 CLEAN, APPLY PROTECTIVE FINISH AND SEALING COMPOUND AND ATTACH PLATE TO SKIN USING SAME TYPE RIVETS AS ORIGINAL.

13-21-3

Figure 21-3 Partial Replacement of Skin



STEPS:

1. DRESS SKIN TO ORIGINAL SHAPE. REPLACE IF NECESSARY.
2. TRIM OUT DAMAGED INSIDE AND OUTSIDE CHINE ANGLES AND CUT REPLACEMENTS TO LENGTH SHOWN.
3. TACK RIVET INSIDE CHINE IN PLACE. PICK UP ORIGINAL SKIN RIVET HOLES. TACK RIVET OUTSIDE CHINE.
4. CUT SPLICE TO LENGTH SHOWN AND TACK RIVET OVER OUTSIDE CHINE. JOGGLE IF NECESSARY. PICK UP RIVET HOLES.
5. DISMANTLE AND REMOVE SWARF. BURR AS REQUIRED.
6. APPLY PROTECTIVE FINISH AND SEALING COMPOUND, TAKING CARE TO FILL CREVICES. ASSEMBLE WITH RIVETS OF SAME DIAMETER AND MATERIAL AS ORIGINAL INSTALLATION.

13-21-5

Figure 21-4 Chine Insertion Repair

Chines

33 Repair a damaged chine angle or plate by cutting out the damaged portion and inserting a new piece of the same size, gauge and specification as the damaged part. Restore the adjacent shell plating to shape and repair any damage to stringers, frames and bulkheads. Use the existing rivet holes in the plate. Enlarge distorted rivet holes for the next larger size rivet. (Refer to Part 5, preceding.) Cut insertion pieces from similar material, shaped and trimmed to a good fit between the ends to form a butt joint. In order to ensure watertightness insert fabric impregnated with neoprene or an equivalent water seal between insertion pieces, butt-straps, and hull plating before rivetting. A typical example of an insertion repair is shown in Figure 21-4.

Pressed Frames

34 Remove minor deformation of flanges or beads which did not result in rupture of the metal, using a mallet and wooden backing block. Take special care in straightening a member to avoid fracture, and examine for cracks which may have developed during the straightening

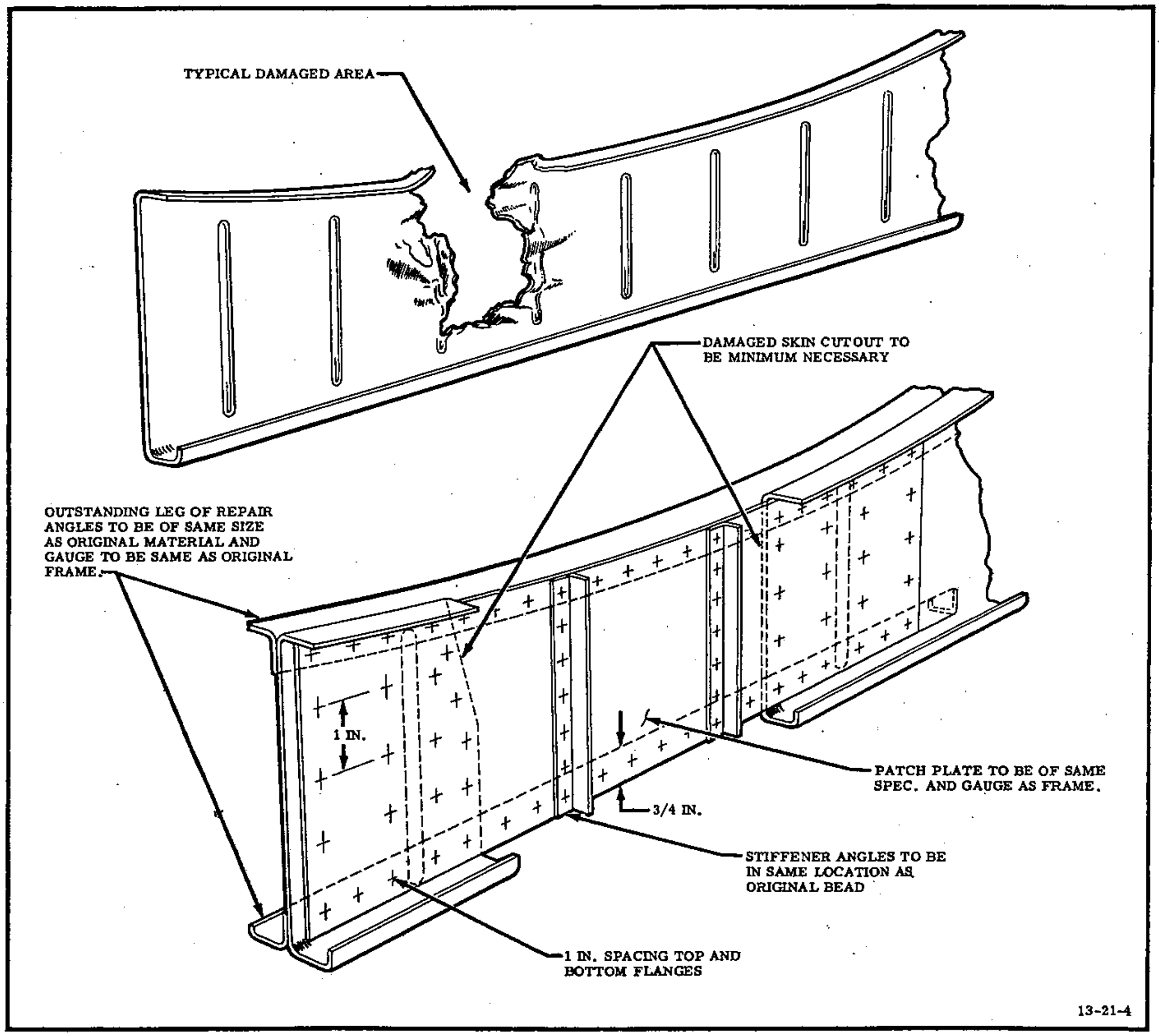


Figure 21-5 Pressed Frame Repair

operation. Damage resulting in rupture of the metal, severe deformation, or both, may be repaired by patching or replacement, as shown in Figure 21-5.

Built-up Frames

35 Repair damage to webs in the same manner as damage to skins. (See Figure 21-6.) Repair extensive damage to frames involving the top and bottom flange angles, stiffeners and web as shown in Figure 21-7. Note that web is lapped at both ends of the repair. Where the thickness of the lapping web does not exceed .040 inch, it is not necessary to joggle the adjacent members. The method shown here for splicing of large members is typical and should be followed where this type of repair is needed.

Keel Truss

36 Repair of the keel is similar to that of built-up frames, (see Figure 21-6). In splicing top flange members, ensure that the total area of the splice members is equal to the area of the members being spliced.

Lower Keelson Extrusion

37 Splice the lower keelson extrusion by the method shown in Figure 21-8. Refer to the applicable Structural Repair Manual for the aircraft for diagram showing location of permissible repairs to lower keelson. Do not splice rubbing strips within 20 inches of the splice in the main keelson extrusion.

Stringer Repair

38 Where stringer has a small perforation or buckle in the web or flange, restore to shape as nearly as possible and stop any cracks by drilling a 1/8 inch hole. If the hole in the stringer is ragged, drill out or file as smooth as possible. Cut a cover plate of the same section and gauge (a thicker but not thinner gauge would also be suitable) as the damaged stringer from a spare length for patching. Make this piece at least 4 inches longer than the length of the damage, the exact dimension being governed by the position of the skin rivets through the damaged stringer, 3 inches being allowed beyond each end rivet. The skin rivets covered by the plate must be

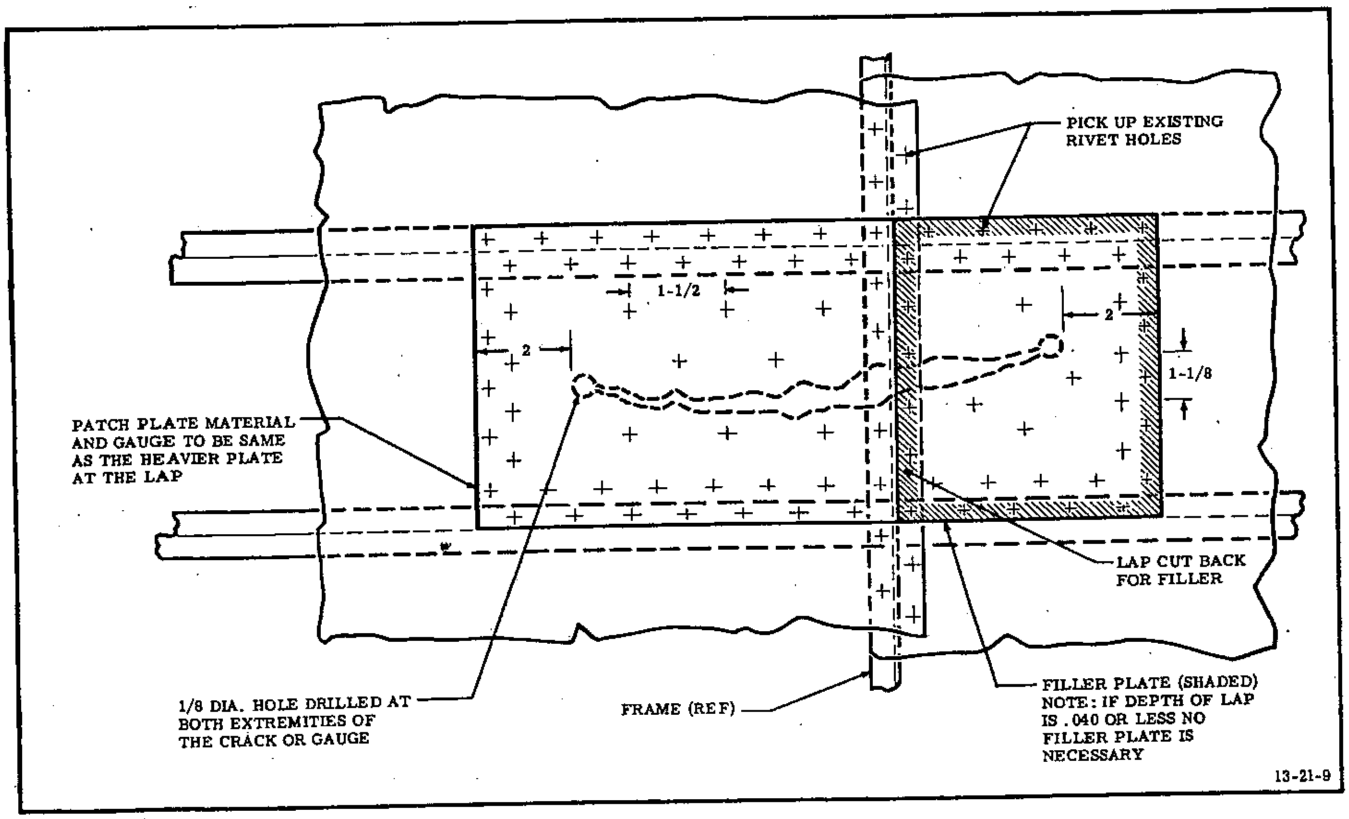


Figure 21-6 Patch Repair

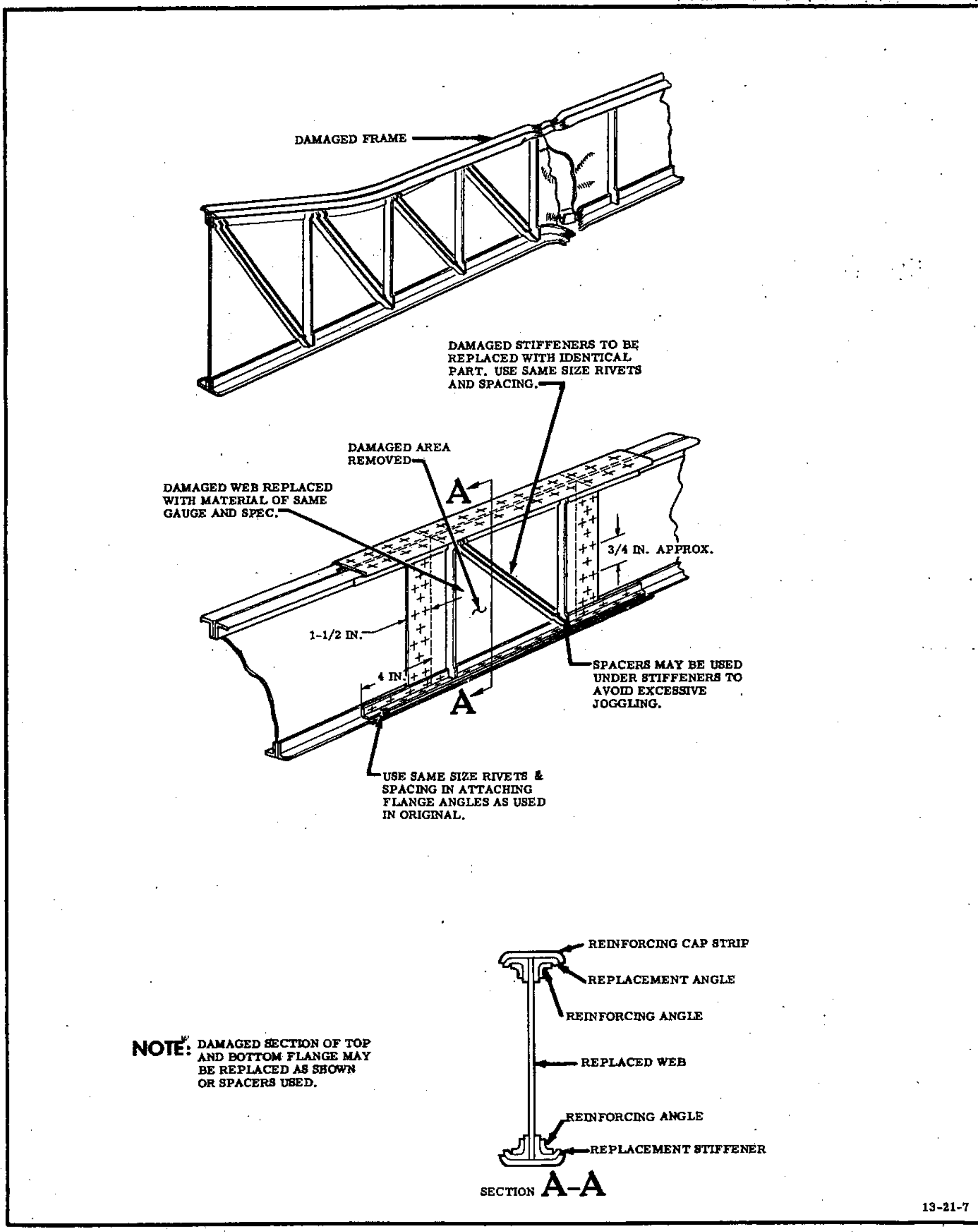


Figure 21-7 Built-up Frame Repair

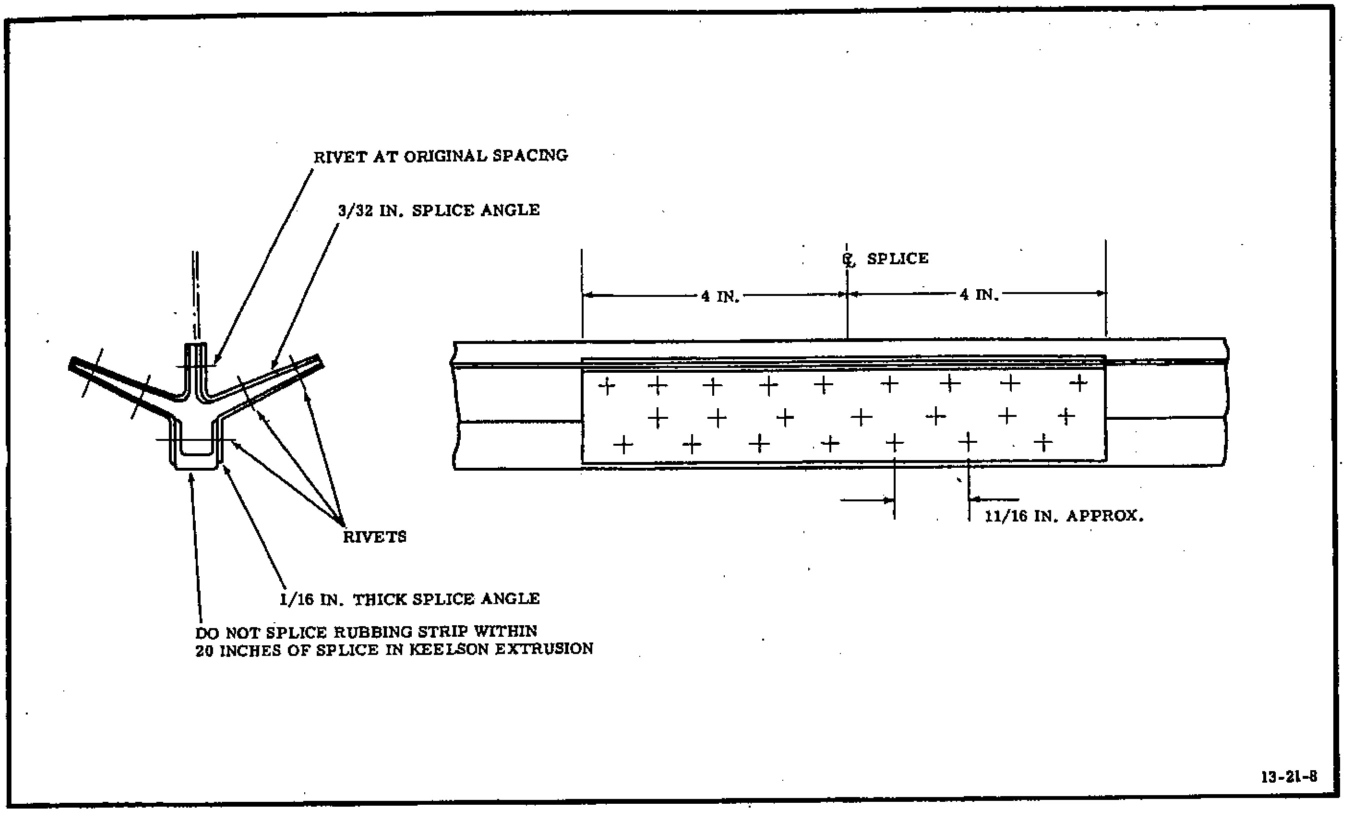


Figure 21-8 Keelson Repair

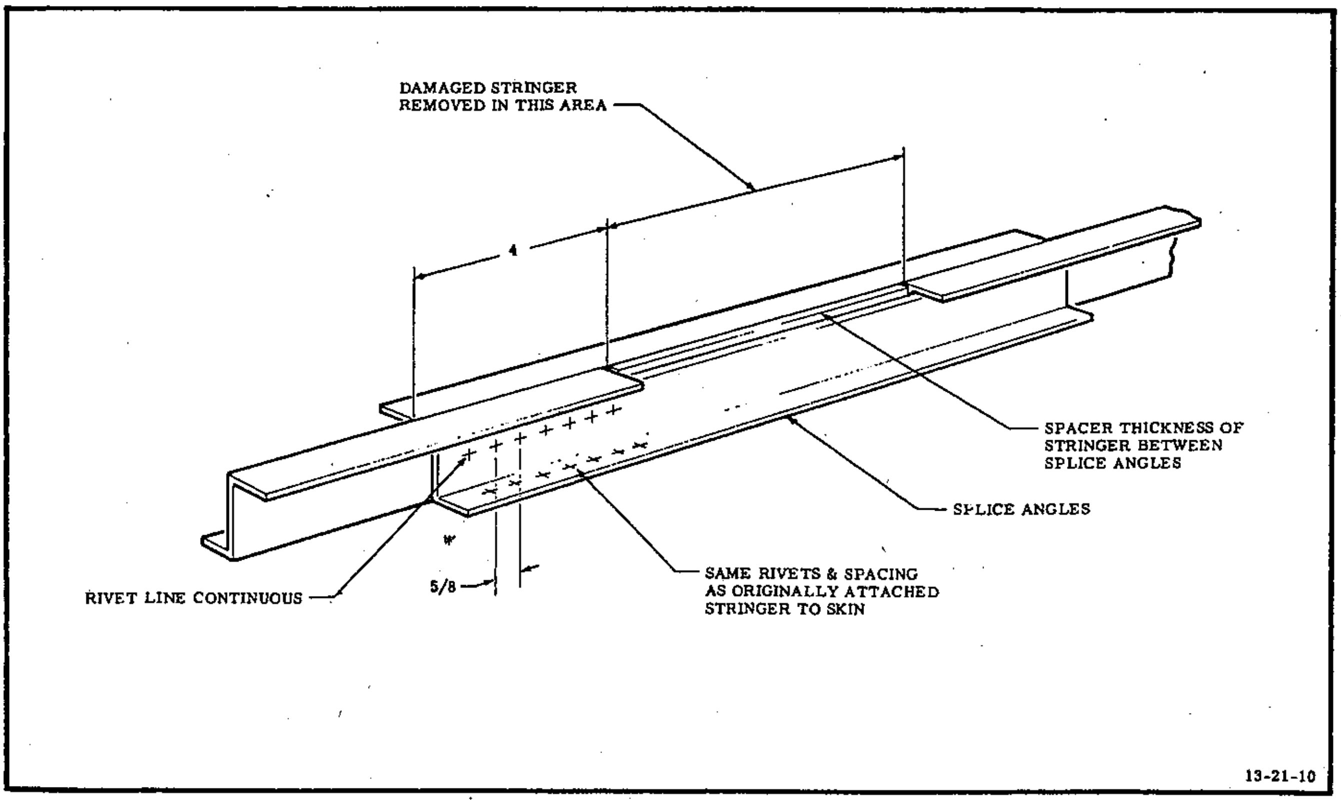


Figure 21-9 Z-angle Repair

carefully drilled and punched out as described in Part 5, preceding.

39 Place the cover plate stringer section in position, drill from the outside of the hull through the existing holes and rivet in place. Drill the additional holes for rivetting and drive the rivets.

40 If the damage is excessive, cut out the damaged portion of the stringer entirely and insert a new piece. Arrange the joints in a suitable position for accessibility using the lap or butt joint. Drill and rivet as previously described. For stringer repair, see Figures 21-7 and 21-9.

Skin Replacement

41 Replacement must be of the same gauge and specification as the original and must be attached with the same size rivets at the same spacing. In case rivet holes have been deformed or elongated, the next larger size rivet may be used. All joints must be waterproofed with fabric impregnated with neoprene or its equivalent.

42 Do not replace a complete skin panel unless the whole, or that particular portion of the airplane affected, is jacked up so that all strains are eliminated.

43 If the damage does not necessitate complete replacement of the panel but is too serious for a repair by patching, repair that portion of the skin as follows:

(a) Cut away the damaged area so that the cutting line runs along the side of a stringer at a distance of 1/4 inch minimum from the inside row of rivets. Vertically, the cut-away should follow down the inside of a frame in a similar manner, or if more convenient, be made down an unrivetted portion of the sheet.

(b) Make up a new skin section or cut from the appropriate spare sheet. Make the overlap along the stringers similar to that of the damaged plate. Make vertical overlaps where the cut is at an unrivetted portion. Install following normal repair procedure. (See Figure 21-10.)

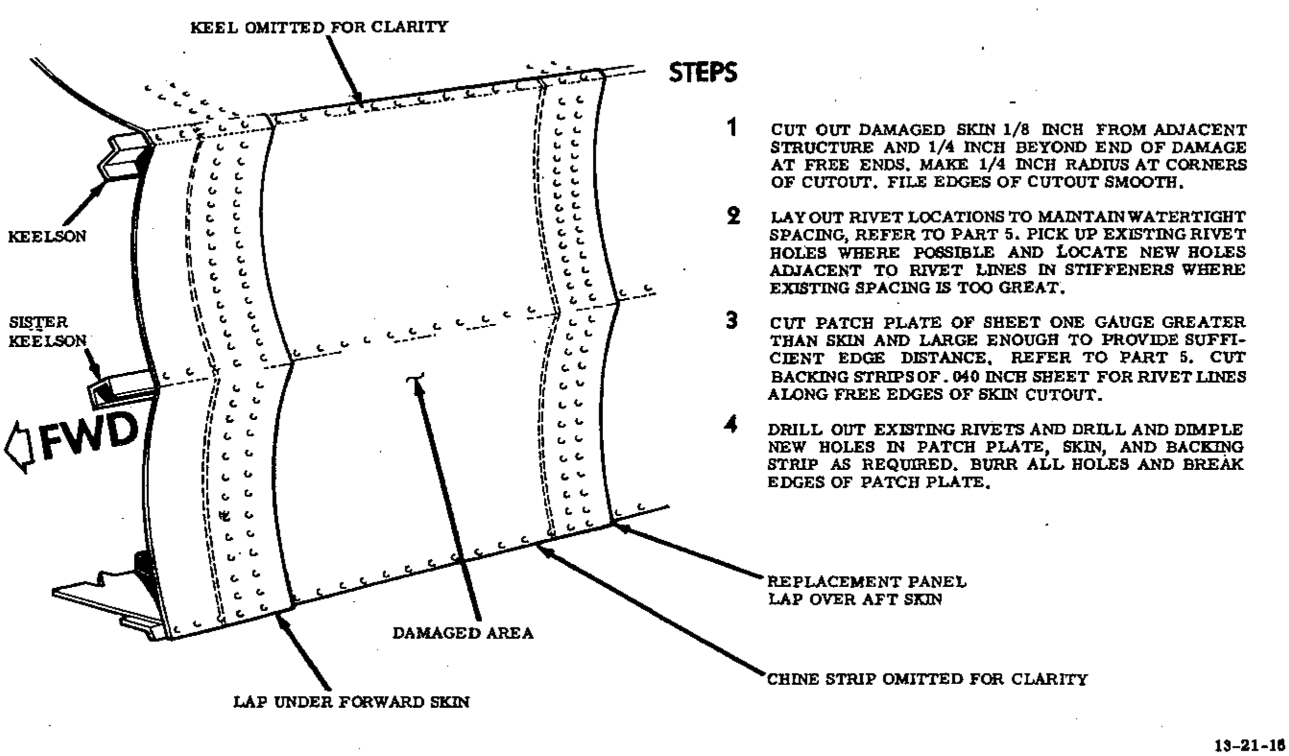
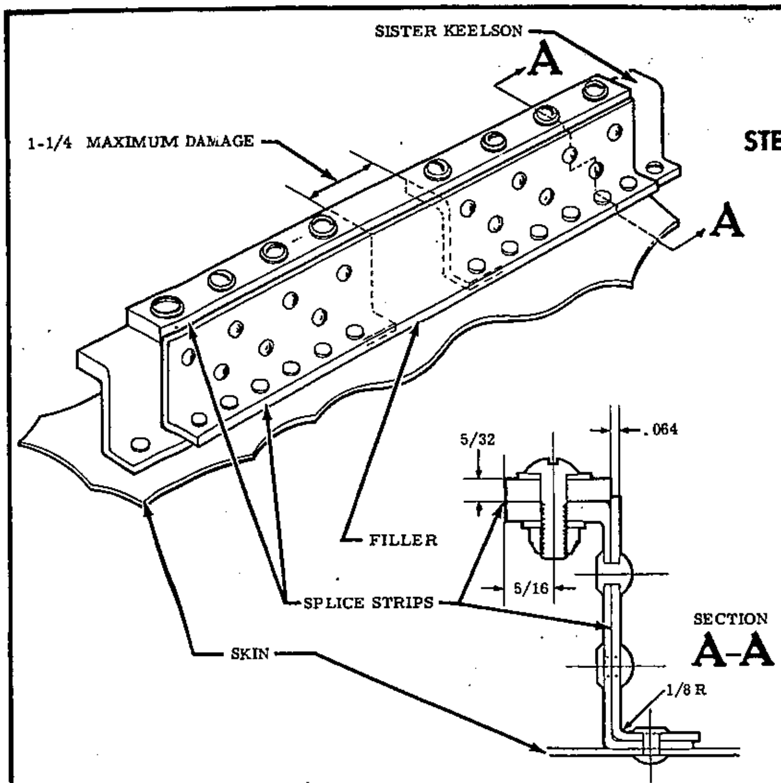


Figure 21-10 Repair for Skin Damage Requiring Replacement



STEPS

1. CUT OUT DAMAGED PORTION (NOT EXCEEDING 1-1/4 INCHES IN LENGTH) OF SISTER KEELSON EXTRUSION. BREAK SHARP EDGES.

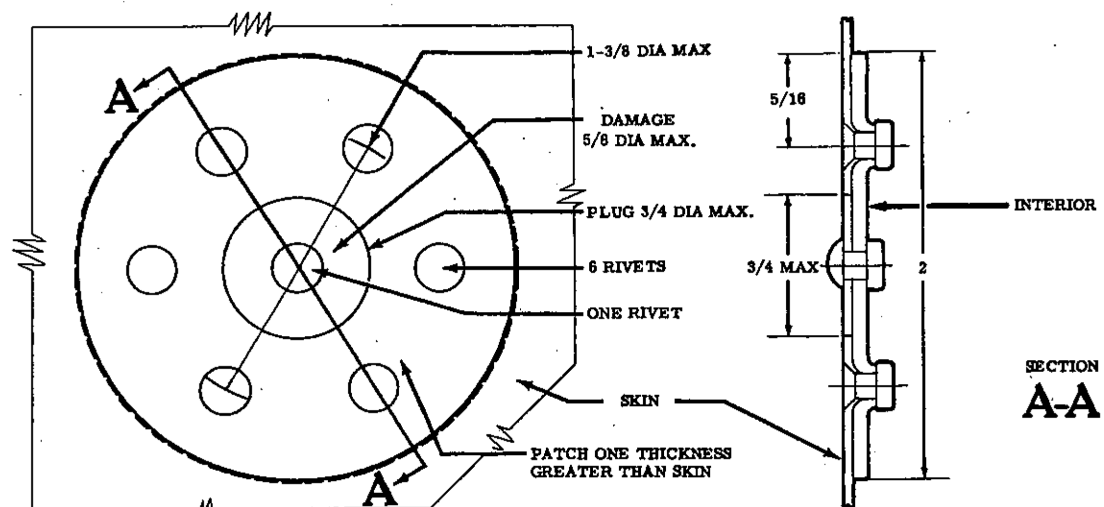
2. MAKE SPLICE STRIPS AS SHOWN IN SECTION A-A AND LONG ENOUGH TO INCLUDE SIX SKIN ATTACHMENT RIVETS ON BOTH SIDES OF CUTOUT. CUT A FILLER OF ALUMINUM ALLOY SAME GAUGE AS BOTTOM LEG OF THE EXTRUSION, FULL WIDTH AND LENGTH OF CUTOUT.

3. LAYOUT AND DRILL HOLES IN SISTER KEELSON EXTRUSION SPLICE STRIPS AND FILLER AS SHOWN. PICK UP EXISTING RIVET HOLES IN BOTTOM LEG OF EXTRUSION FOR ATTACHMENT OF ANGLE SPLICE. BURR HOLES.

4. CLEAN, APPLY PROTECTIVE FINISH AND SEALING COMPOUND, AND ASSEMBLE.

13-21-11

Figure 21-11 Aft Sister Keelson Repair



STEPS

1. CLEAN UP DAMAGE TO CIRCULAR HOLE NOT EXCEEDING 3/4 INCH DIAMETER. FILE EDGE OF HOLE SMOOTH.

2. CUT TWO INCH DIAMETER PATCH PLATE OF SIMILIAR MATERIAL AND ONE LARGER GAUGE THAN SKIN. CUT PLUG OF SAME THICKNESS AS SKIN TO FIT HOLE.

3. LAY OUT SIX RIVETS ON A 1-3/8 INCH DIAMETER CIRCLE IN PATCH PLATE AND SKIN. DRILL AND DIMPLE PATCH PLATE AND SKIN. BURR HOLES AND BREAK SHARP EDGES.

4. CLEAN, APPLY PROTECTIVE FINISH AND SEALING COMPOUND, AND ASSEMBLE WITH RIVETS.

5. DRILL ONE HOLE THROUGH CENTRE OF PLUG AND PATCH PLATE.

6. CLEAN, APPLY SEALING COMPOUND AND INSTALL PLUG.

13-21-12

Figure 21-12 Repair Instructions for Bottom Skin Damage up to 3/4 Inch

TYPICAL FLOAT REPAIRS

Aft Sister Keelson

44 To repair damaged aft sister keelson, proceed as follows:

(a) To repair cleaned-up damage not exceeding 1-1/4 inch in length, see method illustrated in Figure 21-11.

(b) Cleaned-up damage between 1-1/4 inches and 8 inches in length may be repaired in a similar manner if a piece of the original extrusion is used as filler for the length of the cutout.

NOTE

If a piece of the original extrusion is not available, duplicate the section dimensions by welding together plates of similar material, provided that the fabricated piece is used as a splice filler and is thus not depended upon to duplicate the strength of the damaged member.

Repair to Skins

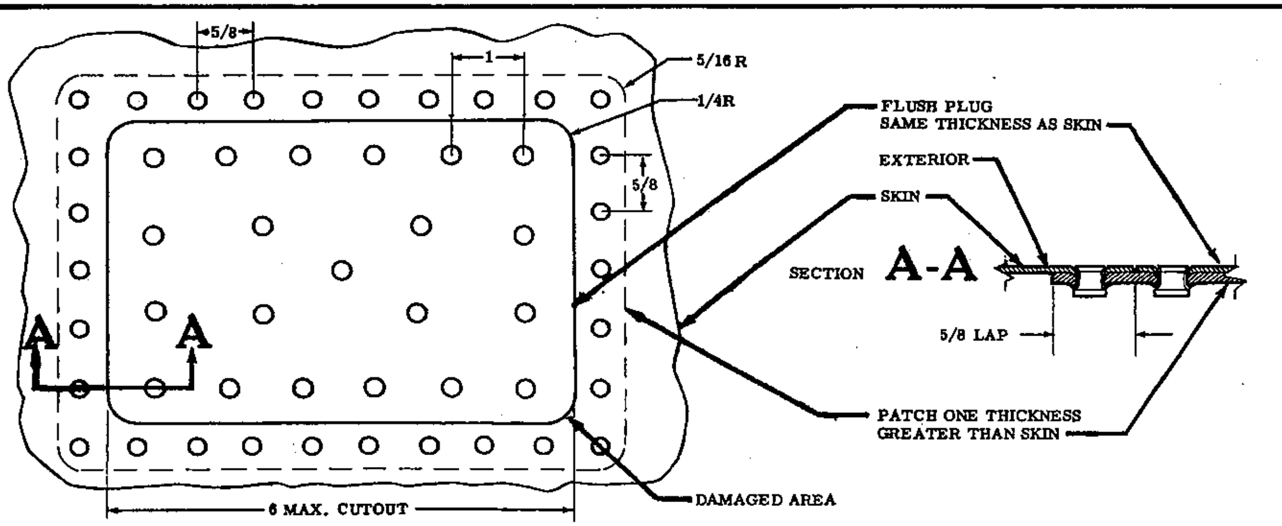
45 To repair bottom skins, proceed as follows:

(a) To repair tears up to 3/4 inch, apply a flush plug patch to inside of skin. (See Figure 21-12.)

(b) To repair tears from 3/4 inch up to 6 inches, apply a flush plug patch as shown in Figure 21-13.

(c) Bottom skins and side skins below the waterline must be repaired either by a surface patch or by replacement. When damage is excessive or when several small patches would be required, replace the panel as shown in Figure 21-10. Skin repair by means of a surface patch is shown in Figure 21-3. The patch plate is attached by new lines of rivets adjacent to the structural members. This is necessary to provide the rivet spacing required for watertightness for repairs below the waterline. For rivetting procedure, refer to Part 5, preceding.

(d) A typical repair for side skins above the waterline and top skins is illustrated in



STEPS

1 TRIM DAMAGED SKIN 1/4 INCH BEYOND ENDS OF DAMAGE TO FORM A RECTANGULAR CUTOUT WITH 1/4 INCH RADIUS CORNERS.

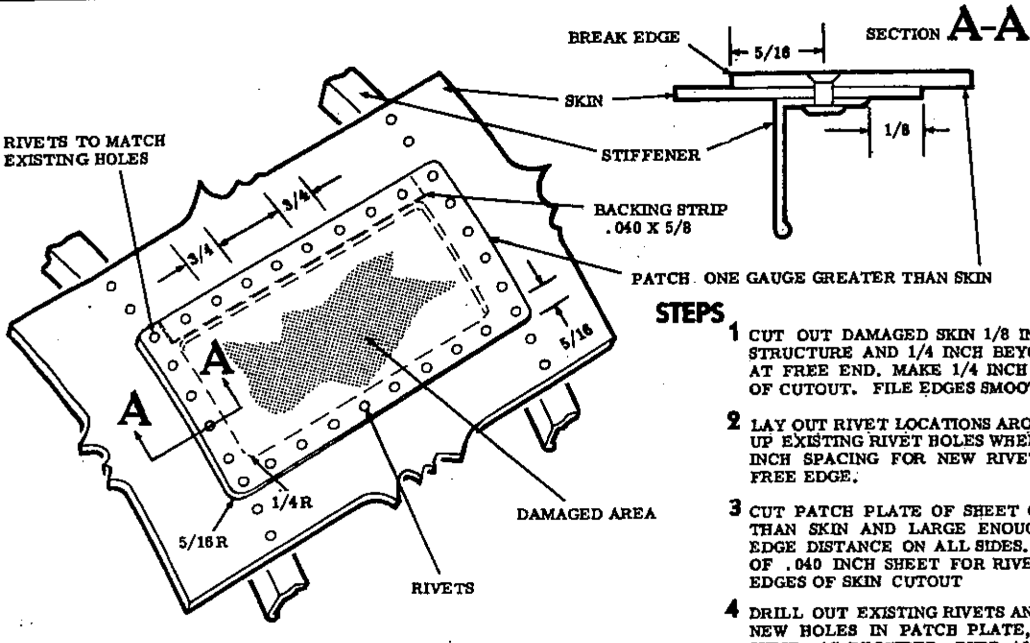
2 CUT PATCH PLATE OF SHEET ONE GAUGE GREATER THAN SKIN AND LARGE ENOUGH TO LAP CUTOUT BY 5/8 INCH ON ALL SIDES. CUT FLUSH PLUG OF SHEET SAME GAUGE AS SKIN TO FIT CUTOUT. BREAK ALL SHARP EDGES.

3 LAY OUT, DRILL, AND DIMPLE HOLES FOR RIVETS IN SKIN, PATCH PLATE AND PLUG AS SHOWN. BURR HOLES. MAINTAIN PROPER SPACING AROUND PATCH PLATE TO ENSURE WATER TIGHTNESS. REFER TO PART 5.

4 ASSEMBLE PLUG TO PATCH PLATE. CLEAN, APPLY PROTECTIVE FINISH, AND SEALING COMPOUND BEFORE ASSEMBLY. INSTALL PATCH PLATE AND PLUG ASSEMBLY TO THE INSIDE OF SKIN. CLEAN, AND APPLY SEALING COMPOUND BEFORE ASSEMBLY ONTO STRUCTURE.

13-21-13

Figure 21-13 Repair Instructions for Bottom Skin Damage of 3 to 6 Inches



STEPS

1 CUT OUT DAMAGED SKIN 1/8 INCH FROM ADJACENT STRUCTURE AND 1/4 INCH BEYOND END OF DAMAGE AT FREE END. MAKE 1/4 INCH RADIUS AT CORNERS OF CUTOUT. FILE EDGES SMOOTH.

2 LAY OUT RIVET LOCATIONS AROUND CUTOUT TO PICK UP EXISTING RIVET HOLES WHERE POSSIBLE. USE 3/4 INCH SPACING FOR NEW RIVET LOCATIONS ALONG FREE EDGE.

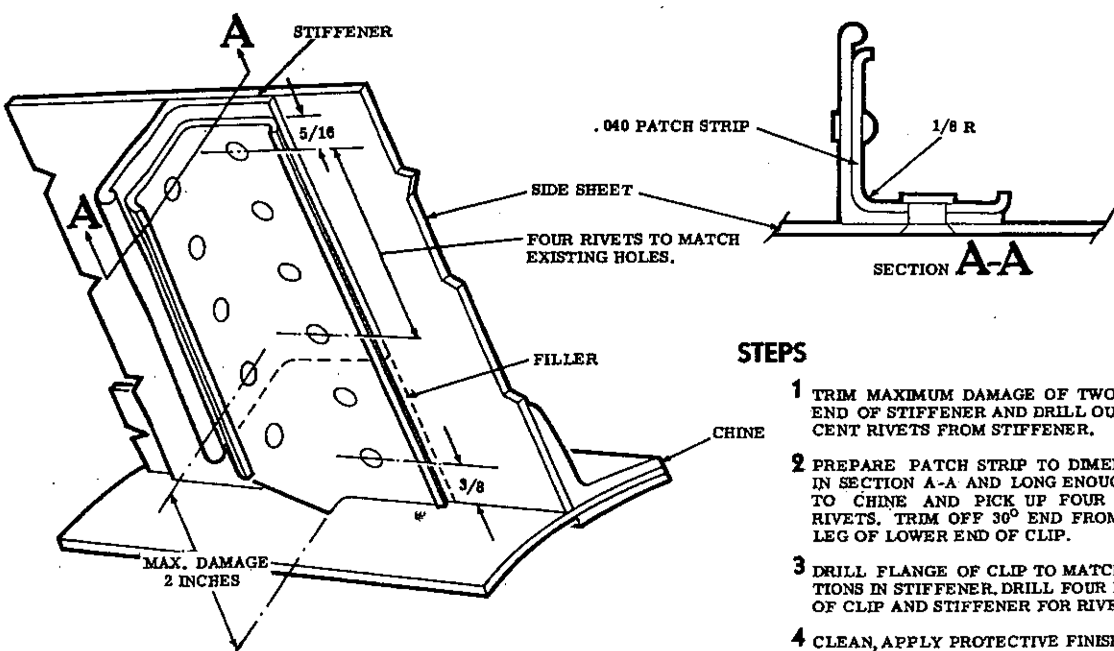
3 CUT PATCH PLATE OF SHEET ONE GAUGE GREATER THAN SKIN AND LARGE ENOUGH TO PROVIDE 5/16 EDGE DISTANCE ON ALL SIDES. CUT BACKING STRIPS OF .040 INCH SHEET FOR RIVET LINE ALONG FREE EDGES OF SKIN CUTOUT

4 DRILL OUT EXISTING RIVETS AND DRILL AND DIMPLE NEW HOLES IN PATCH PLATE, SKIN, AND BACKING STRIP, AS REQUIRED. BURR ALL HOLES AND BREAK SHARP EDGES.

5 CLEAN, APPLY PROTECTIVE FINISH AND SEALING COMPOUND, AND ASSEMBLE. REPLACE DRILLED OUT RIVETS WITH SAME SIZE AS ORIGINAL RIVETS, IF POSSIBLE.

13-21-15

Figure 21-14 Skin Repair Involving Structure Above Waterline



STEPS

1 TRIM MAXIMUM DAMAGE OF TWO INCHES FROM END OF STIFFENER AND DRILL OUT FOUR ADJACENT RIVETS FROM STIFFENER.

2 PREPARE PATCH STRIP TO DIMENSIONS SHOWN IN SECTION A-A AND LONG ENOUGH TO ATTACH TO CHINE AND PICK UP FOUR DRILLED OUT RIVETS. TRIM OFF 30° END FROM UPSTANDING LEG OF LOWER END OF CLIP.

3 DRILL FLANGE OF CLIP TO MATCH HOLE LOCATIONS IN STIFFENER. DRILL FOUR HOLES IN LEGS OF CLIP AND STIFFENER FOR RIVETS.

4 CLEAN, APPLY PROTECTIVE FINISH AND SEALING COMPOUND AND ASSEMBLE.

13-21-17

Figure 21-15 Repair for Lower End of Side Stiffeners

Figure 21-14. The repair shows an external patch plate attached to the adjacent structure.

(e) Repair damage to the lower end of side stiffeners by the use of the patch clip shown in Figure 21-15.

(f) Repair damage to the rivetted flange of the stiffener which does not extend into the corner radius after clean-up as shown in Figure 21-16.

Material Specifications

46 For table showing item numbers, materials specifications and manufacturers, see Figure 21-17.

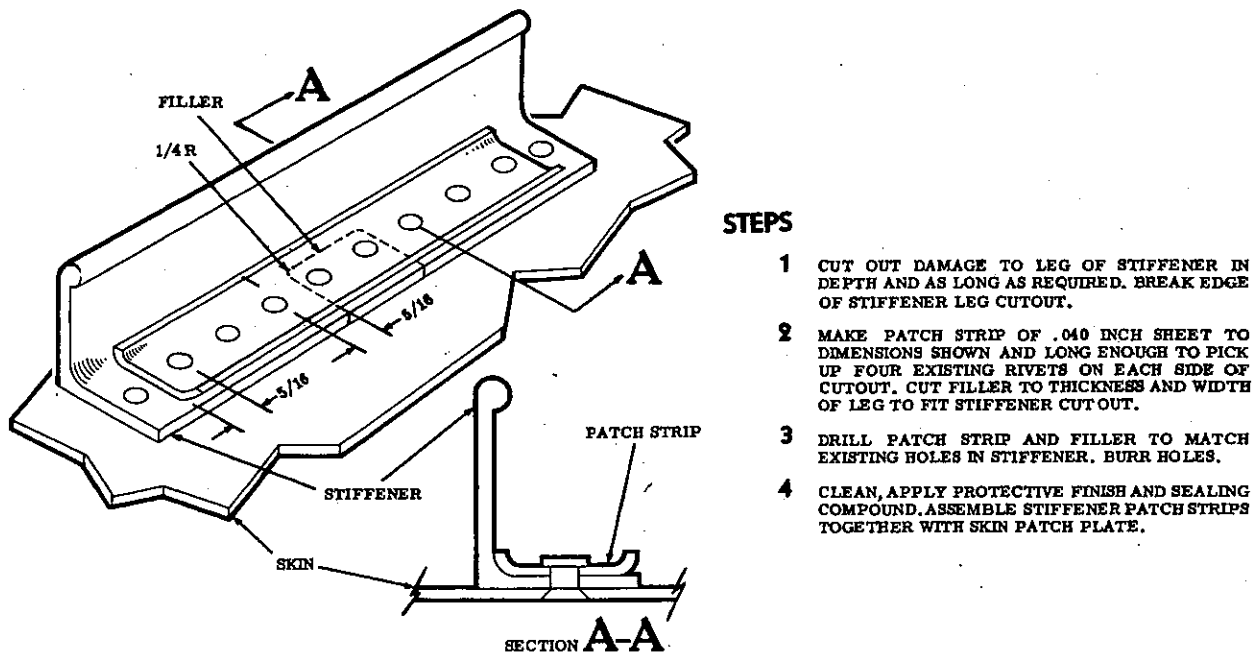


Figure 21-16 Stiffener Flange Repair

Item No.	Material	RCAF Ref	Specification	Manufacturer
1	Primer, Zinc Chromate	33A/462	MIL-P-6889A	
2	Surfacer		MIL-S-794 (US)	
3	Sandpaper No.360 grit	29/1868		
4	Lacquer, Glossy	33A/	MIL-L-7178-1 (US)	
5	Sandpaper No.400 grit	29/1867		
6	Rubbing Compound		52-R-17 AER	

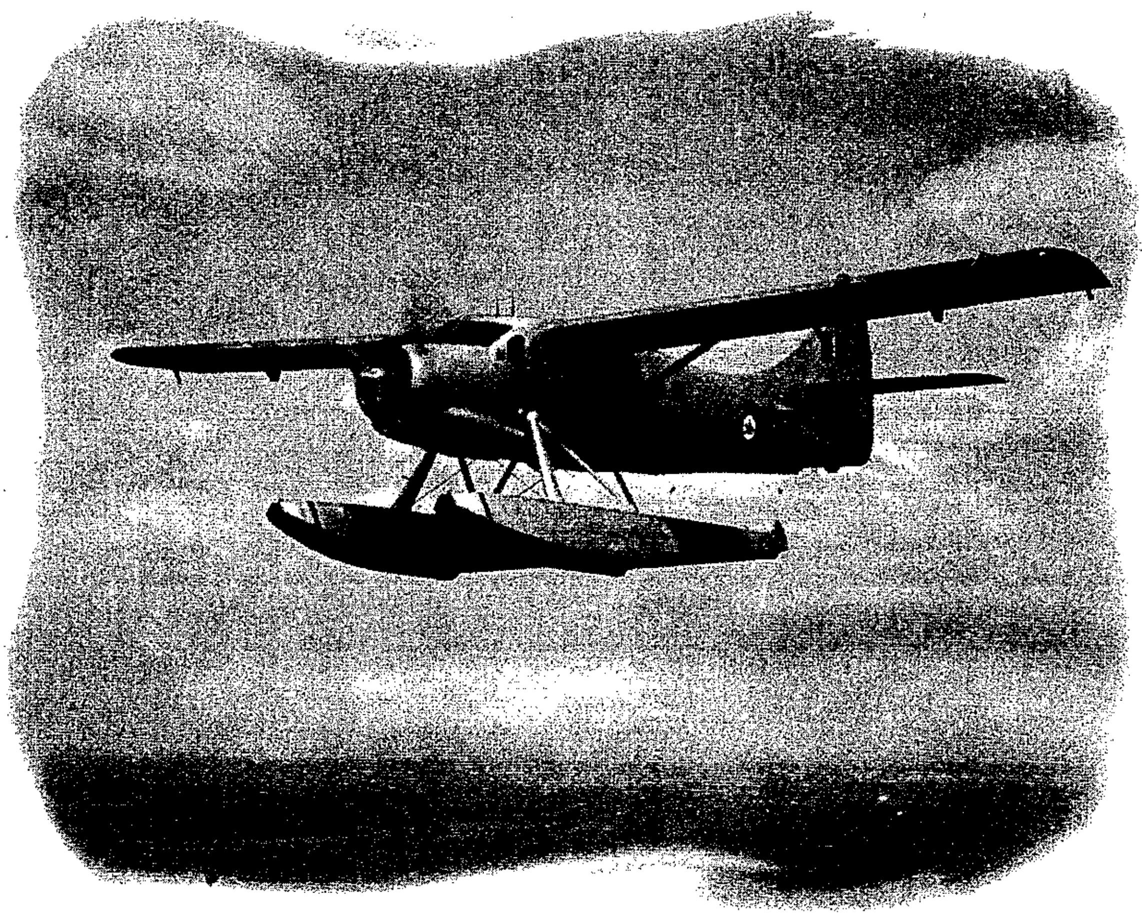
Figure 21-17 (Sheet 1 of 2) Table of Material Specifications

Item No.	Material	RCAF Ref	Specification	Manufacturer
7	Wax, Polishing, Wadding Wax, Polishing, Liquid	33C/689 33C/651	C-7/a	Canadian Hanson & Van Winkle, 15 Morrow Ave., Toronto, Ontario.
8	Thinner	33A/	TT-T-266 (US)	
9	Paint, Anti-fouling	33A/	MIL-P-5051-1 (US)	
10	Acid, Chromic	33C/494	O-C-303	
11	Toluene	33A/467	TT-T-548A	
12	Tape, Neoprene, Coated	32E/or 33G/	AN-T-12	
13	Tape, Neoprene, Plain	32E/or 33G/	AN-T-12	
14	Tape Sealing, PAW	33G/ 5, 6, 7		E.I.Dupont de Nemours & Co., Wilmington, Delaware.
15	Gasoline	34A/52 34A/209	3-GP-25 3-GP-25	
16	Kerosene	34A/217	3-GP-3	
17	Adhesive Neoprene Cement No.1	33G/	MIL-C-5539	
18	Glue, Marine	33G/40	MIL-G-413A	
19	Cement, Bostik, Black No. 292	33G/8	MIL-C-4003	B.B.Chemical Co. of Canada Box 1447, Montreal, Que.
20	Cement, Bostik, White No, 421A	33G/27	421-A	B.B.Chemical Co. of Canada, Box 1447, Montreal, Que.
21	Grease, Heavy	34A/178	3-GP-682	

Figure 21-17 (Sheet 2 of 2) Table of Material Specifications

PART 22

STRUCTURAL TUBING REPAIR



PART 22

STRUCTURAL TUBING REPAIR

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PART 22

STRUCTURAL TUBING REPAIR

REPAIR OF STRUCTURAL STEEL TUBING

General

1 Repairs to structural tubing consist of smoothing small nicks, scratches, and dents; reinforcing cracked members and dented areas; splicing damaged members; replacing damaged members when splicing is impractical; and correcting minor distortion. With the exception of correcting minor distortion, all repairs in steel tubing are accomplished by welding. Tubing used for telescope reinforcements or for splicing must be of at least the same tensile strength and wall thickness as that of the original member.

NOTE

Heat-treated aluminum alloy structural tubing is repaired by rivetting. (Refer to Paragraph 57, following.)

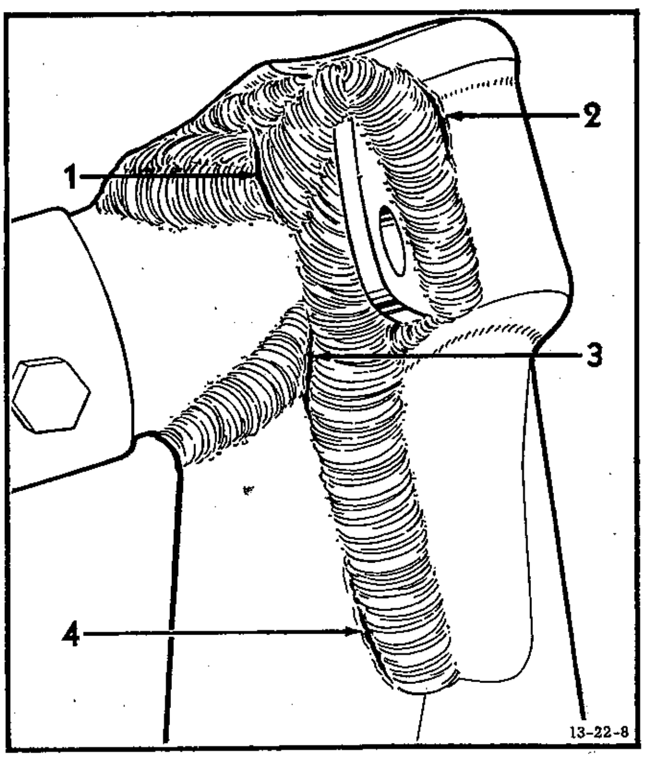


Figure 22-1 Typical Welding Failures

Estimating Extent of Damage

2 When inspecting for damage, examine the structure surrounding any visual damage to ensure that no secondary damage, produced by the transmission of stress along the tube, remains undetected. Damage of this nature usually occurs where the most abrupt change in load travel is experienced. If this damage remains undetected, loads applied in the normal course of operation may cause failure of the part. Examine all joints for cracks, welding flaws, or failures. (See Figure 22-1.)

3 The nature of the damage will determine whether or not a fuselage section must be removed from the fuselage truss. In general, smoothing small dents and correcting minor distortion is accomplished without disassembly.

4 Some forms of damage to tubular structures may be considered negligible. Such damage takes the form of slight indentations, scratches, or minor bowing. Smooth dents not exceeding one-twentieth of the tube diameter in depth, without cracks, fractures, or sharp corners, and clear of the middle third of the length of the member may be disregarded. Examine tubular members carefully for the presence of sharp nicks and deep scratches. These nicks and scratches produce stress concentrations that may cause failure of the part. Smooth out all sharp nicks and deep scratches with a fine file, fine emery paper (Item 2) or steel wool. The intense heat caused by welding necessitates isolating the area to be welded from all parts or members which might be injured by contact with heat. Use sheet asbestos (Item 1), or heavy wet cloths, to provide sufficient insulation to prevent heat distortion or damage to adjacent parts.

NOTE

All fire precautions must be observed before welding is started.

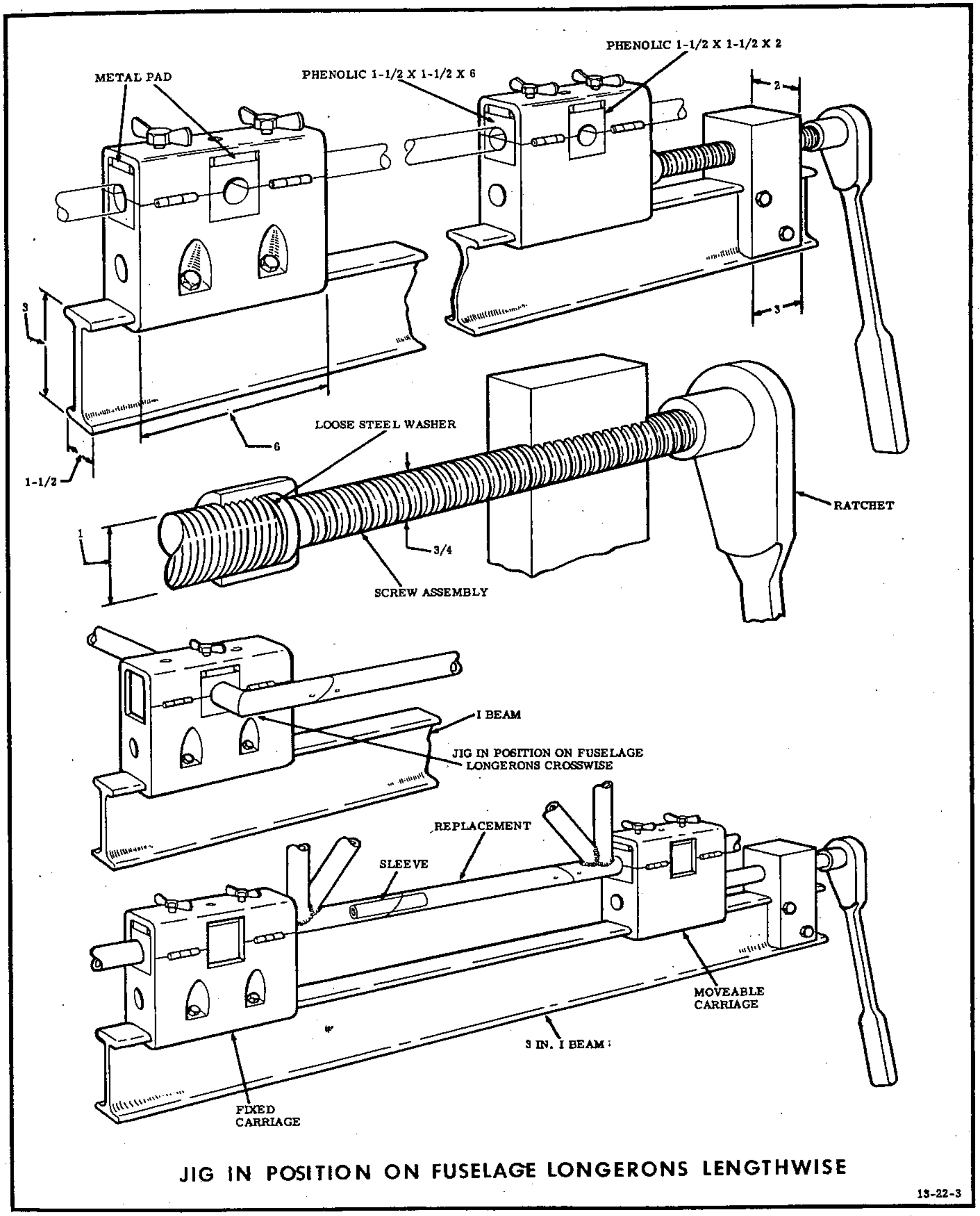


Figure 22-2 Welding Jig for Fuselage Members

WELDING OF STEEL

General

5 Welding consists of fusing the metal of the welding wire or rod with the metal of the joint ends until the joint is built up with new metal. This is done by either electric arc welding or by oxy-acetylene welding.

6 The section of the tube adjoining a gas weld will be annealed by the welding heat for a distance of from 1/4 to 3/4 inch on each side of the weld. In electric arc welding this distance is reduced, as the weld proceeds much faster than in the case of gas welding and no preheating of the material is necessary.

Preparation

7 To prepare for welding, proceed as follows:

(a) Use sandpaper (Item 3) or wire brush to clean affected areas prior to welding. Do not use a brush of dissimilar metal, for example brass or bronze. The small deposit left by a brass or bronze brush will materially weaken the weld and cause cracking and subsequent failure.

(b) If a weld is to be made over a failure in an electric weld bead, remove all of the existing bead before applying a new weld to the area.

(c) Use a combination eye and face shield and a leather apron while welding. Ensure that proper ventilation is provided. The presence of gas vapours is a fire hazard, and all fire precautions must be observed before welding.

CAUTION

After a weld is made, do not file or smooth the weld or apply any solder or other filler to improve the appearance of the weld.

Welding of Assemblies

8 Weld assemblies or sub-assemblies in a jig or fixture which has sufficient rigidity to prevent misalignment due to expansion and contraction of the heated material. The relative position of the parts to be welded must be accurately located and held firmly in place. (See Figure 22-2.) In this manner there will be no internal stress concentration.

Material to be Welded	Specification	Manufacturers Designation	Manufacturer
Carbon and Low Alloy Steels SAE 1020, 4130, etc.	ROD		
	MIL-E-6843 Class E-10013	Planeweld #1	Lincoln Electric Co. of Canada Ltd.
	MIL-E-6843 Class E-10010	Shield Arc #100	
	FLUX		
	Not normally used		
Class E-10013 rods are shallow penetration type rods used for welding sections up to 0.129 inch thickness. This rod is suitable for use with both alternating and direct currents. When using direct current, the work is positive polarity, rod negative. Class E-10010 rods are deep penetration type rods used for welding sections over 0.129 inch thickness. This is suitable on direct current only with the polarity reversed, i.e. rod positive.			

Figure 22-3 Arc Welding Rods and Flux

Electric Arc Welding of Steel

9 Before starting to weld, ensure that surface of parts to be welded is free of loose scale, oxide, oil and foreign matter. Use jigs, clamping devices, and tack welding to control warping and ensure proper alignment. (See Figure 22-2.) Preheat only heavy fittings and forgings, and chamfer only on material of .140 inch wall thickness and greater.

10 Use electric arc-welding rods in accordance with Figure 22-3. In general, a heavily coated, mild steel welding rod should be used with the diameter of the electrode not greater than the tube wall thickness unless the operator increases the travel speed sufficiently to prevent overheating, undercutting, and burning through the metal.

11 Hold length of arc to approximately one-eighth inch. Use polarity recommended by electrode manufacturer or as found suitable for the job. All tack welding and weld endings must be accomplished using a crater eliminator if available. (See Figure 22-4.) The small hole or crater at the weld end creates a stress concentration and fatigue point, and must be eliminated if possible.

12 Avoid rewelding, as porosity in the weld may result. When a weld is built up by two or more beads or passes, the preceding weld must be cleaned free of scale or flux by chipping and scraping, followed by brushing with a wire brush. Do not dress weld by removing metal from the joint unless further welding is to be done on the dressed region.

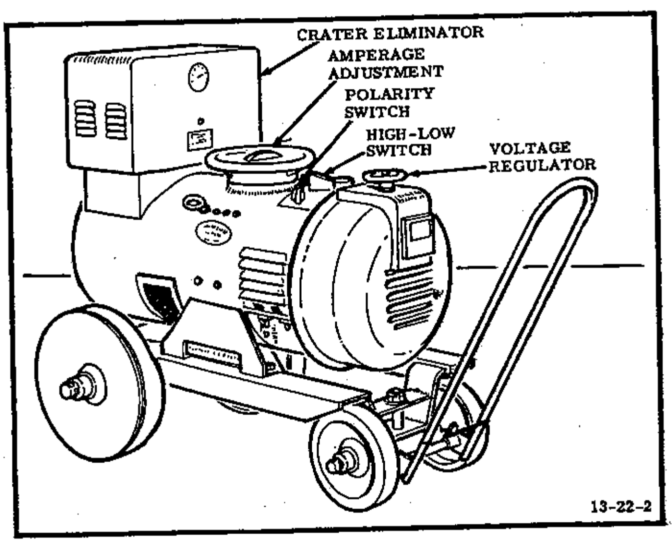


Figure 22-4 Arc Welding Generator with Crater Eliminator

13 Unless otherwise specified, make the maximum width of welds 1/4 inch for material thickness of not over .040 inch. Make the depth of penetration between 25% and 40% of the thickness of the base metal.

Rosette Welds

14 Rosette welds are used to fuse an inner tube with an outer tube. Where a rosette weld is used, make hole in outer tube only and of sufficient size to ensure fusion of the inner tube. Use a hole diameter one-fourth the diameter of the outer tube. See Figure 22-5 for location of rosette welds.

Heat-treated Parts

15 For heat-treated parts use a welding rod suitable for producing values comparable to those of the original parts. Such parts must be reheat-treated to the manufacturer's specifications after welding.

Anti-corrosion Treatment

16 Refer to Part 23, following for anti-corrosion treatment of welded steel tubing after welding repairs are completed.

Oxy-acetylene Welding of Steel

17 The oxy-acetylene process is the more flexible type of welding and generally more convenient for repair work on aircraft. However, electric arc welding is acceptable, and repairs outlined are applicable for either type of welding. Keep flame pointed in the direction of welding in order to preheat the material. Maintain as neutral a flame as possible, for an excess of acetylene in the flame will carbonize the weld and an excess of oxygen will oxidize the weld. (See Figure 22-6.) The feather part of the flame should not be more than 1-1/2 times the length of the flame cone and not more than one-eighth inch long. Avoid rewelding, as overheating and porosity may result. At the end of the weld do not raise the torch suddenly from the weld, as this action may cause a pinhole in the weld. Do not dress welds by removing metal from the joint unless further welding is to be done on the dressed region. If the thinnest of the tubes to

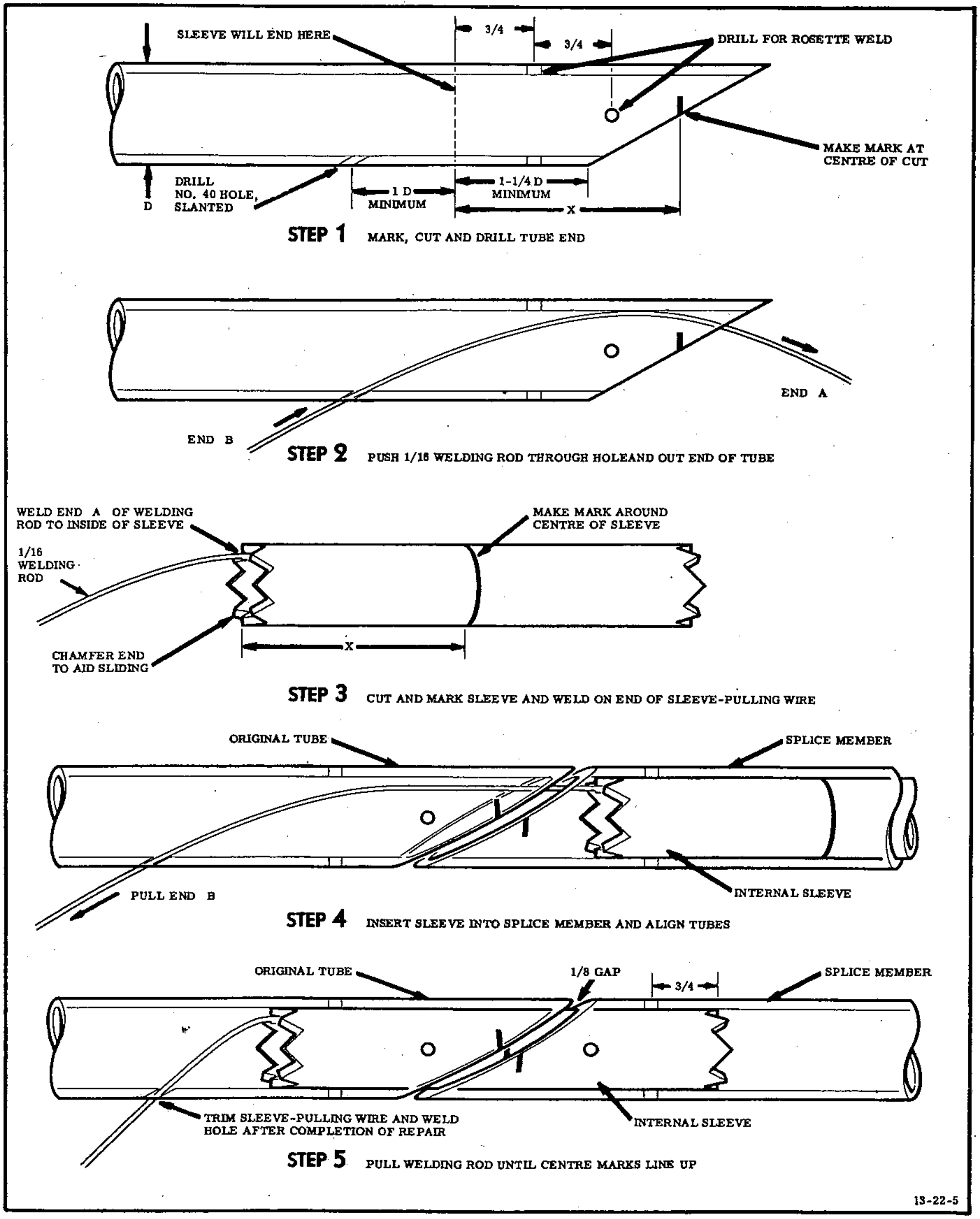


Figure 22-5 Centering Inner Sleeve in Steel Tube

be welded is less than 040 inch, the maximum width of the weld should not exceed one-quarter inch.

18 Welding wire used for oxy-acetylene welding of chrome molybdenum tubing must conform to Figure 22-7. Use torch tips of proper size for the thickness of the material to be welded. Commonly used torch tip sizes as given in Figure 22-8 are satisfactory.

Welding Fluxes

19 Welding fluxes are mixtures, in either liquid, powder or solid form, consisting of various chemicals which, at a heat equal to the welding temperatures of the weldable metals, will unite with the oxides in the weld to form a slag, thus purifying the weld. Due to the various welding temperatures of different weldable metals, several types of flux are required.

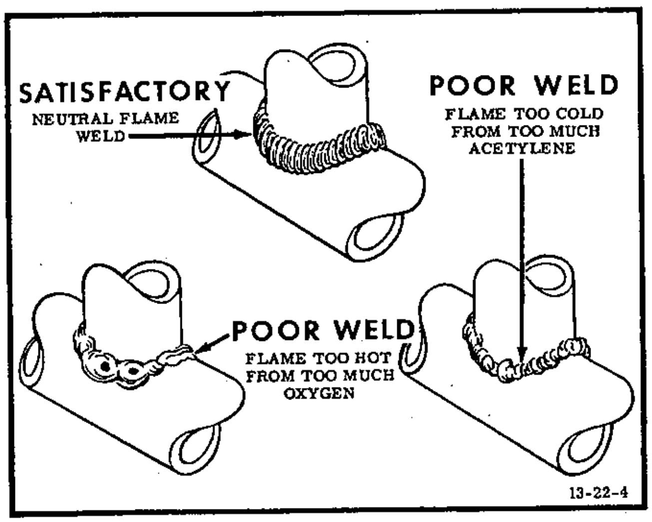


Figure 22-6 Weld Types

20 Usually, when welding chrome molybdenum steel and mild carbon steel, no flux is required. However, if difficulties are experienced, the following flux is recommended and should be applied to the surface of the metal:

Boracic Acid (Item 5)	35.5%
Sodium Chloride (Item 6)	30.1%
Potassium Carbonate (Item 7)	26.7%
Colophony (Item 8)	7.6%

21 To prevent corrosion of the metal, remove flux as soon as weld has cooled. Clean off flux by brushing with boiling water. If weld is inaccessible, immerse part in a cold 10% solution of sulphuric acid (Item 4) for 30 minutes, or a 5% solution of sulphuric acid at 66°C (150°F) for 10 minutes.

22 Remove acid by immersion in mild alkaline bath, followed by thorough washing in hot water and drying with hot or compressed air. (Refer to Part 20, following.)

Welding Torch Technique

23 The torch used for welding should be light, compact, well balanced, and particularly adapted to welding steel up to 3/16 inch in thickness. To light the torch, open the oxygen valve slightly, turn the acetylene valve wide open, and light with a flint lighter at the tip. If the flame snaps out the acetylene gas pressure should be increased slightly. If the flame burns a short distance away from the tip, the acetylene pressure is too great and should be reduced at the regulator.

Material to be Welded	Specification	Manufacturers Designation	Manufacturer
Carbon and Low Alloy Steels SAE 1020, 4130, etc.	ROD		
	MIL-R-5632 Class 2	Oxweld #32CMS	Dominion Oxygen Co.
	FLUX		
	Not Required		

Figure 22-7 Gas Welding Rods and Flux

Torch Flame

24 There are three general types of flame possible with oxy-acetylene; the neutral flame, the carburizing or reducing flame, and the oxidizing flame, identifiable as follows:

(a) The neutral flame can be identified by its clear, well-defined, white cone and is generally preferred as it gives a thoroughly fused weld.

(b) The carburizing or reducing flame can be identified by a long, feathery edge, without any white cone. It introduces carbon into the weld, and is produced when an excess of acetylene is burned.

(c) The oxidizing flame can be identified by a small, pointed, white cone and its envelope of flame. It will oxidize or burn the metal and result in a porous weld. It may be used to cut metal in emergencies when cutting equipment is not available.

Condition of Completed Welds

25 After welding, remove scale by wire brushing or sandblasting. The finished weld should incorporate the following characteristics:

(a) The seam should be smooth and of uniform thickness.

(b) The weld should be built up to provide extra thickness at the seam.

Thickness of Steel	Diameter of Hole in Tip	Drill Size
.015 to .031	.026	No. 71
.031 to .065	.031	No. 68
.065 to .125	.037	No. 63
.125 to .188	.042	No. 58
.188 to .250	.055	No. 54
.250 to .375	.067	No. 51

Figure 22-8 Torch Tip Sizes

(c) The weld metal should taper off smoothly into the base metal.

(d) No oxide should be formed on the base metal at a distance of more than one-half inch from the weld.

(e) The weld should show no signs of blowholes, porosity or projecting globules.

(f) The base metal should show no signs of pitting, burning, cracking or distortion.

(g) The beads must be of correct size and number.

(h) The depth of penetration must be sufficient to ensure fusion of base metal and filler rod.

Inspection for Defective Weld

26 Make the following test of suspected welds:

(a) Soak the part in oil (Item 9) or heated paraffin.

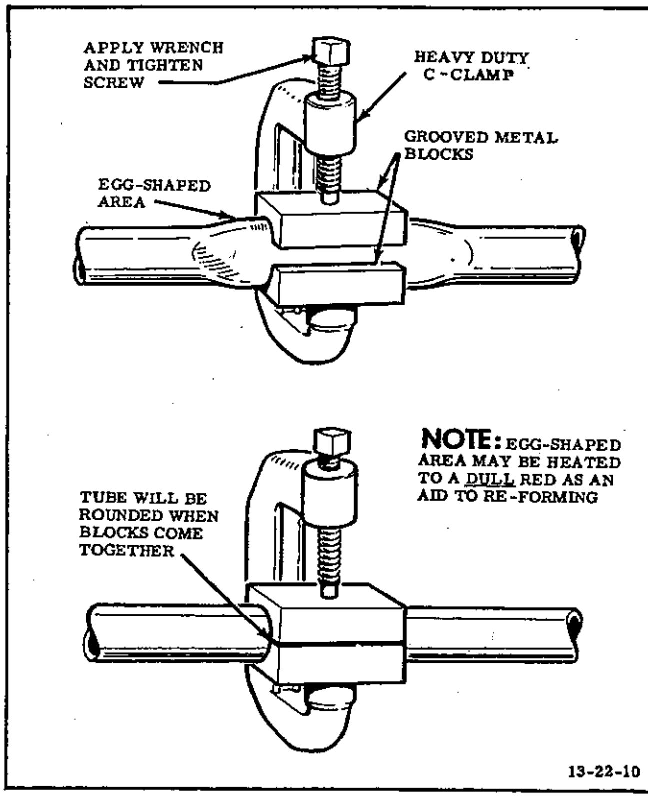


Figure 22-9
Correcting Oval-shaped Steel Tube Distortion

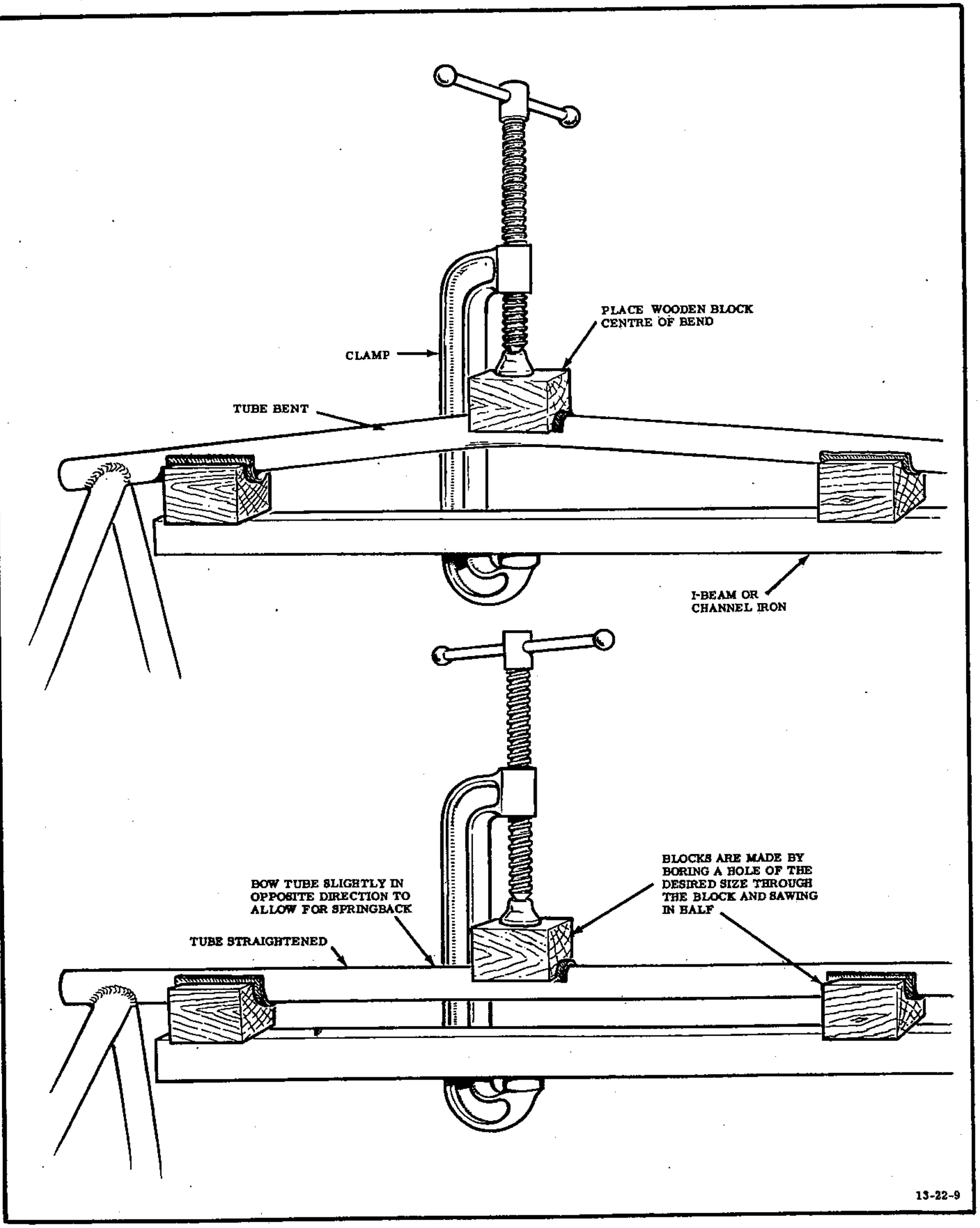


Figure 22-10 Straightening Bowed Steel Tubes

(b) Clean thoroughly and apply a coat of talc (Item 10). Cracks in the weld will be evident by the appearance of oil from the cracks.

(c) Clean the part and mark location of crack for subsequent repair.

Testing the Completed Repair

27 Test the completed repair in the following manner:

(a) Apply air pressure of approximately 30 psi to a convenient point on the structure, plugging the outlet.

(b) Apply a heavy mixture of soap suds (Item 11) over the suspected weld. A deficiency will be indicated by the formation of large bubbles over the defective weld. Defective welds must be re-welded.

Anti-corrosion Treatment

28 Refer to Part 23, following, for anti-corrosion treatment of welded steel tubing after welding repairs are complete.

Smooth Dents in Steel Tubes

29 A minor smooth dent in steel tubing is removed as follows:

(a) Remove one of the self-tapping screws provided at the extremities of the main steel tubes and apply an air pressure of upwards of 75 psi to the inside of the steel truss.

(b) Heat the dented area evenly to a dull red, (see heat colour chart in Part 4) with an acetylene torch until the internal air pressure forces out the dent and restores the original tube contour.

(c) If internal air pressure and heat are not sufficient to remove the dent, tack weld a welding rod to the centre of the dent and pull on the rod while heating the area.

(d) After the dent is removed, allow the area to cool and then release the internal air pressure.

(e) Re-treat for anti-corrosion purposes as detailed in Part 23.

CAUTION

Do not apply heat above a dull red to the middle third of the length of any tube.

Steel Tubes Out of Round

30 If the tubing is partially flattened to an oval shape, the circular section may be restored, cold, by pressure applied by grooved steel form blocks, (see Figure 22-9), as follows:

(a) Drill a steel block to the diameter of the damaged tube, saw the block along the axis of the hole and separate the two sections of the block.

(b) Apply the two form block sections to the oval-shaped area on the affected tube.

(c) Slip a heavy clamp over the blocks, tighten the clamp, and exert pressure on the area until the oval-shaped tube area is restored to the normal circular shape. If difficulty is encountered in shaping the tube in the cold condition, heat the area to a dull red (see heat colour chart in Part 4), then apply the steel blocks and clamp.

(d) Remove the clamp and the blocks.

(e) If the oval-shaped area is longer than the length of the steel form blocks, re-apply the form blocks and the clamp to successive affected areas until the entire length of the oval-shaped area is restored to the normal circular shape.

Bowed Steel Tubes

31 Steel tubes which have been bowed without evidence of cracking may be straightened in the cold condition as follows, (see Figure 22-10):

(a) Cut three hardwood blocks grooved to fit the contour of the tube, and line the grooves with leather or canvas.

(b) Obtain a length of channel iron equal to the length of the bow in the tube. Locate one of the grooved blocks at either extremity of the bow and apply the channel iron beam so that the beam spans the bowed area and backs up the two blocks. Apply the third block on the opposite side of the tube at the point of the maximum bend near the centre of the bow.

(c) Slip one end of a heavy C-clamp over the channel iron beam and tighten the clamp down on the block at the centre of the bend. In order to allow for springback of the tube, continue tightening the clamp until the tube is bent slightly in the opposite direction. (See Figure 22-10.)

(d) Remove the clamp and the blocks.

(e) Check the alignment of the tube by placing an accurate straightedge on both the side and the top of the tube. If the straightedge check reveals a slight bow in the tube, re-apply the blocks and clamp, and check until the tube lines up with a straightedge in both reference planes.

(f) If cracks appear at the point where the maximum bow was corrected, drill a No. 40 (.098) hole at the ends of the crack and weld a split steel sleeve over the area as outlined in Paragraph 34, following.

(g) In every case where a bent tube is restored, carefully test all adjacent welded joints for cracks, and repair the cracks.

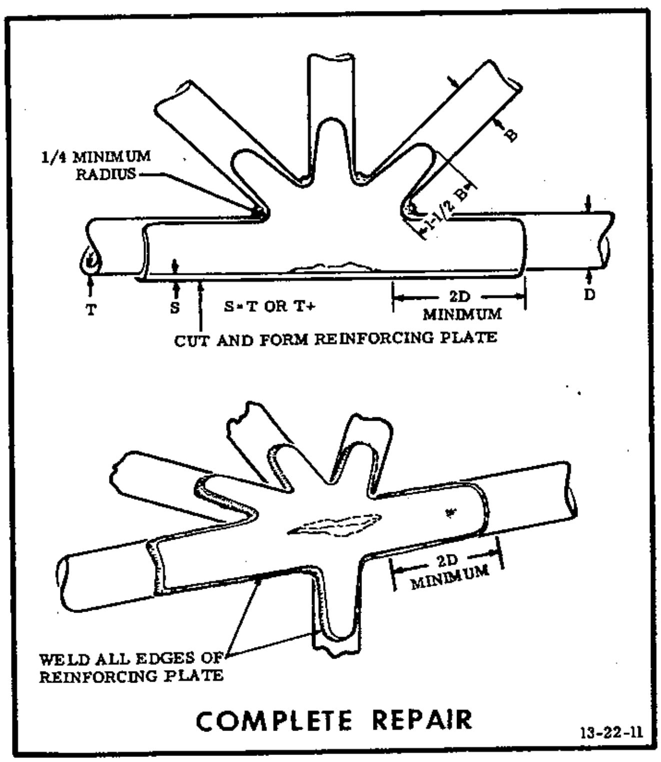


Figure 22-11 Dent Reinforcement at Steel Tube Cluster Joint

Small Cracks at Steel Tubing Cluster Joints

32 If it is necessary to check an individual tubing joint for cracks, proceed as follows:

(a) Apply a liberal coat of light oil (Item 9) to the affected area.

(b) Thoroughly wipe the oil from the joint.

(c) Spray with mixture of talc (Item 10) and alcohol. A crack in the joint will usually be shown by the appearance of oil on the talc from the crack recess. (See Figure 22-1.)

(d) Remove all finish from the area by rubbing with steel wool or a wire brush.

(e) If the crack is located in an original weld bead, carefully chip, file or grind out the existing weld bead and reweld over the crack along the original weld line.

(f) When grinding off the original weld bead, take particular care to avoid removing any of the existing tube or gusset material.

(g) If the crack is near a cluster joint but away from the original weld bead, remove the finish from the area, drill No. 40 (.098) holes at the ends of the crack, and weld an overlapping doubler over the area. No more than two cracks may be repaired in the same general area.

(h) Apply one coat of zinc chromate primer, (refer to Part 23, following), to the area from which the finish was previously removed.

(j) Apply finish coats to match the adjacent surface.

Sharp Dents at a Steel Tube Cluster Joint

33 Repair sharp dents at a steel tube cluster joint by welding a formed steel patch plate over the dented area and surrounding tubes (see Figure 22-11). To prepare the patch plate proceed as follows:

(a) Cut a section of steel plate of a thickness equal to or greater than that of the damaged tube. Trim the reinforcing plate so that the plate extends a minimum of two times the diameter of the tube from the nearest edge of the dent and over adjacent tubes 1-1/2 times the diameter of the tube.

(b) Remove existing finish on the damaged cluster joint area to be covered by the reinforcing plate.

(c) Form reinforcing plate before any welding is attempted.

(d) Cut and tack-weld the plate to one or more of the tubes forming the cluster joint, then heat and pound it around the joint contour as required to produce a smooth contour. Avoid unnecessary heating of the reinforcing plate while forming. Allow a gap of no more than one-sixteenth inch from the contour of the joint to the reinforcing plate. While forming the plate, exercise care to prevent damage at the apex of the angle formed by any two adjacent fingers of the plate.

(e) After the reinforcing plate is formed and tack-welded to the cluster joint, weld the plate edges to the cluster joint.

(f) At the conclusion of the repair, refer to Part 23, following, for a method of protecting the surface.

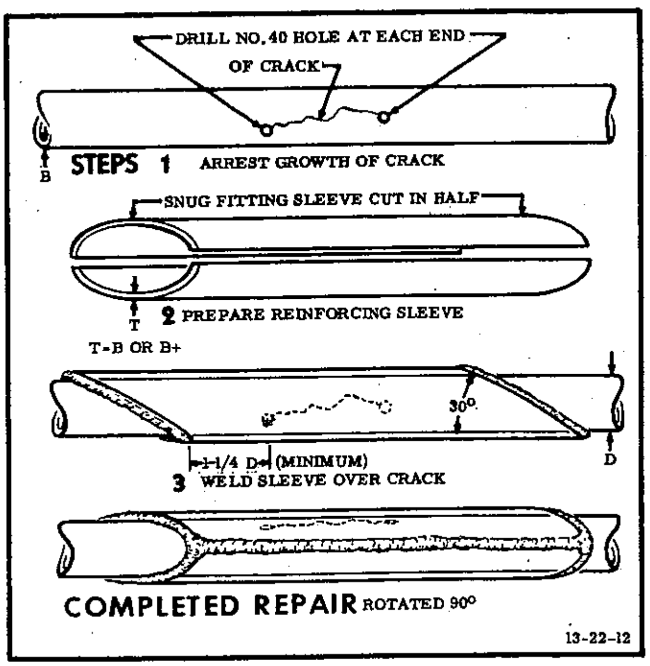


Figure 22-12 Dent or Crack Reinforcement in Steel Tubing

Repairing Sharp Dents or Cracks

34 If a crack appears in a length of steel tube, usually as the result of previously straightening the tube, drill a No. 40 (.098) hole at each end of the crack and remove the finish around the tube for a distance of approximately three inches on each side of the damage. If the damage is in the form of a sharp dent which cannot be removed by any of the methods previously outlined, remove the finish in the same manner.

35 In order to reinforce the dented or the cracked area, select a length of steel tube having an inside diameter approximately equal to the outside diameter of the damaged tube and of the same wall thickness. Diagonally cut the steel sleeve reinforcement at a 30° angle on both ends, so that the distance of the sleeve from the edge of the crack or dent is not less than 1-1/4 times the diameter of the damaged tube. (See Figure 22-12.) Cut through the entire length of the reinforcing sleeve and separate the half sections of the sleeve. Clamp the two sleeve sections to the proper positions on the affected areas of the original steel tube. Weld the reinforcing sleeve along the length of the two sides, and weld both ends of the sleeve to the damaged steel tube as shown. Repeat anti-corrosion procedure, (refer to Part 23, following), and refinish as required.

SPLICED REPAIRS

General

36 Welded tubular structures may be repaired as described in the following paragraphs. However, control surfaces such as the elevators, rudder and ailerons should not be repaired if the added weight will change their aerodynamic characteristics by inducing flutter or vibration.

37 Damaged tubular members are replaced by splicing in a new section of tubing held in place by the use of reinforcing sleeves. Two types of sleeve are available, internal, (see Figures 22-5 and 22-13), and external (see Figure 22-14). Two types of splice welds are permitted, the fishmouth and the 30° diagonal. The fishmouth is the preferable type. When using the external sleeve, the sleeve is fishmouthed or diagonally cut and the inside structural member is square cut. When using the internal sleeve, the sleeve is

notched and the outside structural member is fishmouthed or diagonally cut. Internal sleeve repairs require rosette welds, located as shown in Figures 22-5 and 22-13. Although rosette welds are not essential for external sleeves, they strengthen the joint and are recommended.

NOTE

Internal sleeve repairs are lighter, produce less bulge and require less welding, while external sleeve repairs are stronger and easier to apply.

Precautions

38 Any tubular member originally welded into a part of the structure may be spliced according to the methods outlined, provided the following precautions are considered:

(a) Splices are not to be made in the middle third of the bay.

(b) Only one repair may be made in any one bay of a structural member.

(c) When a tube has to be removed at a joint, it must be carefully removed so as not to disturb other members terminating at that joint.

(d) If a member is damaged at a joint so that it is impossible to retain a stub to which another member can be attached, the member must be replaced entirely in the case of web members. In the case of continuous longerons, make the splice in an adjacent bay.

(e) No splices may be made by butt welding any member between station points.

(f) If the welded assembly was heat-treated subsequent to welding, the repaired assembly must be reheat-treated to the same strength.

(g) Material used to replace a section of original tubing, or used as a liner, must be of the same material and strength as the original tubing.

(h) To avoid putting additional stress on a structure being repaired, ensure that the structure is adequately supported prior to cutting any damaged member. Use a jury strut or protected trestles, and attempt to duplicate original condition prior to cutting by straightening bowed tubing and supporting the aircraft in normal flying condition.

Determination of Repair Tubing Sizes

39 For the proper size of tubing to be used in external and internal sleeve splices using

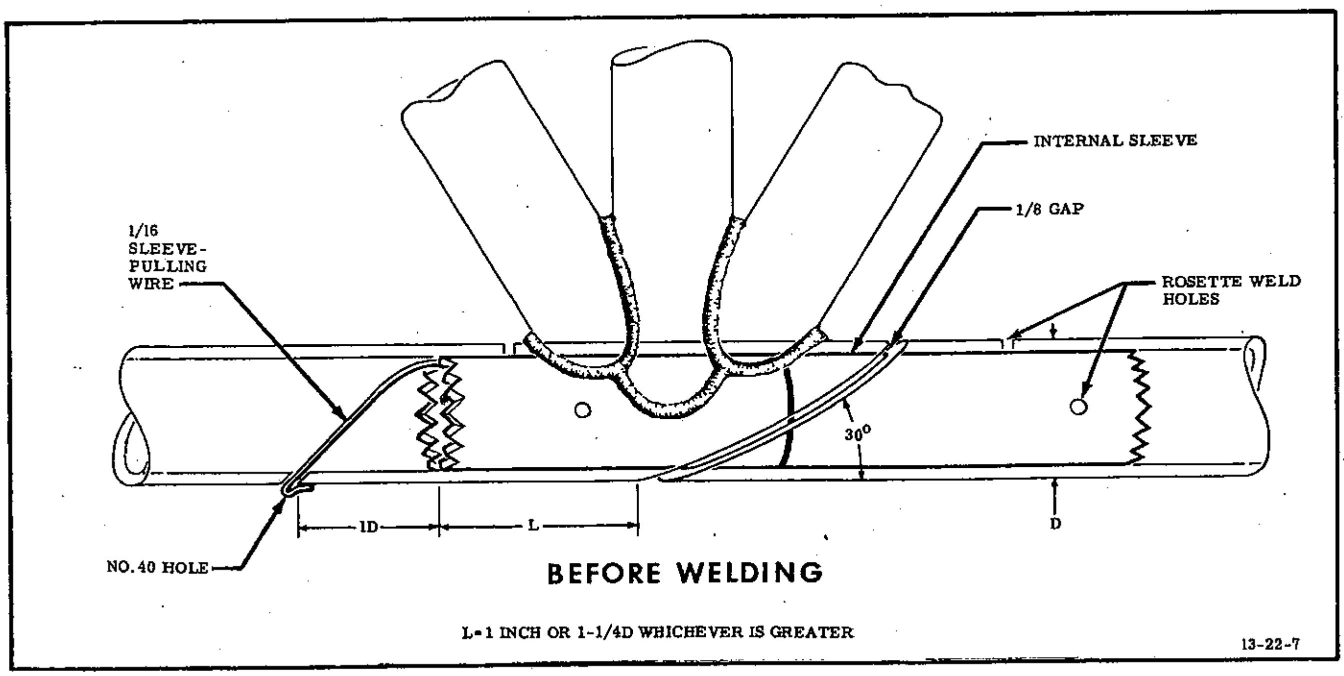


Figure 22-13 Steel Tube Inner Sleeve Splice

SAE1025 and SAE4130X steels, see Figures 22-15 and 22-16.

Initial Measurement

40 Before cutting any tubular member prior to making the repair, take a measurement between centre lines of the stations adjacent to the member to be repaired. In this way the original dimension may be maintained while splicing in the new tube, ensuring proper alignment of the structure. If tube is bent, it will be necessary to straighten it before obtaining this dimension. (See Figure 22-10.) The dimension may be obtained from the drawing of the part, or it may be taken from adjacent stations on the the opposite side of the structure wherever two sides of the structure are identical.

Splicing Structural Tube by Outer Sleeve Method

41 Splice structural tube by outer sleeve method as follows:

(a) Cut out the damaged section of the tube, locating the cuts away from the middle third of the tube section.

(b) Cut a replacement tube of same material to match the outside diameter, wall thickness and length of the removed tube. This replacement tube must bear against the stubs of the original tube with a tolerance of one thirty-secondth of an inch.

(c) Select a length of steel tubing of inside diameter approximately equal to the outside diameter of the damaged tube and of the same wall thickness. This outer sleeve tube material must fit about the original tube with a maximum tolerance of one sixty-fourth of an inch. From this material, cut two sections of tubing, diagonally or fishmouth, each of such a length that the nearest ends of the outer sleeve are a minimum distance of 1-1/4 tube diameters from the ends of the cut on the original tube. (See Figure 22-14.)

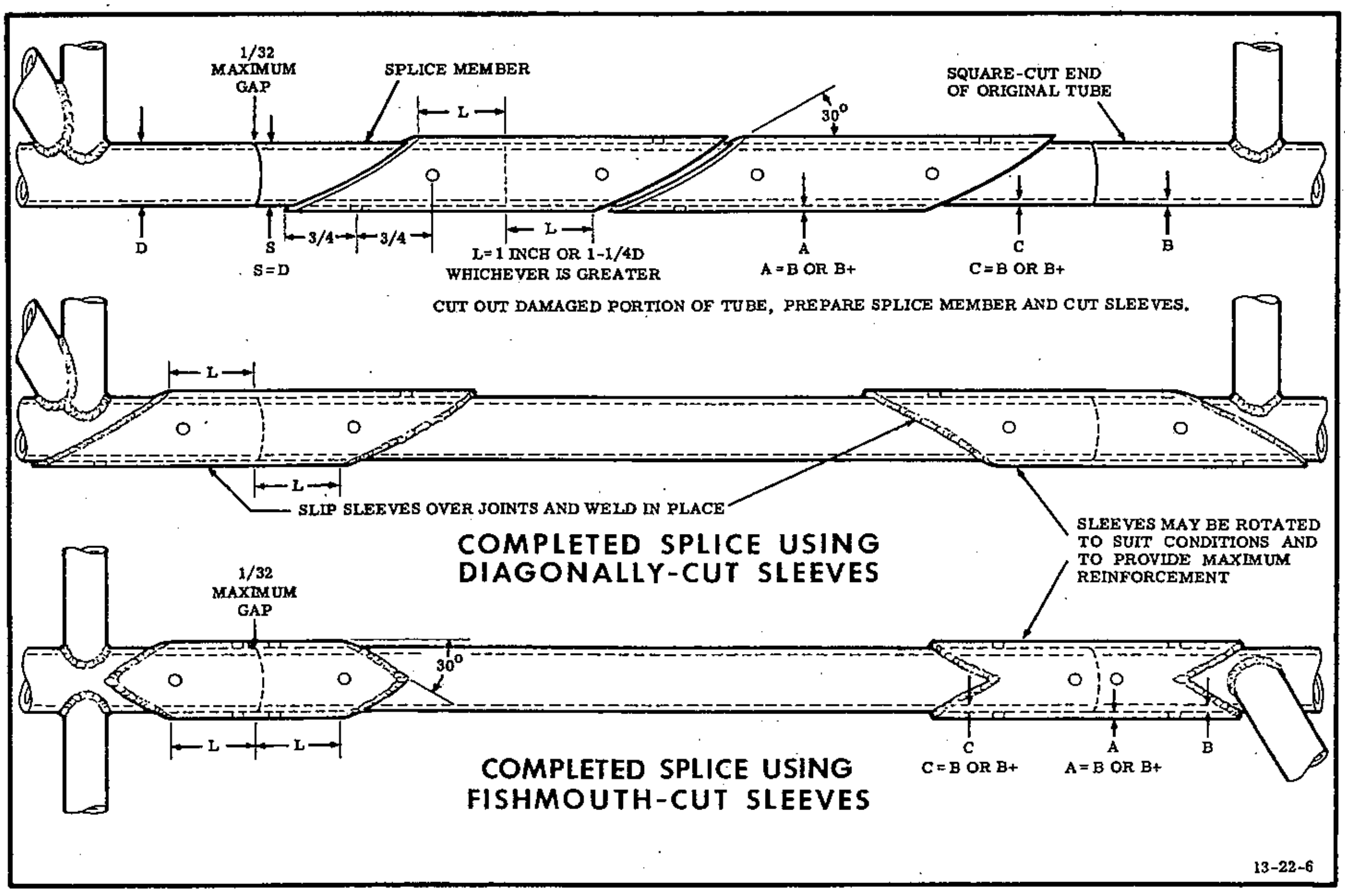


Figure 22-14 Steel Tube Outer Sleeve Splice

Material A	Diameter Inches		Wall Thickness - Inches															
			A = .028				A = .035				A = .049				A = .058			
			1025		4130		1025		4130		1025		4130		1025		4130	
	A,B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C
1025	5/8	1/2	.028	.049	.028	.028	.035	.049	.028	.035	.049	.065	.035	.049	.058	.083	.049	.058
4130			.058	.083	.028	.049		.095	.035	.049			.049	.065			.058	.083
1025	3/4	5/8	.028	.035	.028	.028	.035	.049	.028	.035	.049	.065	.035	.049	.058	.083	.049	.058
4130			.058	.065	.028	.035		.083	.035	.049		.120	.049	.065			.058	.083
1025	7/8	3/4	.028	.035	.028	.028	.035	.049	.028	.035	.049	.065	.035	.049	.058	.083	.049	.058
4130			.058	.065	.028	.035		.083	.035	.049		.120	.049	.065			.058	.083
1025	1-	7/8	.028	.035	.028	.028	.035	.049	.028	.035	.049	.058	.035	.049	.058	.083	.049	.058
4130			.058	.058	.028	.035		.083	.035	.049		.120	.049	.058			.058	.083
1025	1-1/8	1-	.028	.035	.028	.028	.035	.049	.028	.035	.049	.058	.035	.049	.058	.083	.049	.058
4130			.058	.058	.028	.035		.083	.035	.049		.120	.049	.058			.058	.083
1025	1-1/4	1-1/8	.028	.035	.028	.028	.035	.049	.028	.035	.049	.058	.035	.049	.058	.083	.049	.058
4130			.049	.058	.028	.035		.083	.035	.049		.120	.049	.058		.120	.058	.083
1025	1-3/8	1-1/4	.028	.035	.028	.028	.035	.049	.028	.035	.049	.058	.035	.049	.058	.065	.049	.058
4130			.049	.058	.028	.035		.083	.035	.049		.120	.049	.058		.120	.058	.065
1025	1-1/2	1-3/8	.028	.035	.028	.028	.035	.049	.028	.035	.049	.058	.035	.049	.058	.065	.049	.058
4130			.049	.058	.028	.035		.083	.035	.049		.120	.049	.058		.120	.058	.065
1025	1-5/8	1-1/2	.028	.035	.028	.028	.035	.049	.028	.035	.049	.058	.035	.049	.058	.065	.049	.058
4130			.049	.058	.028	.035		.083	.035	.049		.095	.049	.058		.120	.058	.065
1025	1-3/4	1-5/8	.028	.035	.028	.028	.035	.049	.028	.035	.049	.058	.035	.049	.058	.065	.049	.058
4130			.049	.058	.028	.035		.083	.035	.049		.095	.049	.058		.120	.058	.065
1025	1-7/8	1-3/4	.028	.035	.028	.028	.035	.049	.028	.035	.049	.058	.035	.049	.058	.065	.049	.058
4130			.049	.058	.028	.035		.083	.035	.049		.095	.049	.058		.120	.058	.065
1025	2	1-7/8	.028	.035	.028	.028	.035	.049	.028	.035	.049	.058	.035	.049	.058	.065	.049	.058
4130			.049	.058	.028	.035		.083	.035	.049		.095	.049	.058		.120	.058	.065

A - Original Tube   B - Replacement Tube   C - Inside Sleeve

Figure 22-15 Internal Repair Tube Sizes

Material A	Diameter Inches		Wall Thickness - Inches																			
			A = .028				A = .035				A = .049				A = .058				A = .065			
			1025		4130		1025		4130		1025		4130		1025		4130		1025		4130	
	A,B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C
1025	1/2	5/8	.028	.028	.028	.028	.035	.028	.035	.028	.049	.049	.049	.028	.058	.049	.058	.028	.065	.058	.065	.028
4130			.058	.049	.028	.028	.065	.049	.035	.028	.095		.049	.049	.120		.058	.049			.065	.058
1025	5/8	3/4	.028	.028	.028	.028	.035	.035	.035	.028	.049	.049	.049	.028	.058	.049	.058	.035	.065	.058	.065	.035
4130			.058	.049	.028	.028	.065	.058	.035	.035	.095		.049	.049	.120		.058	.049			.065	.058
1025	3/4	7/8	.028	.028	.028	.028	.035	.035	.035	.028	.049	.049	.049	.028	.058	.049	.058	.035	.065	.058	.065	.049
4130			.058	.049	.028	.028	.065	.058	.035	.035	.095		.049	.049	.120		.058	.049			.065	.058
1025	7/8	1-	.028	.028	.028	.028	.035	.035	.035	.028	.049	.049	.049	.035	.058	.058	.058	.035	.065	.058	.065	.049
4130			.058	.049	.028	.028	.065	.058	.035	.035	.095		.049	.049	.120		.058	.058			.065	.058
1025	1-	1-1/8	.028	.028	.028	.028	.035	.035	.035	.028	.049	.049	.049	.035	.058	.058	.058	.049	.065	.058	.065	.049
4130			.058	.049	.028	.028	.065	.058	.035	.035	.095		.049	.049	.120		.058	.058	.120		.065	.058
1025	1-1/8	1-1/4	.028	.028	.028	.028	.035	.035	.035	.028	.049	.049	.049	.035	.058	.058	.058	.049	.065	.058	.065	.049
4130			.058	.049	.028	.028	.065	.058	.035	.035	.095		.049	.049	.120		.058	.058	.120		.065	.058
1025	1-1/4	1-3/8	.028	.028	.028	.028	.035	.035	.035	.028	.049	.049	.049	.035	.058	.058	.058	.049	.065		.065	.049
4130			.049	.049	.028	.028	.065	.058	.035	.035	.095		.049	.049	.120		.058	.058	.120		.065	
1025	1-3/8	1-1/2	.028	.028	.028	.028	.035	.035	.035	.028	.049	.049	.049	.049	.058	.058	.058	.049	.065		.065	.049
4130			.049	.049	.028	.028	.065	.058	.035	.035	.095		.049	.049	.120		.058	.058	.120		.065	
1025	1-1/2	1-5/8	.028	.028	.028	.028	.035	.035	.035	.028	.049	.049	.049	.049	.058	.058	.058	.049	.065		.065	.049
4130			.049	.049	.028	.028	.065	.058	.035	.035	.095		.049	.049	.120		.058	.058	.120		.065	
1025	1-5/8	1-3/4	.028	.028	.028	.028	.035	.035		.028	.049	.049	.049	.049	.058	.058	.058	.049	.065		.065	.058
4130			.049	.049	.028	.028	.065	.058	.035	.035	.095		.049	.049	.120		.058	.058	.120		.065	
1025	1-3/4	1-7/8	.028	.028	.028	.028	.035	.035		.028	.049	.049	.049	.049	.058	.058	.058	.049	.065		.065	.058
4130			.049	.049	.028	.028	.065	.058	.035	.035	.095		.049	.049	.120		.058	.058	.120		.065	
1025	1-7/8	2-	.028	.028	.028	.028	.035	.035		.028	.049	.049	.049	.049	.058	.058	.058	.049	.065		.065	.058
4130			.049	.049	.028	.028	.065	.058	.035	.035	.095		.049	.049	.120		.058	.058	.120		.065	

Figure 22-16 External Repair Tube Sizes

(d) Deburr the edges of the sleeves, replacement tube and original tube stubs. Slip the two sleeves over the replacement tube, line up the replacement tube with the original tube stubs, and slip the sleeves out over the centre of each joint. (See Figure 22-14.) Adjust the sleeves to suit the area and to provide maximum reinforcement.

(e) Tack weld the two sleeves to the replacement tube in two places before welding. Apply a uniform weld around both ends of one of the reinforcing sleeves and allow the weld to cool. Then weld around both ends of the remaining reinforcing tube. (See Figure 22-14.)

(f) Allow one sleeve to cool before welding the remaining tube, to prevent undue warping.

(g) For anti-corrosion and surface finish refer to Part 23, following.

Splicing of Streamline Tubing by Outer Sleeve Method

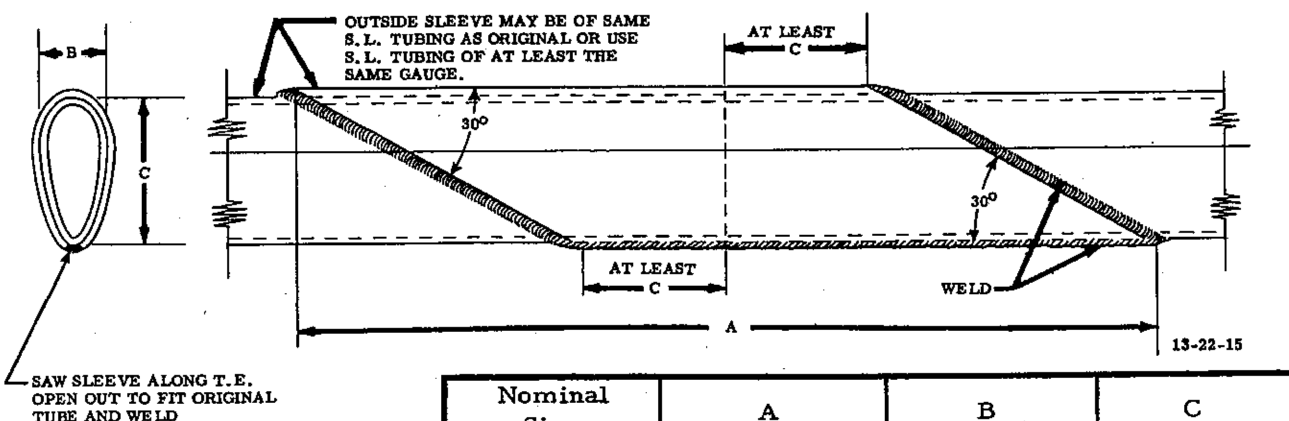
42 For splicing of streamline tubing by this method see Figure 22-17.

Splicing Structural Tubes using Larger Diameter Replacement Tubes

43 This method of splicing structural tubes requires the least amount of cutting and welding but cannot be used where the damaged tube is cut too near the adjacent joints, or where bracket mounting provisions make it necessary to maintain the same replacement tube diameter as the original. To effect this type of repair proceed as follows:

(a) Cut the original damaged tube, leaving a minimum short stub equal to 2-1/2 tube diameters on one end, and a minimum long stub equal to 4-1/2 tube diameters on the other end. (See Figure 22-18.) The cuts must be away from the middle third of the affected tube.

(b) Select a spare length of steel tubing having an inside diameter approximately equal to the outside diameter of the damaged tube and of the same wall thickness as, or greater than, the damaged tube. This replacement tube



A - Minimum Length of Sleeve

B - Streamline Tube Length of Minor Axis

C - Streamline Tube Length of Major Axis

Nominal Size	A	B	C
1	7.324	.572	1.340
1-1/4	9.128	.714	1.670
1-1/2	10.960	.858	2.005
1-3/4	12.784	1.000	2.339
2	14.594	1.144	2.670
2-1/4	16.442	1.286	3.008
2-1/2	18.268	1.430	3.342

Figure 22-17 Streamline Tube Splice using Outer Split Sleeve

should fit about the original tube with a maximum tolerance of one sixty-fourth of inch. From this replacement tube material, cut a section of tubing of such a length that each end of the tube is a minimum distance of 1-1/4 tube diameters from the end of the cut on the original tube. Use a fishmouth-cut replacement tube wherever possible, (see Figure 22-18), however a diagonally-cut tube may also be used.

(c) Deburr edges of replacement tube and original tube stubs. If a fishmouth cut is used, file the sharp radius of the cut with a small, round file.

(d) Drill replacement tube for rosette welds located as shown in Figure 22-5.

(e) Slip the replacement tube over the long stub, then back over the short stub. Centre the replacement tube between the stubs of the original tube.

(f) Tack weld one end of the replacement tube in several places, then weld completely around the end. In order to prevent distortion, allow the weld to cool completely.

(g) Weld the remaining end of the replacement tube to the original tube and weld rosettes.

44 Refer to Part 23, following, for anti-corrosion procedure and surface finish as required.

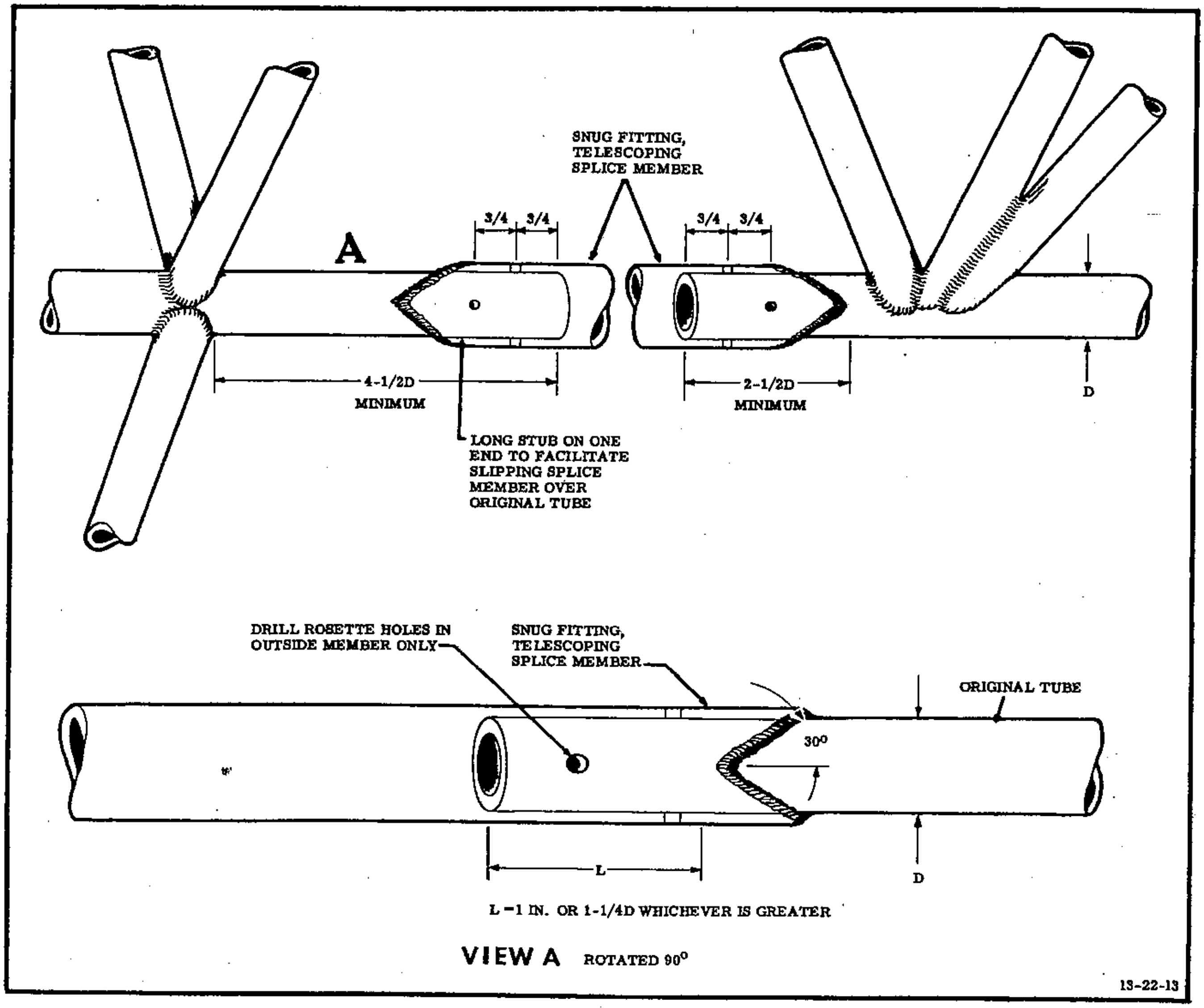


Figure 22-18 Fishmouth Splice using Larger Size Replacement Tube

Splicing Structural Tube by Inner Sleeve Method

45 For partial replacement of a tube, the inner sleeve splicing method is used where a smooth tube surface is required. (See Figure 22-13.) Proceed as follows:

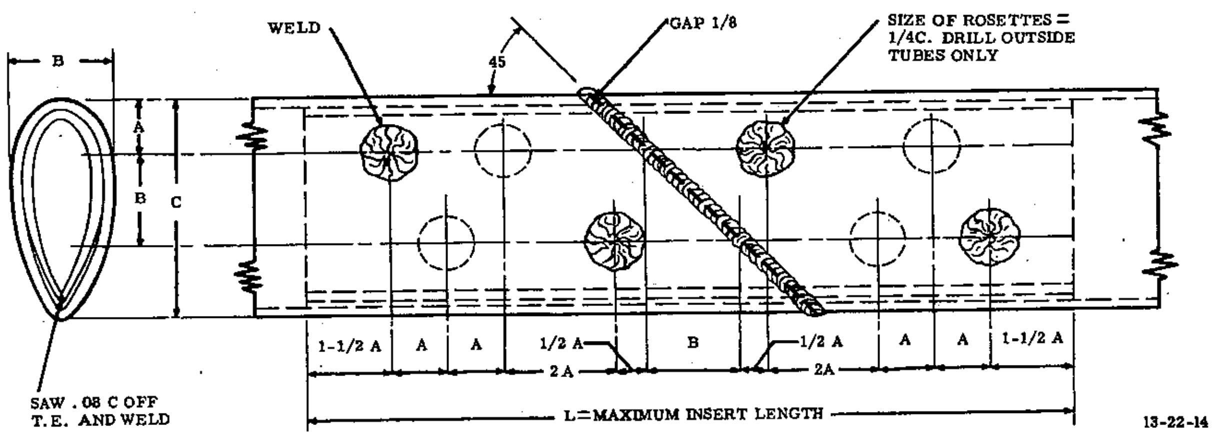
(a) Diagonally cut out the damaged portion of the tube with a hacksaw, locating the cuts away from the middle third of the affected tube section. Deburr the edges of the cuts.

(b) Diagonally cut a replacement tube to match the diameter, wall thickness, and length of the removed portion of the damaged tube.

(c) At each end of the replacement tube allow a 1/8 inch gap from the diagonal cuts to the stubs of the original tube.

(d) Select a length of steel tubing of the same wall thickness and of an outside diameter approximately equal to the inside diameter of the damaged tube. This inner sleeve should fit snugly within the original tube, with a maximum tolerance of one sixty-fourth of an inch. From this inner sleeve tube material cut two sections of tubing, each of such a length that the ends of the inner sleeve will be a minimum distance of 1-1/4 tube diameters from the nearest end of the diagonal cut. (See Figure 22-13.) Notch ends of inner sleeves as indicated in Figure 22-5.

(e) With thin paint, metal dye, or emery paper (Item 2) make a narrow mark around the centre of the reinforcing sleeve. Mark the outside of the diagonally cut original tube stub midway along the diagonal cut. (See Figure 22-5.)



Insert Tube is of Same Streamline Tubing as Original

A - 2/3 B

B - Minor Axis Length of Original Streamline Tube

C - Major Axis Length of Original Streamline Tube

Nominal Size	A	B	C	L
1	.382	.572	1.340	5.16
1-1/4	.476	.714	1.670	6.43
1-1/2	.572	.858	2.005	7.72
1-3/4	.667	1.000	2.339	9.00
2	.763	1.144	2.670	10.30
2-1/4	.858	1.286	3.008	11.58
2-1/2	.954	1.430	3.342	12.88

Figure 22-19 Landing Gear Streamlined Tube Splice using Split Insert

(f) Drill holes in stub tubes for rosette welds as shown in Figure 22-5.

(g) At a minimum distance of 2-1/4 times the tube diameter, measured from the nearest end of the diagonal cut, centre punch the tube and start drilling the No. 40 hole at a 90° angle. After a shallow hole is started, slant the drill toward the cut and drill at a 30° angle. Slanting the hole in this manner aligns the edges of the hole with the line of pull of the sleeve-pulling wire, and prevents the wire from scraping the hole edges. Deburr the edges of the hole with a round, needle-point file. Obtain a length of 1/16 inch welding or brazing wire, insert one end into the drilled hole, and push the wire out the end of the tube, (see Figure 22-5). Weld the end of the wire to the inside of the reinforcing sleeve.

(h) Slip the sleeve into the replacement tube so that the welded wire is 180° from the drilled hole. If the inner sleeve fits very tightly in the replacement tube, chill the sleeve with dry ice or in cold water. If necessary, polish down the diameter of the sleeve with emery cloth. Chilling or polishing allows more clearance from the inner sleeve to the inside wall of the tube stubs. Align the original tube stubs with the replacement tube.

(j) Pull on the exposed end of the sleeve-pulling wire until the centre mark on the sleeve is directly in line with the centre mark on the diagonal cut, (see Figure 22-5). When this occurs, the inner sleeve is centered beneath the joint.

(k) Sharply bend the pulling wire over to hold the sleeve in position. At each side of the replacement tube, weld the inner sleeve to the tube stubs through the 1/8 inch gap between the stubs, (see Figure 22-5). Completely fill the 1/8-inch gap and form a weld bead over the gap.

(m) Weld up rosette welds.

(n) Snip off the pulling wire flush with the surface of the tube and weld over the hole.

(p) Refer to Part 23, following, for anti-corrosion procedure. Refinish as required. See Figure 22-2 for a suitable type of fuselage welding jig.

REPLACING STRUCTURAL TUBES

General

46 When tubes are severely damaged, replace them. Tube replacement is necessary where an original tube stub is too short to attach a replacement and where splice welds would be made in the middle third of a member.

Removal of a Member at Joint or Cluster

47 To remove a member at a joint or from a cluster of tubes, use a fine-toothed hacksaw and remove the tube carefully and completely from the structure. While cutting out the tube, exercise caution to prevent any damage to adjacent tubes or welds. Where new welds are made over existing welds, completely chip or file off the old welds. When installing a new tube member, allow a clearance of one thirty-secondth of an inch at either end for expansion. After the new tube has been welded in place, clean the welded joints with a wire brush or steel wool. Refer to Part 23, following, for the anti-corrosion procedure. Refinish as required.

Landing Gears

48 Landing gears made of round tubing may be repaired using standard repairs and splices.

49 Landing gears made of streamlined tubing may be repaired by using methods detailed, with limiting dimensions as shown in Figure 22-19.

Ski Pedestals

50 Damaged pedestals made of steel tubing may be repaired by using any of the applicable methods.

Wing and Tail Surface Brace Struts

51 When spare parts are not available for the repair of these components, use the repair methods detailed in previous paragraphs with limiting dimensions as shown in Figure 22-17. Steel brace struts may be spliced at any point along the length of the strut provided the splice does not overlap any part of an end fitting. The jury strut attachment is not considered an end fitting, therefore, a splice may be made at this point. The repair procedure and workmanship should be such as to minimize

distortion due to welding and the necessity for subsequent straightening operations. Every repaired strut should be carefully observed during initial flights to ascertain that the vibration characteristics of the strut and attaching components have not been adversely affected by the repair. The check should cover a wide range of speed and engine power combinations.

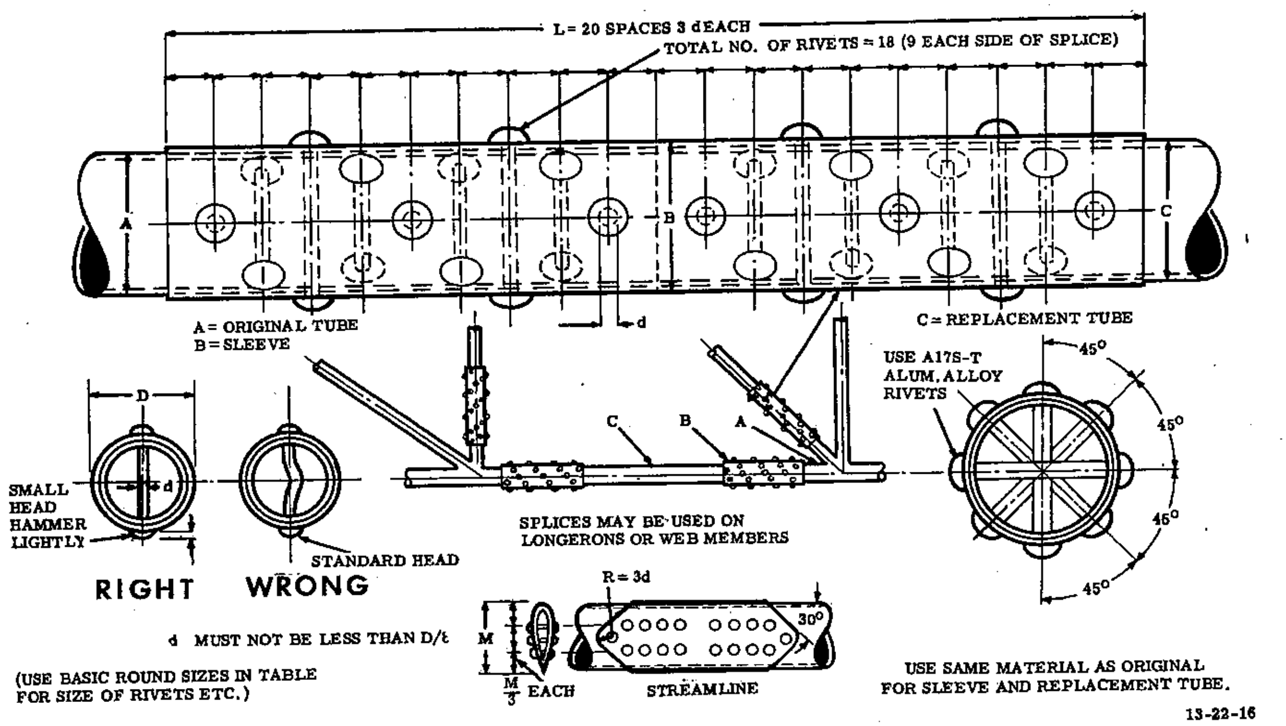
52 When making repairs to wing and tail surface brace members pay particular attention to proper fit and alignment to avoid eccentricities.

Engine Mounts

53 Engine mount members are repaired by using a larger diameter replacement tube telescoped over the stub of the original member and using fishmouth and rosette welds.

Check of Alignment

54 Repairs to engine mounts are governed by accurate means of checking alignment. When repairs are made, the original alignment of the structure must be maintained. This is done by measuring the distance between points of



A, C*	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2	1-5/8	1-3/4	1-7/8
	.065	.065	.065	.065	.058	.058	.058	.058	.058	.058
B	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2	1-5/8	1-3/4	1-7/8	2
	All .058 Thick									
Rivet Dia.	5/32	5/32	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4
L	9-3/8	9-3/8	11-1/4	11-1/4	11-1/4	11-1/4	15	15	15	15

* Includes all Thicknesses up to and Including Maximum Shown.

Figure 22-20 Typical Tubular Repair for Aluminium Alloy.

corresponding members that have not been distorted, and by reference to the manufacturer's drawings.

Cause for Rejection

55 If any member is out of alignment, the engine mount must be replaced.

Engine Mount Ring Damage

56 Minor damage, such as a crack adjacent to an engine attachment lug, may be repaired by rewelding the ring and extending a gusset or a mounting lug past the damaged area. Engine mount rings which have been extensively damaged should not be repaired but should be replaced unless the method of repair is specifically approved by engineering authority.

Rivetting of Tubes

57 Round or streamline tubular members may be repaired by splicing and rivetting as shown in Figure 22-20. Splices in struts should not overlap the fittings.

58 When solid rivets go completely through hollow tubes, their diameter should be at least one-eighth of the outside diameter of the outer tube. Rivets which are loaded in shear should be hammered only enough to form a small head, and no attempt should be made to form the standard head. The amount of hammering required to form the standard head often causes the rivet to buckle inside the tube. Correct and incorrect examples of this type of rivet application are shown in Figure 22-20.

Attachment of Built-in Fittings

59 Repair structural members, which have built-in fuselage fittings, according to the standard procedures described, or replace the member and reweld the fitting in place, taking care to ensure correct alignment.

Bending of Tubing

60 To bend a tube, cut a length approximately 8 inches longer than the finished size. Drive a wooden plug into one end, pack tightly with fine

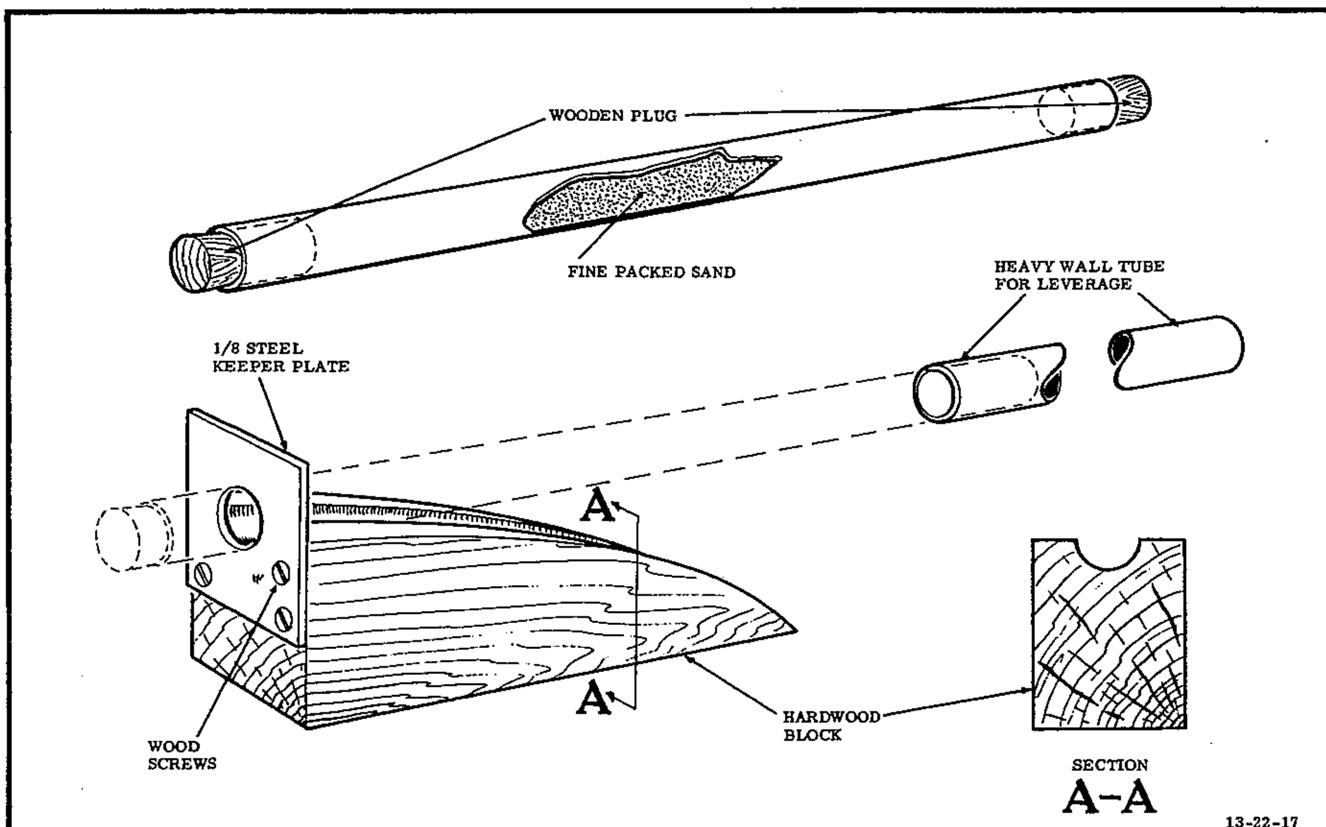


Figure 22-21 Bending Jig for Structural Tubing

sand, and drive a wooden plug into the open end. Make a hardwood bending jig, (see Figure 22-21), somewhat smaller than the required radius of the tube to be bent to allow for spring back. Clamp jig securely in a vise. Insert one end of the tube into the keeper hole, and, with a heavy walled tube slipped over the other end to give added leverage, bend tube around the form. Trim ends to required length and install.

Material Specifications

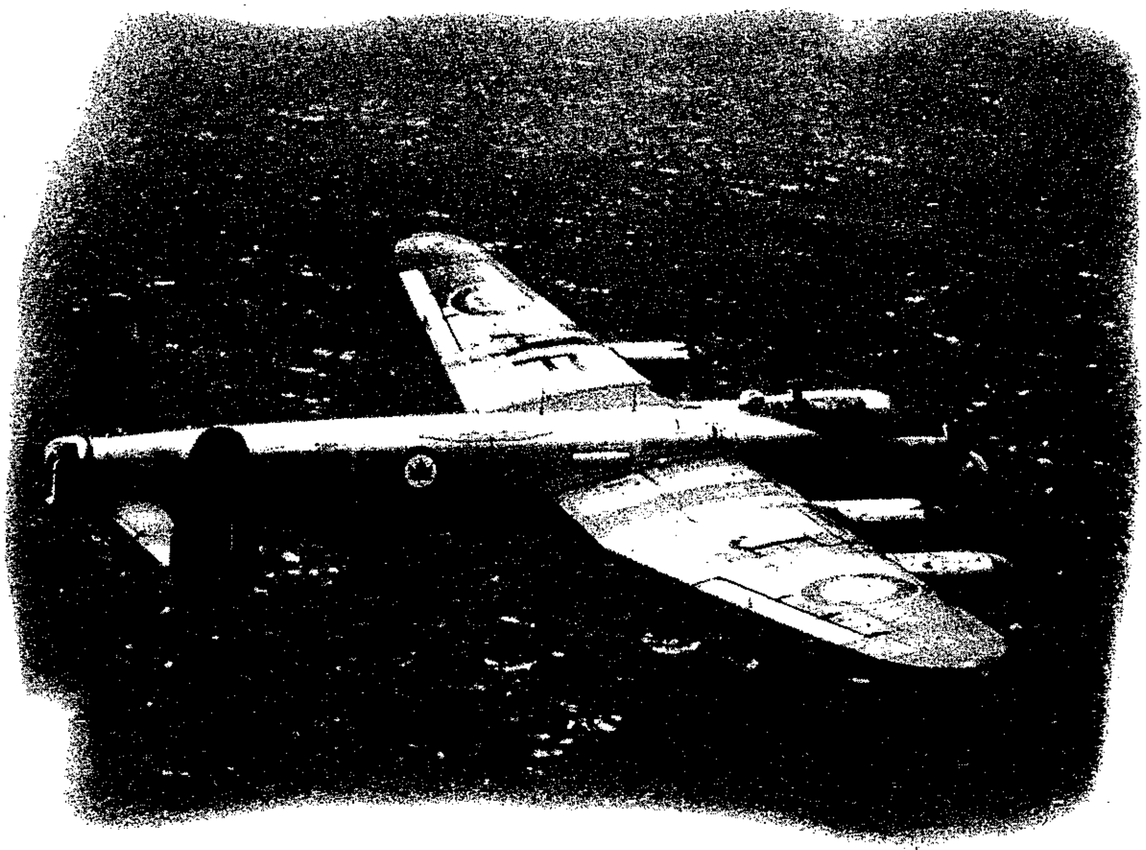
61 For material specifications, item numbers and manufacturers, see Figure 22-22.

1	Asbestos, Sheet	32E/	MIL-A-17472	Commercial Grade
2	Paper, Emery, Fine	29/1834		
3	Sandpaper	29/1868		
4	Acid, Sulphuric	33C/4	15-GP-8a	
5	Acid, Boracic	14B/		Commercial Grade
6	Sodium Chloride	33C/525		Commercial Grade
7	Potassium Carbonate			
8	Colophony			Technical Grade
9	Oil, ME, SAE10W	34A/35	3-GP-45	
10	Talc, Chalk, French	33C/11	MAT-2-1	
11	Soap, Bubble Fluid, Diluted 1 to 10	33C/NIC		B.W.Deane & Co. 3620 Namur St., Montreal

Figure 22-22 Table of Material Specifications

PART 23

ANTI-CORROSION PRECAUTIONS



PART 23

ANTI-CORROSION PRECAUTIONS

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(Continued)

(Continued)

LIST OF ILLUSTRATIONS

PART 23

ANTI-CORROSION PRECAUTIONS

ANTI-CORROSION PRECAUTIONS

General

1 The prevention of corrosion is of primary importance in aircraft maintenance. Corrosion is the oxidation or similar chemical change in the composition of a metal. Removal of dirt is a primary concern, since such accumulations in aircraft crevices absorb moisture which aids corrosion. Moisture-proof joints are important in corrosion control. For aircraft areas most susceptible to corrosion, see Figure 23-1.

Cleanliness

2 The best preventive maintenance is a high standard of cleanliness, combined with immediate action if corrosion is found. Instructions and approved methods for cleaning aircraft as detailed in EO 50-10A-2A are to be followed. Precautions for the use of liquid soap as detailed in EO 50-10-2B are to be adhered to, as too strong a mixture is liable to cause corrosion.

Factors Stimulating Corrosion

3 Atmospheric corrosion is stimulated by a damp atmosphere, since this maintains a film of water on the metal, an essential condition for corrosion. Other factors are oxygen (air) dissolved in this water film; acids or acid gases in the atmosphere, near the gun blast tubes, or batteries; salts that dissociate in water producing an acid reaction; contact of dissimilar metals (electrolytic corrosion); and the presence on the metal of a depolarizing surface, such as mill scale on iron.

Factors Inhibiting Corrosion

4 Factors inhibiting corrosion are the use of a self-sacrificing metal, such as zinc, to protect iron or steel; protective coating, such as aluminum on aluminum alloy; passivating of steels, or so treating them that they are insoluble in acids and do not precipitate metals from solutions; or inducing formation of protective surface films (as of chromate).

Types of Corrosion

5 The four main types of corrosion are:

(a) Intergranular (surface) corrosion.

(b) Intergranular (intercrystalline) corrosion.

(c) Dissimilar metal (electrolytic) corrosion.

(d) Stress corrosion.

6 For complete information regarding methods of recognizing and combating these forms of corrosion, refer to EO 05-1-2AH.

Stress Corrosion

7 The effect of corrosion on a metal while it is under stress is often much more severe than under ordinary conditions. This is particularly true of metal members subjected simultaneously to fatigue stress and corrosion. Under such conditions, the number of stress applications required for failure of the metal is very much less than under non-corrosive conditions. A condition of internal stress may also serve to accentuate the destructive effect of what otherwise would be a mild corrosive attack. For example, hard-drawn brass tubing may crack under the action of relatively light surface corrosion, or the heads of rivets may snap off. Tightly drawn up bolts of non-ferrous metals may behave similarly.

COATINGS

General

8 To prevent surface corrosion of all types of aircraft metals, various finishes are applied as protection. The kind of metal

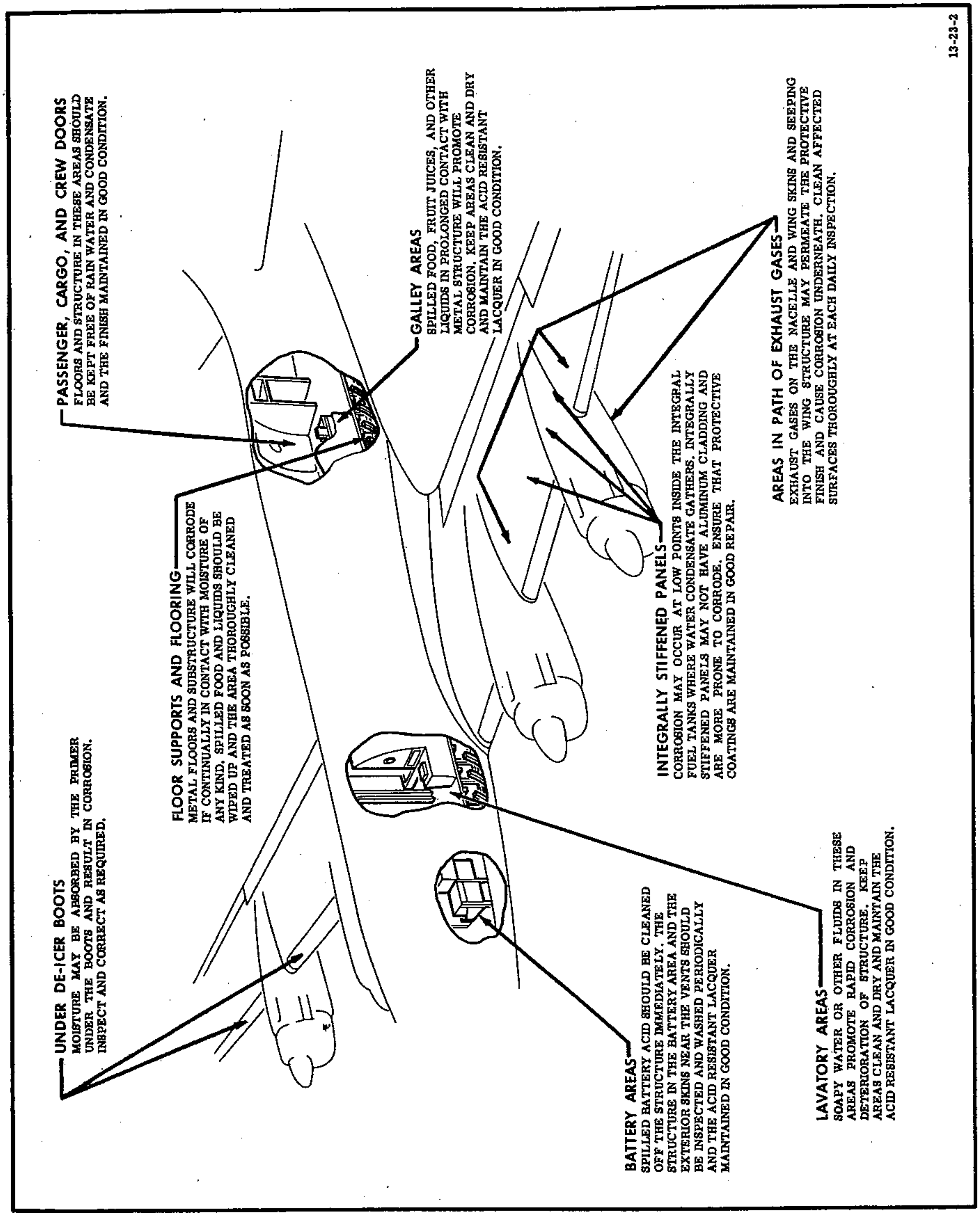


Figure 23-1 Areas most Susceptible to Corrosion

on which the finish is to be applied will determine the type of finish employed. On steel and its alloys several types of finishes are used. On magnesium only a few protective coatings may be applied.

9 The primary purpose of applying protective coatings is to stop corrosion in its first stage. All metal parts must be protected on both internal and external surfaces. Among the types of coating used to protect steel are peelable plastic films, waxes, metallic soaps, paints, lacquers, primers, petroleum-based compounds and metallic films.

Paints

10 Some paints protect the surface of metal by the formation of an impenetrable film, others exert a chemical protective action. Paints serve to protect the surface from dampness, sea water, oxidizing gases, smoke, etc. Periodic inspection of painted surfaces is necessary to check surface cracks, peeling or spalling, which leaves the surface vulnerable to corrosive action.

Metallic Films

11 Metallic coatings may be applied to ferrous metals by dipping parts to be protected into hot baths of the coating metal, by electro-plating from an appropriate solution, by metal spraying or by Sherardizing. The more common methods of hot dipping are galvanizing and tinning. Chromium, nickel, cadmium and copper plating are the more common methods of electroplating. The anodic oxidation process or anodizing is used exclusively for coating aluminum alloys.

Hard Drying Coatings

12 Hard drying coatings are usually employed for semi-permanent coverage of outside steel surfaces. Normally, such materials are either paints or non-oxidizing asphaltic materials. These contain thinners to facilitate application. Upon evaporation of the thinner, a hard, tough surface results which is reasonably resistant to wear and weather. The length of protection afforded by these materials varies widely according to their character and the kind of weather to which the protected surfaces are exposed.

PETROLEUM-BASE PREVENTIVE MATERIALS

General

13 Four types of petroleum-base rust preventive materials are used:

(a) Lubricating oils and greases.

(b) Specially prepared rustproofing oils.

(c) Heavy non-drying compounds.

(d) Hard-drying coatings.

Greases and Oils

14 Lubricating greases and oils are temporary preventatives of corrosion on finished machine parts, tools, etc., while they are being shipped, stored, or otherwise not in service. They are suitable only when the steel is stored in a place where the conditions conducive to rusting are not severe and where the steel is protected against atmospheric condensation due to temperature changes. It is usually true that the heavier the oil, the better the protection, but no straight mineral oil or grease will give long-time rust prevention.

Straight Petroleum Oils

15 These are well-refined lubricating oils containing no fatty oils or other added materials. Either a paraffin or naphthene-base oil can be used with good results. Light oils having a viscosity of from 85 to 250 seconds Saybolt universal at 100°F are used, chiefly for the temporary protection of sheet steel. They furnish good rust protection and lubrication between the sheets in a stack, although they do not give complete protection to the steel against rusting in the presence of moisture. Water will tend to penetrate a straight mineral oil film and cause rusting of the steel beneath, sometimes within a few hours.

Special Rustproofing Oils

16 Many rustproofing oils are composed chiefly of petroleum lubricating oils with or without volatile thinners, to which have been added small amounts of other protective materials. The thinner acts as a solvent to reduce the viscosity and aid in uniformly spreading a thin layer of the rust preventing material.

They are particularly useful when storage conditions are such that steel surfaces are exposed to atmospheric changes but they are not intended for protection under outdoor atmospheric conditions, although the better grades will provide such protection to a limited extent. They will give a long-time protection to steel that is not exposed directly to the elements and they will give much better service in this respect than a straight mineral oil.

Heavy Non-drying Rustproof Compounds

17 These include petroleum compounds which are relatively viscous and non-hardening but which can be applied with a brush or heated for a dipping operation to produce a waterproof film. Some of these materials penetrate beneath existing rust and prevent further deterioration of the metal underneath. Most of them can be readily removed with a solvent, such as kerosene. They are especially suitable for the protection of steel surfaces during storage or shipment under unfavourable weather conditions.

18 Oils and greases may be applied by brushing, dipping, slushing or spraying. During wet-grinding operations, rust-preventative oils should be mixed with cutting fluids to reduce subsequent corrosion.

REFINISHING CORRODED OR REWORKED METAL SURFACES

General

19 Use the following instructions for the refinishing of corroded or reworked metal parts and assemblies. These treatments apply regardless of previous treatment of the part. The finishes specified are to be omitted from metal surfaces forming electrical bonds when such finishes prevent proper electrical bonding.

Procedures for Aluminum

20 The following refinishing procedure applies to aluminum parts, assemblies, etc., which are not subsequently painted and from which the corrosion can be removed, leaving a surface which is practically free from pits or, in the case of clad aluminum materials, the corrosion can be removed leaving a surface in which the pits do not extend beyond the cladding. Refer to Paragraph 21, following.

21 On 2S, 3S, 52S, 61S and clad aluminum alloys, proceed as follows:

(a) Remove any primer or paint from corroded areas in accordance with Part 20, preceding.

(b) Remove any foreign matter (grease, oil, corrosion products, etc.) from the affected area by wiping with cleaner (Item 1), or water, depending upon the nature of the dirt. Remove corrosion products using cleaning compound (Item 2), Bon Ami (Item 3), fine abrasive paper (Item 4) or fine aluminum wool (Item 5).

(c) Brush on a 5% chromic acid solution using a stiff brush. Keep surface of part wet with the solution for two to three minutes.

(d) Rinse by wiping with a water-saturated cloth or by immersing in running water.

(e) Dry with a cloth or with an air blast.

(f) Apply finishes as follows:

(1) For surfaces forming part of the exterior of the aircraft which are not to be painted, no further finish is required.

(2) For surfaces on the interior of the aircraft, for surfaces not normally visible or for surfaces on the exterior of the aircraft which will be painted, coat with zinc chromate primer (Item 7), if not prohibited by the function of the part, and then coat with finish colour, if required.

22 For all other aluminum alloys proceed as follows:

(a) Clean as specified in Paragraph 21, preceding.

(b) If part is not yet assembled or if it can be removed, anodize. (Refer to Paragraphs 127 to 136 inclusive, following.) For parts which cannot be removed, refer to Part 21, preceding.

(c) Coat the entire part with zinc chromate primer (Item 7) except where priming would interfere with the functioning of the part.

Procedure for Ferrous and Copper Alloys

23 For unplated alloys proceed as follows:

(a) Remove any paint in accordance with Part 20, preceding.

(b) Remove grease, oil, etc., in accordance with Part 20, preceding or by wiping with cleaner (Item 1).

(c) Remove corrosion from parts corroded or reworked prior to assembly, as follows:

(1) Copper alloys: Pickle, (refer to Part 20, preceding)

(2) Ferrous alloys: Sandblast or pickle, (refer to Part 20, preceding).

(3) Heat resistant alloys: Pickle, (refer to Part 20, preceding).

(d) Parts found corroded during maintenance checks must be removed whenever possible, and treated as above for unassembled parts. Otherwise, use the following procedure:

(1) Remove primer or paint from affected areas in accordance with Part 20, preceding.

(2) Remove corrosion products using fine abrasive (Item 4), cleaning compound (Item 2) or Bon Ami (Item 3).

(3) No additional finish is required.

24 For cadmium plated alloys, strip parts showing any signs of corrosion and replate, whenever possible, (refer to Paragraphs 31 to 40 inclusive, following). This includes superficial corrosion of the plating as well as corrosion of the base material. Corrosion of the base material is evidenced by the discolouration of the plate (brown or red for steel, bluish-green for copper alloys). If part is superficially corroded (white corrosion products), and it is not desirable to remove or disassemble the part, wash off the affected area,* remove corrosion by using fine abrasive, cleaning compound or Bon Ami, and treat with 5% chromic acid solution (Item 6) for two to three minutes. Wipe dry and coat with two coats of primer and two coats of lacquer (Item 8).

25 For chromium plated alloys from which the plating has been removed or which have corroded due to cracking, breaking or peeling of the chromium plating, strip and replate, (refer to Paragraphs 41 to 52 inclusive, following). Nickel plated parts which have become corroded must be stripped and replated. Nickel plated parts which have become discoloured by heat (typical blue-grey to black colour) should not be considered as corroded and will not normally have to be refinished.

Procedure for Magnesium Alloys

26 For parts corroded or reworked prior to assembly, proceed as follows:

(a) Remover primer or paint, (refer to Part 20, preceding).

(b) Remove corrosion products and apply the proper chemical treatment in accordance with Paragraphs 141 to 146 inclusive, following.

(c) Finish as required by the applicable finish specification.

27 For parts corroded or reworked after assembly, whenever possible remove parts and treat as in Paragraph 26, preceding, for unassembled parts. Otherwise, proceed as follows:

(a) Remove primer or paint from affected areas, (refer to Part 20, preceding), and clean off other foreign matter by wiping with a cloth soaked with water or cleaner.

(b) Remove corrosion products using fine abrasive (Item 4), cleaning compound (Item 2) or Bon Ami (Item 3).

(c) Apply chrome-pickle solution, prepared as described in Paragraphs 147 and 148, following, with a small brush. Apply small amounts of fresh solution continuously until it has been on the surface for two minutes. Avoid an excess of the solution and do not allow it to come into contact with other metals.

(d) Wash surface thoroughly with cloth saturated with water. Do not rub. Make certain that all chrome-pickle solution is removed from cracks, recesses and faying surfaces. Finish reworked surfaces as specified in the applicable finish specification.

PROTECTION OF STEEL TUBULAR MEMBERS AFTER WELDING

General

28 Use the following procedure for the protective treatment of interior surfaces of sealed steel tubular members.

NOTE

This treatment must be performed after all welding is completed.

Treatment

29 Treat sealed tubular members after welding, brazing or heat treatment is completed, as follows:

(a) Heat compound (Item 9), or linseed oil (Item 10), to 160° to 180° F and maintain the temperature.

(b) Apply heated protective material to the interior surfaces of the part by pressure through drilled holes in the member, or, in the case of small parts, by immersing in a bath of the material.

(c) Check the progress of the hot material by its radiation of heat through the exterior surface of the member.

(d) Rotate parts given the immersion treatment in the hot material so that each hole may at some time be uppermost and until bubbles have ceased to rise.

30 For aircraft exposed to sea atmosphere, proceed as follows:

(a) Apply cold corrosion-preventive compound (Item 11) to the interior surfaces of the part by pressure through drilled holes in the member, or, in the case of small parts, by immersing in a bath of the compound.

(b) Ensure that all interior surfaces of the member are thoroughly coated as follows:

(1) Apply the pressure-fed preventive to each drilled hole until the overflow is observed.

(2) Rotate immersed small parts in the preventive so that each hole may at one time be uppermost and until bubbles have ceased to rise.

(c) Seal the drain holes of the pressure-fed members by any convenient temporary method, such as tape or screws, and hold the material within the members for at least two minutes.

(d) Drain the treated parts thoroughly as follows:

(1) Drain large multi-section parts three to four hours with frequent change of position to ensure proper drainage of all low points and pockets.

(2) Small parts must be drained and rotated until all excess material has been removed.

(e) After parts have drained thoroughly, seal drilled holes by inserting a proper sized drive-screw which has been coated with unreduced zinc chromate primer (Item 7). If linseed oil is used as the protective material, use cotton wrapping cord (Item 12) about the drive-screw, in addition to the primer, to obtain a proper seal.

(f) Thoroughly clean the exterior of treated members with a clean cloth moistened with cleaner (Item 1).

(g) Dry surfaces with an air blast or soft cloth.

(h) Refinish as required.

CADMIUM PLATING

General

31 Cadmium plating is an electrical anti-corrosion process, using 6 to 12 volts d.c., by which cadmium is deposited directly on the surface of the material to be protected. Prior to plating, it is essential that the metal to be plated be properly cleaned. The following instructions are to be used as a guide by personnel engaged in cadmium plating.

Plating Tanks and Equipment

32 Ensure the following equipment is available:

(a) Plating tanks made of steel or other authorized materials.

(b) Anodes of the ball or bar type, made of 99.9% (minimum) pure cadmium metal.

Allow approximately 2 pounds of anode per Imperial gallon of solution and locate in accordance with good plating practice.

(c) Rinse tanks, for hot water maintained at 180° to 212°F, and for cold water, of the recirculating type. Maintain a constant supply of clean water.

(d) A voltmeter and an ammeter in the electrical system.

(e) The plating solution at room temperature.

33 The initial make-up of the chromic acid solution is 5% by weight chromic acid (Item 6).

NOTE

When making solutions or adding chemicals to existing solutions, agitate the tank by compressed air until it is certain that the chemicals have been completely dissolved, or as in the case of calcium sulphate, the reaction is complete.

Cleaning of Parts

34 Clean parts prior to plating as follows:

(a) Clean by vapour degreasing, or with alkaline cleaner followed by rinsing in cold water, (refer to Part 20, preceding).

(b) Where parts are welded, scaled or corroded, follow with acid pickling and rinsing in cold water or sandblasting using a fine grit, (refer to Part 20, preceding).

(c) Remove any firmly adhering dirt by scrubbing with powder (Item 3) and rinsing in hot water.

(d) Before replating, reclean parts after stripping previous cadmium plate.

Masking

35 Mask parts to be selectively plated as follows:

(a) Clean in accordance with Paragraph 34, preceding, and coat areas of parts which are to remain unplated with stop-off lacquer (Item 14). Apply a sufficient number of coats of the lacquer to ensure adequate stop-off protection. Masking tape (Item 15) may be wrapped around the area to be protected and the lacquer applied to cover the tape completely and overlap onto the part.

(b) Avoid all fingermarks and other contamination of the surface of the part when applying the lacquer.

(c) Allow the lacquer to dry, then reclean with alkaline cleaner, (refer to Part 20, preceding), and rinse in cold water. Do not use vapour degreasing on parts coated with the lacquer.

Thickness of Plating

36 The thickness of the cadmium deposit must not be less than .0003 inch nor more than .0010 inch, except as follows or where otherwise shown by drawing:

(a) The thickness of the cadmium deposit on externally threaded parts must not be less than 0002 inch, except where otherwise shown by drawing.

(b) Parts whose dimensional tolerances do not permit .0003 inch are to be given the maximum thickness of plating compatible with dimensional tolerances.

(c) Holes, recesses, internal threads and other areas where a controlled deposit cannot be normally obtained and which cannot be touched by a sphere 3/4 inch in diameter are not subject to a thickness requirement.

Plating

37 When plating, proceed as follows:

NOTE

Parts must be plated as soon as possible after completion of cleaning.

(a) Immerse the parts as cathodes in the plating tank and plate for a time and at a current density and voltage consistent with good plating practice.

(b) Rinse in cold water. Make sure that residue from the plating solution is thoroughly washed out of recesses and the inside of hollow parts.

(c) Immerse all parts in the chromic acid solution (refer to Paragraph 33, preceding) at room temperature for 2 to 3 minutes.

(d) Rinse in hot water.

(e) Dry in air blast.

(f) Remove the stop-off lacquer from masked parts by mechanical action or with thinner (Item 16).

(g) Apply cadmium plating last to parts which are to be both chromium and cadmium plated.

Baking of Parts after Plating

38 For baking of parts after plating, refer to Paragraphs 63 to 68 inclusive, following.

Stripping of Cadmium Plate

39 When it is required to strip cadmium plate, immerse the parts in a solution of 1.2 pounds per Imperial gallon of ammonium nitrate (Item 17), until the cadmium is removed, then rinse in cold water.

Quality of Plating

40 Inspect plating as follows:

(a) The surface of parts prior to plating must be reasonably smooth and free from irregularities.

(b) After plating, the deposit of cadmium must be smooth, fine grained, adherent and free from blisters, pits, nodules, burning, discolouration and other defects.

(c) Superficial staining resulting from rinsing and slight discolouration resulting from baking are not cause for rejection

HARD CHROME PLATING

General

41 The following information and procedure is to be used for the hard chrome plating of steel and copper alloys.

Types of Plating

42 Chrome plating consists of two types; Type 1, used for decorative purposes only and commonly known as flash plating, and Type 2, classes A and B. Class A plating is performed on parts to the finish dimension, and requires no subsequent grinding operation. Class B plating is performed when it is intended to plate oversize and grind the part to the finish dimension after plating. Unless otherwise noted on the drawing, the minimum plating thickness after grinding must be 0.002 inches.

Plating Tanks and Equipment

43 Prior to plating ensure that the following equipment is available:

(a) Rinse tanks constructed of mild steel, of the recirculating type, to maintain a constant supply of clean water.

(b) Earthenware crocks to contain the bright dip and hydrochloric acid solutions.

(c) Plating tanks made of steel or other approved materials.

(d) Heating and cooling coils, anodes and linings of plating tanks made of lead containing 7% tin or of an approved synthetic organic material.

(e) The number and location of anodes required in plating tanks consistent with good plating practice. Conforming anodes are required for plating parts on which significant surfaces would not otherwise receive an adequate and uniform deposit.

(f) Facilities for agitation of the electrolyte by means of compressed air.

(g) Connectors for suspending parts from bus bars, made of aluminum or copper, and of such a size that they do not overheat during plating.

(h) A reversible electric circuit through the plating tank.

(j) Control equipment consisting of a voltmeter, an ammeter and, for the heating and cooling system, an automatic means of controlling the temperature of the electrolyte within the specified limits.

Preparation of Plating Solution

44 To prepare the plating solution, proceed as follows:

(a) Fill the clean tank to approximately two-thirds of its capacity with water and heat to about 125°F.

(b) Add, in small portions and with vigorous stirring, 2.7 pounds of compound (Item 18) for each Imperial gallon of final solution. Air agitation and/or paddles may be used for stirring while the solids are added but stirring must be continuous to prevent caking of the material on the bottom of the tank.

(c) While adding the compound, add the balance of the water needed to bring the solution to the working level and continue heating to maintain the solution temperature at 125°F.

(d) Stir the solution for a minimum of six hours to make sure that the compound is properly dissolved. Note that the compound does not dissolve completely. A small residue will remain undissolved and should be left in the tank.

(e) Near the end of the stirring period, raise the temperature of the solution to 150°F, while stirring is continued. After the temperature has reached 150°F, it should be reduced to the normal operating temperature, 125° (±5°)F.

Bright Dip Solution

45 Make bright dip solution as follows:

Sulphuric acid (Item 19)	45.0% by volume
Nitric acid (Item 20)	7.0% by volume
Hydrochloric acid (Item 21)	0.5% by volume
Water	47.5% by volume

Cleaning of Ferrous Alloy Parts Prior to Plating

46 To clean ferrous alloy parts prior to plating proceed as follows:

(a) Clean by vapour degreasing, or with alkaline cleaner followed by rinsing in cold water, in accordance with Part 20, preceding.

(b) Where parts are corroded or scaled, follow with acid pickling and rinse thoroughly in cold water in accordance with Part 20, preceding. If closely dimensioned areas are involved, treat such areas so that the dimensions are not appreciably affected.

(c) Remove adhering dirt by scrubbing with Bon Ami (Item 3). Corrosion and surface oxidation may be mechanically removed by buffing or by scrubbing. Following either of these operations, rinse the parts in hot water.

(d) Electroclean as instructed in Part 20, preceding, and rinse in hot water.

(e) When required, parts may be dipped for a maximum of 30 seconds in a 50% (by volume) solution of hydrochloric acid (Item 21) to remove any superficial oxidation. Parts must then be rinsed in cold water.

(f) Parts which are to be replated over an existing plating of chromium, or after stripping, must be subjected to the complete cleaning cycle before replating.

Cleaning of Copper Alloy Parts

47 To clean copper alloy parts, proceed as follows:

(a) Clean by vapour degreasing. (Refer to Part 20, preceding.)

(b) Remove surface oxidation and tarnish by buffing.

(c) Rinse in cold water.

(d) Immerse for not more than 30 seconds in bright dip solution (refer to Paragraph 45, preceding). The part must be uniformly bright on withdrawal from the bright dip solution.

(e) Rinse in cold water.

Masking of Parts

48 To mask parts, proceed as follows:

(a) Clean parts as instructed in Paragraph 46, preceding, for ferrous alloy and Paragraph 47, preceding, for copper alloys.

(b) Apply sufficient coats of lacquer (Item 22) to ensure adequate stop-off protection.

Masking tape (Item 15) may be wrapped around the area to be masked before applying lacquer.

(c) Avoid contamination of the surface of the part to be plated when applying the lacquer.

(d) Allow the lacquer to dry and reclean as follows:

(1) Clean ferrous alloys with alkaline cleaner, rinse in cold water and follow with electrocleaning. (Refer to Part 20, preceding.)

(2) Clean unmasked areas of copper alloys with a cloth dampened with thinners (Item 16) then immerse part in bright dip solution, (refer to Paragraph 45, preceding).

Plating Procedure

49 Immediately following cleaning and without drying, proceed as follows:

(a) Immerse parts in the plating tank and allow to reach bath temperature.

(b) Reverse etch ferrous alloy parts only by making parts anodes in the plating tank and applying a voltage of 4 to 6 volts for 1 minute at a current density of 3 amperes per square inch. Do not subject copper alloy parts to this reverse current treatment.

(c) With parts as cathodes, plate to the required thickness. Maintain the current density at 3 amperes per square inch. At 3 amperes per square inch, approximately 0.0020 inch of chromium plate should be deposited per hour.

(d) If ferrous alloy parts are removed from the plating tank after the start of the plating operation for thickness measurements or for any other reason, reverse the current for one minute when the parts are replaced in the plating solution before continuing the plating.

(e) Rinse parts in hot water, (180° to 212°F).

(f) Dry with an air blast.

NOTE

For parts which are to be both chromium and cadmium plated, apply the chromium plating first.

Treatment after Plating

50 To treat after plating, proceed as follows:

(a) Remove stop-off lacquer from selectively plated parts by mechanical action or by means of thinners if lacquer (Item 22) has been used.

(b) For parts requiring baking after chromium plating for the relief of hydrogen embrittlement, refer to Paragraph 64, following. Bake such parts as specified.

Stripping of Chromium Plate

51 When stripping of chromium plate is required, mask off unplated areas of selectively plated parts prior to immersion in the stripping solution and proceed as follows:

(a) Immerse the parts in a 20% (by volume) solution of hydrochloric acid (Item 21) until the chromium is removed. Rinse thoroughly in cold water. Do not leave parts in stripping solution longer than necessary to remove plate.

(b) Examine parts frequently during the stripping to ensure that they do not remain in the solution longer than the time required for complete stripping.

Quality of Plating

52 The surface finish of parts prior to plating must be reasonably smooth and free from irregularities detrimental to the final finish. After plating, all classes and types of chromium deposits must be smooth and free from frosty areas, indications of burning, pits and nodules. Type 1 deposits must be bright. When only a portion of a part is plated, the deposit must be so finished that the plated area blends smoothly with the adjacent unplated area. Where possible, check the thickness of chromium deposit on Type 2 plated parts by micrometer or other approved methods.

ZINC PLATING

General

53 Though cadmium is definitely superior in some respects to zinc, tests have shown that zinc coatings are as good as cadmium coatings of equal thickness as a protection against exposure to weather in industrial, rural, suburban and sea coast atmospheres.

Restrictions Governing the Use of Zinc Plating

54 Zinc plating may be substituted for cadmium plating with the following exceptions:

(a) Since zinc is not as corrosion resistant as cadmium in the presence of salt water, all parts subject to salt spray or salt water must be cadmium plated.

(b) When zinc is in contact with steel at high temperatures and subject to stress or vibration, the steel tends to crack. In the case of exhaust manifolds this is likely to cause failure of the part. All brackets, fittings and hardware in contact with exhaust manifolds or other parts subject to high temperature must be cadmium plated.

(c) All nuts and bolts of corrodible steel must be cadmium plated.

(d) Where electrical grounding is involved, zinc may not make a satisfactory substitute for cadmium, since the electrical contact resistance of a zinc plated surface is higher than that of a cadmium plated surface. Lead plating is satisfactory in this respect, but lead should not be used in contact with aluminum, magnesium or zinc. Substitution of either lead or zinc for cadmium, in applications involving electrical grounding, must be approved by engineering authority.

(e) Parts such as springs, lock washers etc., made of high or medium carbon steel and subject to appreciable alternating stress in service, must be cadmium plated. The zinc plating process often causes hydrogen embrittlement which results in breaking of the part under repeated stress.

(f) Zinc plating is unsatisfactory in applications where the white corrosion products which may be formed from zinc coatings may interfere with the normal functioning of the part, or affect adjacent parts such as magneto and carburettor parts. Where such corrosion products might be a detriment to the normal operation of the part, zinc plating may only be used at the discretion of engineering authority.

55 Providing the restrictions in Paragraph 54, preceding, are adhered to, zinc plating may be substituted for cadmium plating without further engineering authority. It should be noted, however, that the tolerance on zinc plating must conform to that specified for the original cadmium plating.

Procedure

56 Parts are zinc plated by dipping them in molten zinc maintained at a temperature between 800° and 925°F.

Other Coatings

57 The following anti-corrosion processes are included for information purposes and are not to be used except with engineering authority:

(a) Sherardizing: Parts are Sherardized by heating them in an atmosphere of zinc powder. The zinc combines with the surface of the metal part to increase its hardness, durability and corrosion resistance. The process is carried out by heating the parts in a closed, rotating chamber containing zinc powder at a temperature of about 700°F. Sherardizing is not considered to be as effective as zinc or cadmium plating.

(b) Parkerizing: Parkerizing consists of heating the parts to be treated in a bath of dilute iron phosphate. The bath is kept at about 190°F by means of steam coils. When the work is immersed, a rapid stream of bubbles passes off for a period of 30 to 45 minutes. When the bubbles stop, the coating process is complete. The coating left on the treated part is a basic ferrous-ferric phosphate. The surface is dull grey in colour and turns to a deep black after it is coated with paraffin oil. This process has the added advantage of coating the inside of tubular members which cannot be done by any electroplating process. This property is particularly important for seaplanes where moisture is frequently trapped in crevices or inside tubular members.

(c) Bonderizing: Bonderizing is the same as Parkerizing, except for the addition of reagents to the bath to speed up the reaction. The process is completed in from three to five minutes by this method. Bonderizing has the same characteristics as Parkerizing with reference to paint adherence and penetration in crevices. Neither of these coatings is very corrosion resistant in itself but either is quite satisfactory when painted. These and similiar processes are frequently referred to as compound phosphate rust-proofing.

PHOSPHATE TREATMENT

General

58 The following procedure for phosphate treatment is to be used only where required by engineering drawings or modifications, finish specifications, and in the Electrofilm dry lubricant process. Parts fabricated from aluminum, magnesium and copper alloys and parts having soft soldered joints must not be phosphate treated.

NOTE

On brazed assemblies, where only the brazed joint is of copper alloy, perform brazing and welding operations prior to phosphate treatment.

Solutions Required

59 The following solutions are required for the phosphate treatment:

(a) Mild alkaline cleaner, (refer to Part 20, preceding).

(b) Vapour degreasing liquid, (refer to Part 20, preceding).

(c) Phosphate treatment liquid, containing 3.5 Imperial gallons of compound (Item 23) to 100 Imperial gallons of water.

(d) Chromic acid dip solution containing 0.100 to 0.125 ounces of chromic acid (Item 6) per gallon of solution.

(e) Stripping solution consisting of 50% (by volume) hydrochloric acid (Item 21) and 50% water.

Types of Phosphate Treatment

60 There are two types of phosphate treatment; one providing resistance to abrasion and the other protection against corrosion. For abrasion resistance type of protection, proceed as follows:

(a) Clean the parts by either a mild alkaline immersion of 5 to 7 minutes at 180° to 212°F and rinse in cold water, or vapour degrease by an immersion of 2 to 5 minutes at 180° to 195°F.

(b) Immerse the parts in the phosphate treatment liquid for 10 minutes at 190° to 210°F.

(c) Rinse the parts in cold water for 2 minutes.

(d) Immerse the parts in chromic acid solution for 1 minute at 180°F.

(e) Rinse the parts in hot water (160°F minimum) until they come up to the temperature of the water.

(f) Bake those parts requiring hydrogen embrittlement relief, (refer to Paragraphs 63 to 68 inclusive, following). Parts requiring more than one plating operation, such as cadmium plating followed by phosphate treatment, are to be baked only after the final plating.

(g) Finish the parts by coating completely with oil (Item 57).

61 For corrosion protection, proceed as follows:

(a) Clean the parts. (Refer to Paragraph 60 (a), preceding.)

(b) Immerse the parts in the phosphate treatment liquid for 30 minutes minimum at 190° to 210°F.

(c) Rinse the parts in cold water for 2 minutes.

(d) Immerse the parts in chromic acid solution for 1 minute at 180°F.

(e) Rinse the parts in hot water (160°F minimum) until they come up to the temperature of the water.

(f) Bake parts requiring hydrogen embrittlement relief, (refer to Paragraph 60 (f) preceding.

(g) Finish the parts with primer (Item 7) or coat with compound (Item 9) as required by the applicable finish specification.

Stripping

62 When required, the phosphate coat may be stripped by immersion in the stripping solution (Item 21) at room temperature. The

parts are then rinsed in cold water. Parts must not be left in the stripping solution longer than necessary to remove the phosphate coating, since the solution will readily attack bare metal, as well as dissolving cadmium and zinc plating.

BAKING OF STEEL FOR RELIEF OF HYDROGEN EMBRITTLEMENT

General

63 Steels in the heat treated or cold worked condition are susceptible to embrittlement by hydrogen and resultant cracking, as a consequence of pickling, electrocleaning and electroplating. The following instructions cover the procedure to be used for the baking of carbon steels (e.g. SAE 1045, SAE 1060, SAE 1095, etc.), alloy steels (e.g. SAE 4130, SAE 4340, SAE 6150, NE 8630, NE 8740 etc.) and heat treatable corrosion resistant steels (e.g. AISI 410, AISI 416, AISI 420, AISI 501, etc.), but are not applicable to non-heat treatable corrosion resistant steels (e.g. AISI 302, AISI 321, AISI 347, AISI 405, AISI 430, etc.).

Parts Requiring Baking

64 The following classes of low alloy and corrosion resistant steel parts must be baked for relief of hydrogen embrittlement:

(a) All parts heat treated to 160,000 psi, (Rockwell C-36) and over.

(b) All springs.

(c) All parts which have been shot peened for increase of fatigue resistance.

Processes after which Baking is Required

65 Baking for relief of hydrogen embrittlement is carried out on the classes of parts referred to in Paragraph 64 preceding, at the following times:

(a) After cadmium plating.

(b) After hard chromium plating.

(c) After hard nickel plating.

(d) After phosphate treating.

(e) After pickling (sulphuric and hydrochloric acid mixture for non-corrosion resistant steels, nitric and hydrofluoric acid mixture for corrosion resistant steels).

(f) After electrocleaning.

66 Parts, on which more than one of the above processes are required (e.g. pickling, followed by cadmium plating), are to be baked once only after the final operation.

Procedure

67 Baking for relief of hydrogen embrittlement consists of heating the parts to the proper temperature and soaking for the following periods:

(a) All except soft soldered parts: 3 hours minimum at 375° (±25°) F.

(b) Soft soldered parts: 5 hours minimum at 325° (±25°) F.

68 Do not flex or otherwise stress parts, such as springs, between the commencement of the first operation which induces hydrogen embrittlement and the completion of the baking operation. Where the baking temperatures would influence the previous heat treatment of a part, (i.e., reduce its physical properties, such as in the case of carburized parts, where the baking temperature may be equal to or above the tempering temperature), refer to engineering authority for instructions.

METAL SPRAYING

General

69 The following instructions present general requirements for the apparatus, material and procedure to be used in metal spraying of aircraft parts for protection against corrosion and for building up worn metal surfaces. The information is applicable to metal spraying as performed with coating material in wire or powder form.

Equipment

70 The apparatus consists of a metal spray gun, air cleaner and equipment for preparation of surfaces for metal spraying, as follows:

(a) The metal spray gun is provided with two-stage oxygen and acetylene regulators capable of maintaining uniform delivery pressures at any dial setting in the pressure range from 5 to 50 psi, and is equipped with accurate indicating pressure gauges.

(b) An oil and water extractor must be used in the air line to the metal spray gun in order to ensure clean, dry air.

(c) Suitable operations must be performed to ensure proper cleaning and surface preparation of the part to be sprayed.

Preparation of Parts

71 Perform all welding operations, if required, prior to metal spraying. Prepare surfaces to be sprayed with metal by removing all foreign material and corrosion products, then roughening by sand blasting, machine tool operation, electric bonding or combination of these methods.

72 Undercut by machining, if necessary, the worn surfaces of bearing journals to be repaired or build up by metal spraying to provide a thickness of deposited metal after finishing or fitting, not less than the minimum thickness shown in Figure 23-2. The undercut section should extend 1/4 inch or more beyond the bearing area whenever practicable, and the ends cut at acute angles so that the deposited coating will be dovetailed or keyed to the shaft or journal. The undercut section must be degreased prior to roughening.

73 If practicable, roughen worn journals and bearing surfaces by cutting spiral or annular grooves in the undercut section and spreading and roughening the ridges or lands thus produced with a rotary roughening tool.

Blasting

74 Roughen surfaces to be metal sprayed for corrosion prevention by suction or direct pressure blasting, using one of the abrasives listed in Paragraph 75, following. Hold the blast nozzle approximately eight inches from and perpendicular to the work being blasted.

Materials

75 The following materials are recommended:

(a) Sand (item 24), a hard silica type, jagged or angular, of approximately 40 mesh, for corrosion prevention coatings. The sand must be washed and dry, and is not to be re-used without screening to remove fine particles. Sand which has been used for blasting any other group of metals must not be re-used for blasting light alloys such as aluminum and magnesium, or corrosion resisting alloys such as stainless steel and inconel.

(b) Silicon carbide and aluminum oxide (Item 25) types of non-metallic abrasives with good cleavage fracture properties and of approximately 40 mesh for corrosion prevention applications can be used. The preceding re-use restrictions apply.

Scale Removal

76 Remove heavy scale from steel parts by directing the blast nozzle at an angle of about 40° to the work. After the scale has been removed, roughen the work by blasting with the nozzle perpendicular to the work surface.

Pressure and Time

77 The operating pressure and blasting time required for roughening vary with the type of equipment and abrasive used, the material being roughened and the degree of anchorage required. Exercise caution in selection of blasting pressure and time to prevent excessive

Diameter of Shaft	Minimum Thickness of Deposit Metal After Finishing		
	Reciprocating Rods and Light Duty Journals, etc.	Heavy Duty Journals Crankshaft, etc.	Press Fits
Less than 3	.030	.040	.020
3 to 6	.040	.050	.030
Over 6	.050	.060	.040

Figure 23-2
Minimum Thickness of Deposited Metal

dimensional loss and warping of the work, especially when structural parts, thin sections and soft materials are involved.

NOTE

Keep the surface absolutely clean. Handle only with gloved hands or by means of suitable holding devices. After a surface has been prepared, apply metal coat as soon as possible to avoid contamination.

Coating Metal Surfaces

78 In coating metal surfaces, proceed as follows:

(a) Hold the spray gun 4 to 6 inches away from the surface and as nearly perpendicular to the surface as possible. The gun nozzle must not be held at an angle less than 45° to the surface as the fine particles will have a tendency to glide over rather than adhere to the surface.

(b) As the gun is passed over a surface, a ribbon of metal is deposited which is heaviest at the centre and tapers off to nothing at the edge. In order to apply a coating which is sufficiently level, lap each ribbon over the adjacent ribbon by approximately one-third the ribbon width

(c) In applying several layers on sheet stock, deposit each successive coating at right angles to the preceding coating, thus forming a criss-cross coating.

(d) The determination of the speed of moving the gun back and forth across the surface depends on the operator. Move the gun fast enough to ensure against depositing an excessively heavy coating but slow enough to permit covering the entire surface.

(e) Worn spindles can best be built up by revolving in a lathe while spraying. Spray the ends of the undercut section first, with the gun nozzle held at approximately 45° to the work. Make sufficient passes in each direction to ensure thorough keying of the sprayed coating into the dovetail of each groove. Thereafter, mount the gun on the tool post perpendicular to the work and continue spraying. Speeds of approximately 50 surface feet per minute and feeds of about 1/16 inch per revolution are preferred.

Quality

79 The sprayed coating must be of fine texture and free of non-atomized particles of metal. Sprayed aluminum coatings of 0.002 to 0.004 inch thickness give satisfactory coverage and protection on aluminum alloy. Aluminum coatings thicker than 0.004 inch may flake when applied to aluminum alloy. Heavier coatings may be used on steel since better anchorage is obtained on steel than on aluminum alloy.

Treatment after Spraying

80 After metal spraying has been applied to a localized area, rub the surrounding edges lightly with a suitable abrasive to remove any metal spray adhering outside of the sandblasted area.

Potassium Dichromate Treatment

81 Whenever possible, steel structural parts which have been spray coated with aluminum alloy, and which are not to be primed, are to be boiled for 30 minutes in a 15% solution of potassium dichromate (Item 26), to increase the resistance to corrosion. After boiling, rinse all parts thoroughly in fresh water and dry. This treatment is not to be applied to sprayed engine cylinders.

Safety Precaution

82 Always wear a force-feed spray mask of an approved type when spraying zinc, cadmium, lead or when sandblasting. The toxic effect of zinc fumes is of a temporary nature but fumes of cadmium and lead are cumulative and are fully as dangerous as silica dust. The toxic effects of aluminum are considered to be negative, but all processing is to be done in a well-ventilated space and the breathing of any fumes in the concentrated form must be avoided.

Inspection

83 Make a visual examination of the processed surface for complete and uniform coverage. The coating must be free from defects such as cracks, porosity and lack of fusion. It must have the appearance of having a uniformly and finely divided grain structure with no evidence of non-atomized or unmelted particles.

84 The operating temperature of light metals is satisfactory if the operator can hold the back of his hand against the work for ten seconds. If he cannot, the work is overheated and should be allowed to cool before proceeding.

Coating Materials

85 Coating materials in the following forms are generally employed with the metal spray gun:

(a) Wire, of aluminum, babbit, brass, bronze, cadmium, copper, low carbon, high carbon and corrosion resisting steel, lead, nickel, tin and zinc Specification AN-W-20. Both .125 inch and .091 inch diameter wires are standard. When ordering replacement wires for spraying, it is necessary to order the size specified for the particular type of gun, as maximum gun efficiency is obtainable only when the correct size wire is used.

(b) Metallic powders are also employed in the spray gun, as follows:

Metal	Nominal Mesh
Aluminum	300
Zinc	300
Brass	150
Copper	300
Bronze	300
Tin	150
Lead	200
Nickel	300

NOTE

To eliminate foreign matter or large particles, metallic powder must be sifted through an 80 mesh screen.

USE OF METAL PUTTY

General

86 Metal putty may be used to restore damaged surfaces to their original aerodynamic smoothness and to reduce the probability of corrosion which may develop in the presence of surface dents and scratches.

Cleaning of Damaged Areas

87 Strip paint, if present, thoroughly with paint remover (Item 28). Clean all areas thoroughly by hand with mops, cloths and brushes in accordance with EO 05-10A-2A.

Repair of Damage

88 Remove ridges raised by scratches by wet or dry sanding with abrasive paper (Item 4). Clean and degrease scratches and dents with paint thinner (Item 28) before filling. The surfaces must be thoroughly dry before proceeding. Use metal putty (Item 27 or 29) to fill the scratches and dents found in the following surface areas:

(a) Leading edges and upper and lower surfaces of mainplanes, horizontal stabilizers and fins, back to a distance equal to one third of the chord.

(b) Ailerons, leading edges only.

(c) Any surface area for improved appearance.

Application

89 Apply the filler with a putty knife in thin coats (a minimum of four layers) to allow the solvent to evaporate. Allow three hours drying between coats. The fill, when complete and dry, should be slightly higher than the metal surface. Rub down and feather to the surface contour by wet sanding with abrasive paper, using plenty of water.

90 Refinish, if required, by etching, priming and lacquering.

NOTE

Because of a short shelf life of ninety days, metal putty (Item 27 or 29) is not stocked but must be purchased LPO by units as required.

CORROSION OF ALUMINUM AND ITS ALLOYS

General

91 Aluminum alloys have the advantage of superior resistance to corrosion. This is due to a thin protective film of aluminum oxide that is always present and which reforms rapidly if broken. There are a few media which have destructive action on this oxide film and against which protective measures must be taken. Processes have been developed for thickening this film artificially.

92 As a class, halides are more corrosive than nitrates or sulphates in contact with aluminum and its alloys. Heavy metals such as copper, lead, cobalt, nickel, etc., are usually deleterious to aluminum. As with other metals, an increase in temperature usually has the effect of reducing corrosion resistance. When aluminum alloy is coupled to a dissimilar metal of less positive potential such as copper, iron, nickel, lead, etc., (see Figure 23-3), there is a hazard of galvanic (electrolytic) corrosion accelerating the deterioration of the alloy depending on the environment. Very high purity aluminum (99.99% minimum aluminum) is extremely resistant to corrosion either by pitting or general surface attack, and is mainly used as a high purity cladding material.

Evaluation of Corrosion

93 In evaluating corrosion, allowance must be made for the type of corrosion encountered. If corrosion is uniform, weight loss in a convenient measurement when translated into thickness loss. If pitting occurs, the depth of penetration should be determined. If intergranular corrosion develops, measure the tensile properties. If the equipment is subjected to stress and minimum mechanical properties are required, tensile losses should be used as a criterion of corrosion.

Types of Corrosion

94 Types of corrosion are as follows:

(a) Uniform surface attack, which is a general deterioration of the whole surface. This occurs when the oxide film is dissolved and the metal exposed.

(b) Pitting, which is a more damaging form of corrosion is frequently associated with halogens and heavy metal salts. It can often be prevented by the use of inhibitors or cathodic protection.

(c) Galvanic corrosion, which will occur when aluminum is in electrical contact with a more noble dissimilar metal, (see Figure 23-3). This type of corrosion is eliminated by proper selection of metals placed in contact, by insulation, cathodic protection, and by control of the area exposed.

(d) Crevice corrosion is liable to occur in joint crevices between two pieces of one metal, and most likely between dissimilar metals. Crevices are to be avoided in original design.

Grouping of Metals			
I	II	III	IV
Magnesium alloys	Cadmium, Zinc, Aluminum and their alloys,	Iron, Lead and Tin and their alloys (except stainless steels)	Copper, Chromium Nickel, Silver, Gold, Platinum, Titanium, Cobalt, Rhodium and their alloys, Stainless Steels, and Graphite

NOTE

The metals shown are those on the surface of the part, e.g. zinc includes zinc casting, zinc coated, zinc hot dip or zinc metal sprayed parts.

Figure 23-3 Insulation of Dissimilar Metals

(1) Aluminum & Alloys (2S, 3S, 4S, 51S, 53S, 61S Clad coated, sheet forms, and 43S cast form.)

(2) Aluminum Alloys (Alloys of all forms other than specified above.) (The heat treated alloys.)

(3) Magnesium Alloys.

(4) Plated Steel, Copper & Alloys (Brass, Bronze etc.)

(5) Unplated Steel (Including the various blackening treatments such as parkerizing, bonderizing etc.)

(6) Unplated Copper & Alloys (Brass, Bronze, etc.)

(7) Corrosion-Resistant Metals (18-8, Monel, Inconel, etc.)

(8) Lead

(9) Wood

(10) Plastics (Plexiglas, Tenite, Micarta, Bakelite, etc.)

(11) Fabric

(12) Rubber & Synthetics Nycar Neoprene Thiokol.

Contact Surfaces	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Aluminum & Alloys	D											
Aluminum Alloys	D	D										
Magnesium Alloys	G	G	A									
Plated Steel, Copper & Alloys	C	C	G	A								
Unplated Steel	C	C	G	F	D							
Unplated Copper & Alloys	C	C	G	A	D	D						
Corrosion-Resistant Metals	C	C	G	A	F	F	A					
Lead	C	C	G	A	F	F	A	A				
Wood	E	E	G	A	E	E	A	A	A			
Plastics	E	E	A	A	E	E	A	A	A	A		
Fabric	B	B	A	A	E	E	A	A	A	A	A	
Rubber & Synthetics	E	E	A	A	E	E	A	A	A	A	A	A

(A) No additional protection, other than original finishes.

(B) No additional protection, unless contacting surfaces are on exterior surfaces, when the metal surface receives two coats of primer, (Item 7) the fabric none.

(C) Each surface to receive two coats of primer. If possible, apply primer (Item 7) before assembly, squeeze out and wipe away excess primer, leaving a fillet. Otherwise, apply a fillet all around the assembly.

D) Each surface should receive two coats of primer.

(E) The metallic surface should receive two coats of primer, the other surface none, except wood which should receive one coat of varnish (Item 30).

9f0 The unplated metallic surface should receive two coats, the other surface none.

(G) The magnesium needs no additional protection. The other surface should receive two coats of primer, applied as in C, except in the case of wood, which should receive two coats of varnish (Item 30).

Note:
The term coat means one sprayed box coat, (a vertical and a horizontal pass with the spray gun). A brush application can build up sufficient film thickness to equal these two sprayed coats.

Figure 23-4 Recommended Protective Treatment for Material Combinations

(e) Intergranular corrosion is a type of corrosion which occurs only with heat treatable alloys and usually only when they have been incorrectly fabricated. (Refer to EO 05-1-2AH.)

Protection and Maintenance

95 Protection and maintenance begins with the design of the equipment but continual surveillance, cleanliness and the use of approved cleaning mixtures are necessary for trouble-free equipment.

Protective Coatings

96 Protective coatings for aluminum are:

(a) Paints, lacquers and varnishes

(b) Chemical

(c) Electrochemical

(d) Electroplated

(e) Alcladding

INSULATION OF DISSIMILAR METALS

Insulation of Magnesium Alloys

97 Contacts between magnesium alloys and other metals must be insulated by applying a total of two coats of zinc chromate primer (Item 7) to each surface. Where it is necessary to omit or remove paint coatings from magnesium alloy in contact with dissimilar metals for the purpose of electrical contact, separate the dissimilar metal contact by installing a shim of 2S, 52S or 53S aluminum alloy not greater than .016 inch thick.

Insulation of other Dissimilar Metals

98 To the faying or contacting surfaces of dissimilar metals in Groups II, III and IV, (see Figure 23-3), apply one additional coat of zinc chromate primer on each surface. It is emphasized that this requirement applies to metals in Group IV, including stainless steels. Special care must be taken to ensure that all cut edges, etc. are painted. Assemble all slip fits using wet zinc chromate primer (Item 7). Seal the edges of points of dissimilar metal contacts with zinc chromate primer after press fits are completed.

99 For additional protective treatment recommended for various material combinations see Figure 23-4.

Cleaning

100 Periodic cleaning of aluminum equipmen is the first step in maintenance. For precautions in the use of liquid soap, refer to EO 50-10-2B. For removal of moist accumulations of dust and dirt, a mild soap and water solution is effective and may be the only cleaning necessary if carried out at regular intervals. Leave surfaces dry after cleaning. To remove grease and wax, use approved mixtures containing benzol, toluol, naphtha, kerosene, or trichlorethylene. For the cleaning of metals refer to Part 20, preceding.

Sea Water Neutralization

101 To neutralize the action of sea water use potassium bichromate (Item 31) which inhibits corrosion of aluminum alloys in the presence of salt water. Place a linen or cotton bag, containing about two ounces of potassium bichromate crystals, at the lowest point of each watertight compartment of all aluminum alloy floats and hulls of aircraft operating on salt water. Replace these crystals when the water pumped from the compartments ceases to be coloured yellow.

Storage of Aluminum

102 Aluminum stores are to be kept dry, well ventilated and at reasonable uniform temperature. New equipment should be checked as received so that wet metal or parts may be separated and aired. Risk of contact with alkalis, nitrates, phosphates, acids and industrial fumes should be avoided.

TREATMENT OF CORROSION

General

103 In most instances, any corrosion tha is found will be surface corrosion, which is first noticed as a dirty white powder deposit similar to dust, which blotches the surface. When the powder is cleaned off, the surface will either be clean or, if the corrosion is more advanced, small clean pits will be evident. This type of corrosion can be easily checked, but if it is allowed to continue uncurbed the blotching will spread over th

surface and corrosion will slowly enter the metal. There are several methods of removing and treating corrosion. The method chosen depends upon the severity of the corrosion.

Light Corrosion (No Pitting)

104 To remove light corrosion products, one of three methods can be used:

(a) Cleaning (for very light corrosion only).

(b) Hand polishing.

(c) Chromic acid (Item 6) treatment.

Moderate Corrosion (Light Pitting)

105 This type of corrosion can be removed either by polishing followed by a chromic acid treatment, or by a chemical mixture of phosphoric acid (Item 22) and alcohol (Item 33) followed by a chromic acid treatment. If the phosphoric acid-alcohol mixture is used, mix in the following proportions and store in a glass or earthenware container:

Butyl alcohol (Item 33)	4 gallons
Water	2 gallons
Isopropyl alcohol (Item 34)	3 gallons
Phosphoric acid (Item 32)	1 gallon
	(14 pounds)
Nacconal NR (Item 36)	0.5 ounce

NOTE

If butyl alcohol (Item 33) is not available, isopropyl alcohol (Item 34) can be used for the entire alcohol content. If isopropyl alcohol is also not available, use denatured ethyl alcohol (Item 35).

106 Apply the cleaner to the surface with cloths or brushes. Do not allow the solution to enter seams or recesses. After two or three minutes, rub the surface lightly with a bristle brush. Thoroughly rinse with clear water. Dry at room temperature or with compressed air.

WARNING

Exercise extreme care when handling the phosphoric acid-alcohol solution. Refer to EO 00-25-4 and EO 00-25-25.

Severe Corrosion (Deep Pitting)

107 Severe corrosion can be removed by one of three methods. Whichever method is used, a chromic acid treatment should follow:

(a) Rub with sandpaper (Item 37) or with aluminum wool (Item 5) and kerosene (Item 38).

(b) Use a buffing wheel and a rubbing compound.

(c) Use a chemical mixture of phosphoric acid and alcohol.

Alclad Penetration Test

108 To determine if the Alclad has been penetrated by corrosion, by scratching or excessive buffing, apply the following test:

(a) Apply one drop of sodium hydroxide solution (Item 39) (one part to four parts water by weight) to the cleaned surface. At the same time, apply one drop to a corrosion-free area.

(b) After two minutes, remove the excess liquid from both areas by blotting with a cloth. Do not rub.

(c) Examine the corroded area with a magnifying glass of not less than four power, and with the beam of a flashlight pointed into the penetrated area. The light is necessary to avoid shadows in recessed areas, which can lead to an incorrect conclusion in regard to the depth of penetration.

(d) If the corroded area is black, corrosion has penetrated to the base metal. The non-corroded area to which the sodium hydroxide was added will provide a comparison, since the corroded area will be darker.

(e) Immediately after inspection, treat the area with a 10% chromic acid solution, (refer to Paragraph 110, following).

109 If the Alclad surface has not been completely penetrated and if the surface is to be protected later by zinc chromate primer and the proper lacquers, use a 10% chromic acid solution to inhibit further corrosion. If the sheet is corroded excessively, replace it. It should be remembered that widely spaced corroded areas will not affect the strength of the metal any more than widely spaced pilot or tooling holes do, provided that the corrosive action has been stopped.

Chromic Acid Treatment (Chromodizing)

110 The chromic acid treatment should always be used in the case of pitting, since it is difficult to remove all corrosion products from the pits. Chromic acid serves as an effective inhibitor to additional corrosive action.

111 Make the chromic acid solution by dissolving 16 ounces of commercial flake chromic acid (Item 6) in one gallon of water. The addition of Nacconal NR (Item 36) will provide a wetting agent and assist in spreading the solution, which must be applied as follows:

(a) Clean and thoroughly dry the surface to be treated.

(b) Apply the solution with a clean cloth or brush.

(c) After five minutes, remove the excess solution with a damp cloth. Since the solution will leave a yellow or brown stain, do not allow to dry on the surface unless the surface is to be coated or finished.

Chemical Removal of Aluminum Alloy Corrosion Products

112 Chromic acid etch may be used to remove corrosion products from all clad aluminum alloy material (clad skins, clad stringers, ribs in flap well, aluminum tubing, etc.). Do not scrape, sand, wire brush or otherwise abrade these clad surfaces, because the protective aluminum cladding adjacent to the corroded area will be removed, leaving a much larger unprotected area susceptible to further corrosion. Proceed as follows:

(a) Mask off nearby non-clad aluminum, plated steel and magnesium as well as cracks and faying surfaces, to keep acid etchant from contacting these areas.

(b) Apply thickened acid etchant to the corroded area of clad aluminum alloy, using a brush or cloth.

(c) With a short, stiff, non-metallic brush, scrub the areas of deep pitting until all corrosion products are removed. Pay particular attention to areas around rivet heads and at butt joints of skins.

(d) Sponge off the acid etchant with a damp cloth that is frequently rinsed out in water. Do not leave etchant in contact with the surface for more than a short time (approximately 10 minutes).

(e) Repeat above steps as necessary, concentrating on the pitted areas, until all corrosion products are removed. The bottom of each pit should appear bright and the metal should be uniformly etched. Questionable areas should be examined with a magnifying glass.

(f) After all corrosion is removed, thoroughly rinse the treated area and dry with warm or compressed air.

(g) Apply the chemical surface treatment and final protective finish indicated for the area involved.

CAUTION

Personnel should wear rubber gloves and goggles while working with acid solutions. If the acid accidentally contacts the skin or eyes, wash it off immediately with large quantities of clear water. Consult the medical officer if the eyes are affected or if the skin is burned. Refer to EO 00-25-4.

Emulsion Cleaning to Remove Corrosive Contaminants

113 To remove corrosive contaminants by emulsion cleaning, proceed as follows:

(a) Clean the affected areas with any approved emulsion cleaner or with cleaner (Item 1). Hand brushes with nylon (or other non-metallic) bristles should be used.

CAUTION

When working in the nose or main landing gear areas, cover tires to protect them from these solvents.

(b) Rub the surface briskly with a mop or cloth.

(c) After the small section has been gone over thoroughly and before it is allowed to dry, rinse with water.

(d) Either allow the surface to dry, or dry with clean cloths, or warm or compressed air

Removing Spilled Battery Acid

114 To remove spilled battery acid, proceed as follows:

(a) Rinse the affected areas with generous quantities of clear water to dilute and remove the acid, being careful not to spread acid into surrounding structure.

(b) After the acid is removed, treat the affected area with liberal quantities of 5% sodium bicarbonate solution (Item 13), applied with brush or cloth.

(c) Continue to add sodium bicarbonate solution until bubbles cease. Allow solution to remain on the surface for five minutes.

(d) Remove the sodium bicarbonate solution by rinsing with clear water, and wipe dry.

Final Protective Finish

115 The purpose of a chemical surface treatment is to inhibit further corrosion of the area and to provide a proper surface to receive a paint finish. The combination of chemical surface treatment and final paint finish constitutes the complete protective coating on the metal surface. The final protective paint finish is applied immediately after the chemical surface treatment. The surface to receive paint must be absolutely clean and dry and free from any contamination beyond the stained appearance due to the chemical surface treatment. Do not attempt to remove such stain or the benefits of the surface treatment will be lost.

Machine Polishing

116 To machine polish, proceed as follows:

(a) Apply a small amount of polishing compound, (such as Item 2) to the surface to be cleaned.

(b) Attach a lamb s wool buffer to the portable buffing machine.

(c) With the machine running, place the buffer on the skin surface. Be sure to keep the machine in motion at all times, otherwise the heat generated may cause the metal to can.

(d) If desired, the swirls and residue left around rivets and seams can be removed by hand polishing with the same compound that was used with the buffing machine.

Chromic Phosphoric Treatment

117 This treatment has two distinct applications, as follows:

(a) The prevention of corrosion on parts which are likely to be affected during normal service conditions.

(b) The inhibition of parts where corrosion has actually commenced due to contact with corrosive elements, such as immersion in sea water.

Preparation of Work

118 All machining, dressing or minor repairs must be completed on the surface to be protected, and the parts should be kerosene washed and degreased. It is imperative that the kerosene wash should remove all aluminum swarf from the parts, as the presence of finely divided aluminum causes rapid decomposition of the trichlorethylene (Item 40) used in degreasing, with consequent development of acidity.

119 Parts which contain steel studs or other steel fittings may be treated. The steel will be discoloured slightly after treatment, but this will not be detrimental. Copper or copper alloys should not be present when new parts are treated, but in certain instances, as in the case of engines undergoing repair where the removal of such inserts would necessitate extensive complementary rectification, the presence of copper alloy parts may be permitted. A careful examination of such fittings should be carried out after treatment to ensure that attack has not occurred to a dangerous extent.

Application of Treatment

120 The composition of the bath is as follows:

(a) Chromic acid (Item 6) 0.75% by weight.

(b) Phosphoric acid (Item 32) 0.50% by volume.

(c) Make up to required volume with water.

121 Immerse parts to be treated in the boiling solution for 45 minutes. After being removed from the bath, wash the treated parts thoroughly in cold running water, then finally dip in clean boiling water and allow to dry.

Safety Precautions

122 Refer to EO 00-25-4, and EO 00-25-25 for precautions when handling chromic acid.

BRUSH ALODIZING OF ALUMINUM AND ALUMINUM ALLOYS

General

123 The alodizing treatment is used on bare aluminum and its alloys to obtain the following results:

(a) Good anti-corrosive qualities.

(b) A good base for paint.

124 The alodizing treatment has poor wear qualities. The irriditing process is similar to the alodizing process but other materials are used. Use the brush Alodine solution for localized areas in repair and overhaul work and for refinishing aluminum alloys from which the original anodic coating has been removed or alclad aluminum alloys from which the cladding has been totally or partially removed in service.

Preparation of Solution

125 Make up the solution in a stainless steel container, as follows:

(a) Pour in 1 pint of Alodine Liquid (Item 41).

(b) Add 1.2 pounds of Alodine Powder (Item 42).

(c) Add 4 quarts of water and stir until all the solids have been dissolved.

(d) Store the solution in polyethylene bottles.

Application

126 To apply, proceed as follows:

(a) Clean metal surfaces to be treated with Alodine, using cleaner (Item 1).

(b) Etch the metal surface with etchant (Item 43) diluted three parts of water to one part of etchant.

(c) Apply the etching solution with a swab or brush and allow it to remain on the surface for one to two minutes.

(d) The etchant readily attacks magnesium and must not be allowed to contact any magnesium parts. Keep the etchant out of seams and faying surfaces.

(e) Scrub the surfaces lightly and rinse thoroughly with water.

(f) Apply the Alodine solution by brush to the surface to be protected, keeping the surface of the metal wet with the solution for a period of five minutes.

(g) Apply the solution evenly. Do not smear.

(h) Rinse thoroughly with cold water.

(j) Dry with compressed air.

ANODIZING OF ALUMINUM AND ALUMINUM ALLOYS

General

127 Anodizing is an anti-corrosive treatment with good wear qualities. It is usually used on bare aluminum alloys that are not to be painted or otherwise protected. The following procedure is to be followed in the anodizing of aluminum and aluminum alloys, using the chromic acid process. The procedure is limited to aluminum alloys containing not more than 5% copper.

Equipment

128 The equipment used is as follows:

(a) The anodizing tank and the caustic soda tank are to be of mild steel. The anodizing tank must have heating and cooling coils for maintaining the solution at the temperature specified, have facilities for agitating the solution by compressed air and be provided with cross-draft ventilation.

(b) The hydrofluoric acid tank, must be a lead-lined, mild steel tank.

(c) Heating coils are to be provided in the hot water rinse tank to maintain the water temperature at 180° to 212°F. Skimming troughs must be provided.

(d) The equipment is to include a motor-generator set of adequate output, a voltmeter and ammeter, preferably of the recording type, and an automatic temperature controller and recorder for the heating and cooling system.

(e) An automatic control unit for the voltage-time cycle and an automatic current cutout are to be used to avoid overloading the generator.

(f) Racks, clamps and wire used for connecting parts with bus-bars are to be made of aluminum alloy. Bus-bars are to be made of electrolytic copper.

Preparation of Solution

129 Make the electrolyte solution of 5% (by weight) chromic acid (Item 6) in water. The chloride and sulphate content of the water must not exceed the equivalent of 0.02% of sodium chloride and 0.05% of sulphuric acid respectively.

Temperature of Solution

130 Maintain the temperature of the solution at 95° (±5°), at all times. Do not use the anodic cycle to bring the temperature up to the required value.

Preparation of Parts

131 Clean all parts as specified in Part 20, preceding. When alkaline degreasing has been used, immerse the parts in the anodic tank while still wet from the rinsing operation. Clean immediately before the anodizing operation.

Procedure for Anodizing

132 Immerse the clean parts in the anodizing bath, ensuring free circulation of the solution to all sections of the work. Avoid masking of parts by one another. Rack parts so that gas generated during the process can escape and no gas pockets can form.

133 After the bath has been loaded and the electrical contacts suitably made, apply a small voltage across the circuit. Increase voltage to 40 (±1) volts, by small increments, during the next 5 to 8 minutes. Do not overload the generator at any time during this period. Maintain the voltage at 40 (±1) volts for a minimum of 60 minutes.

Anodizing of Small Parts

134 Anodize rivets in perforated aluminum containers. When anodizing washers, ensure electrical contact and exposure of the total surface to the solution by mixing with rivets, or by stringing the parts on aluminum wire or rod.

Other Parts

135 Anodize other parts as follows:

(a) Anodize parts and assemblies too large for the bath by partial immersion. Ensure that there is an overlapping by the electrolyte.

(b) Rivetted and spot welded assemblies may be anodized provided they consist of aluminum or aluminum alloys only. Assemblies of this type are to be cleaned by vapour degreasing only.

(c) Selective anodizing must be done using lacquer (Item 22) and not by the stripping method.

(d) Treat forgings and castings to be anodized for the detection of cracks in accordance with these instructions except that the time at 40 volts must be 15 minutes.

(e) Process parts to be bonded separately from parts which are not metal bonded. Use similar anodizing procedure except that, after anodizing, the parts are rinsed in cold water, followed by a short dip (1/2 to 1 minute) in hot water. After anodizing, handle the parts with clean cotton gloves.

Treatment after Anodizing

136 After the anodizing cycle has been completed, observe the following:

(a) Drain and immerse the parts in clean water, at a minimum temperature of 180°F, for not less than 30 minutes, then drain and allow to dry. In the case of anodized fuel, engine oil and hydraulic oil tanks, dry by heating in an oven at 225° to 250°F, if available.

(b) Keep the surface of the rinse bath clean by using a constant flow of water over the skimming trough.

(c) Handle anodized parts carefully to prevent contamination with dirt and grease.

(d) Paint parts, if required, as soon after anodizing as practicable.

(e) If contamination of the anodized surfaces prior to painting has taken place, clean with cloths and thinners or by vapour degreasing.

pH FACTOR

General

137 The concentration of hydrogen ions in a solution is indicated indirectly by a numerical scale called the pH scale. Neutral solutions have a pH of exactly 7. If the pH is a number less than 7 it indicates the presence of an acid. Similarly, a number greater than 7 indicates a basic solution.

Hydrion Paper

138 Special indicators, such as Hydrion paper (Item 44), show varying shades of colour which correspond to the whole range of pH values. To measure the acidity or alkalinity of a solution, place a drop of the solution on the paper.

Gramercy Universal Indicator

139 The Gramercy Universal Indicator (Item 45) is a mixture of solutions of dyes that can be used to measure the pH of a solution. To 10 cc of the solution, 1 cc of the indicator solution is added.

Colour Charts

140 Colour charts for comparison are obtainable from the manufacturers of the testing reagents.

CORROSION PROTECTION OF MAGNESIUM ALLOYS

General

141 The following information is included for the guidance of personnel engaged in anti-corrosion protection of magnesium alloy components.

Cleaning

142 For instructions regarding the cleaning of magnesium alloys, refer to Part 20, preceding.

Types of Treatments

143 Magnesium corrosion preventive treatments are of the following types:

(a) Type 1 Chrome-Pickle Treatment: For temporary storage and shipment, electrical bonding, touching up of previously treated work and brush application when permitted. Applicable to all alloys when close dimensional tolerances are not required.

(b) Type 11 Sealed Chrome-Pickle Treatment: For general long time protection of all alloys when close dimensional tolerances are not required.

(c) Type 111 Dichromate Treatment: For general long time protection of all alloys except those containing 1.5% or more of maganese, and including work for which close dimensional tolerances are required.

(d) Type 1V Galvanic Anodizing Treatment: For general long time protection of all alloys when close dimensional tolerances are required.

NOTE

Parts processed by the above treatments are not to be subjected to temperatures above 500°F.

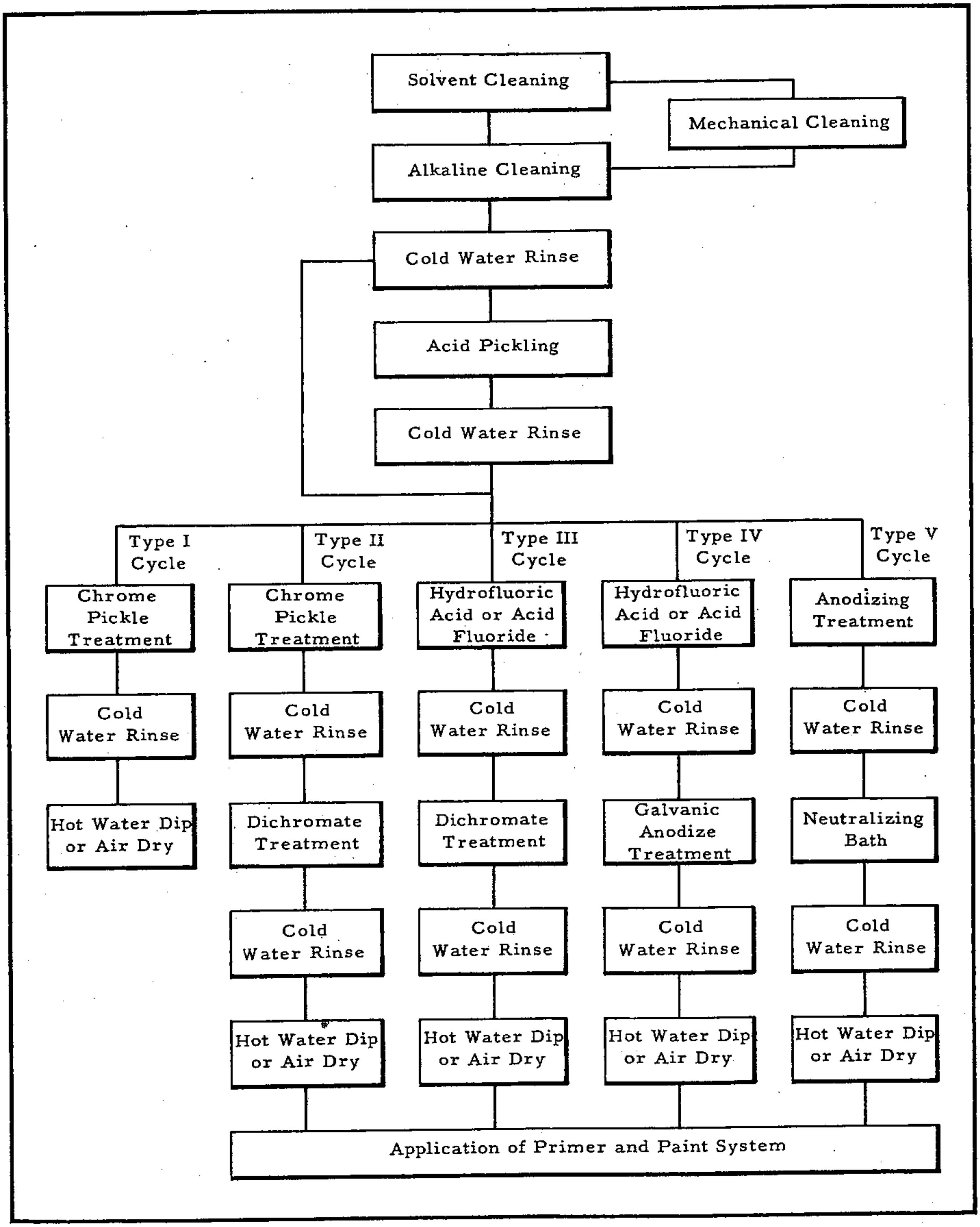


Figure 23-5 Cleaning and Treatment Cycles

(e) Type V Caustic Anodizing Treatment: For general long time protection of all alloys when close dimensional tolerances are not required. Parts processed by this treatment are not to be subjected to temperatures above 680°F.

CAUTION

Use protective clothing and equipment for protection of the eyes, protection from skin contact or inhalation of gases or compounds of nitric, sulphuric, phosphoric and other acids or bases. Refer to EO 00-25-4 and EO 00-25-25.

Applications of Treatments

144 Follow the sequence of the operations to be used for the application of treatments specified as detailed in Figure 23-5. Treated articles must be primed as soon as practical after thorough drying. Clean parts which are handled or processed after sealing or remain unprimed for extended periods prior to painting. Other methods of exposing the parts to the treatment solution than by immersion may be used.

NOTE

Types of tank construction other than those specified may be used provided they do not have an adverse effect on the solutions to be contained.

145 Magnesium base alloys are sometimes furnished with Type I treatment which provides protection during machining, shipment, and storage. The coating resulting from Type I treatment remaining on the unmachined area will impair the film produced by Type III and Type IV treatments and, consequently, must be removed. Type I treatment to which magnesium sulphate has been added, (refer to Paragraph 166, following), leaves a surface which is unfit for painting.

146 Castings containing bearings, studs, or non-magnesium inserts of any nature may sometimes require Types III and IV treatment, as in the case of refinishing work. Brass, bronze, cadmium and steel are unaffected by these treatments. Aluminum, however, is rapidly attacked during the hydrofluoric acid dip. The use of an acid fluoride bath instead of the hydrofluoric acid dip permits the treatment of parts containing aluminum inserts.

PICKLING SOLUTIONS

Chromic Acid Pickle

147 Use chromic acid pickling where parts with tolerance limits are to be finished, since this pickle causes no dimensional loss. It can be used to remove old chemical finishes by alternate immersion in an alkaline cleaner as specified in Part 20, preceding and the chromic acid pickle. This pickle is satisfactory for removal of surface oxidation, corrosion products and for general cleaning of parts. It is not satisfactory for the removal of sand or the effects of blasting and must not be used for parts containing copper-base inserts unless masked off. Excessive amounts of chlorides or sulphates must not be allowed to build up in the solution, as these anions tend to form objectionable films on the metal. This latter condition may be recognized when the solution tends to coat rather than to clean the metal surface.

148 For the solution composition and operation, use a lead-lined steel, stainless steel, or 2S aluminum tank. Mix 24 ounces of chromic acid in enough water to make 1 gallon. With an operating temperature of 190° to 212°F, immerse from 1 to 15 minutes. Bath can be operated at room temperature for a longer time if desired.

Chromic-nitrate Pickle

149 The chromic-nitrate pickle is generally used for removing burned-on graphite lubricants. It is not satisfactory for the removal of sand or the effects of blasting and must not be used for parts containing copper base inserts, unless masked off. Lack of chemical action and a pH of 1.7 or higher indicates depletion of the bath.

150 For the solution composition and operation, use a tank constructed of ceramic, stainless steel, lead-lined, or synthetic rubber-lined tanks or tanks lined with vinyl base materials. Mix 24 ounces of chromic acid (Item 6), 4 ounces sodium nitrate (Item 46) in enough water to make 1 gallon. With an operating temperature of 60° to 90° F and a pH value of 0.0-1.7, immerse from 2 to 20 minutes, as required.

Sulphuric Acid Pickle

151 Sulphuric acid pickling is used on magnesium sand castings to remove the effects of blasting operations. The pickle should be applied before any machining operation, since the amount of metal removed is likely to exceed machining tolerances.

152 For the solution composition and operation, use ceramic, rubber-lined, lead, or other suitable tanks. Mix 3 to 7 fluid ounces of sulphuric acid (Item 19) in enough water to make 1 gallon. With an operating temperature of 70° to 90°F, immerse casting for sufficient time to remove the effects of blasting operations.

Nitric-sulphuric Acid Pickle

153 As an alternate for the sulphuric acid pickle, (refer to Paragraph 151, preceding), a nitric-sulphuric acid pickle may be used. For solution composition and operation, use ceramic, rubber-lined or other suitable tanks. Mix 8 fluid ounces of nitric acid (Item 20), 2 fluid ounces of sulphuric acid (Item 19) and 90 fluid ounces of water. With an operating temperature of 70° to 90° F, immerse part for sufficient time to remove 0.002 inch of surface.

Chromic-nitric-hydrofluoric Pickle

154 For pickling castings, particularly die castings, a chromic-nitric-hydrofluoric pickle may be used. For solution composition and operation, use a tank lined with synthetic rubber or vinyl base material. Mix 37-1/2 ounces chromic acid (Item 6), 3-1/4 fluid ounces nitric acid (Item 20), 1 fluid ounce hydrofluoric acid (Item 48) with enough water to make 1 gallon. With an operating temperature of 70° to 90°F, immerse part for 1/2 to 2 minutes.

Phosphoric Acid Pickle

155 The phosphoric acid pickle may be used for pickling all types of die castings. For solution composition and operation, use a ceramic tank or a tank lined with lead, glass or rubber. Mix 0.9 gallons phosphoric acid (Item 32) with enough water to make 1 gallon. With an operating temperature of 70° to 80°F, immerse part for 1/2 to 1 minute.

Acetic-nitrate Pickle

156 The acetic-nitrate pickle is suitable for removal of mill scale and other surface contamination from magnesium sheet to ensure maximum protective finishing. This pickle can be used on other wrought forms and on solution heat treated magnesium castings. For most effective results the pickle should be allowed to remove 0.0005 inch to 0.001 inch of metal per surface and therefore is not suitable for parts requiring closer tolerances. For solution composition and operation, use an aluminum, ceramic, or rubber lined tank. Mix 25-1/2 fluid ounces glacial acetic acid (Item 47), 6-2/3 ounces of sodium nitrate (Item 46) with enough water to make 1 gallon. With an operating temperature of 70° to 80°F, immerse part for sufficient time to remove 0.0005 to 0.001 inch of metal surface.

TREATMENT PROCEDURE

Type I Treatment

157 The Type I treatment is to be applied to cleaned magnesium parts. Wrought magnesium parts are to be treated in a chrome pickle bath conforming to Paragraph 162 following, and magnesium sand, permanent mould and die castings in a chrome pickle bath conforming to Paragraph 163 following. The parts are immersed and agitated in the proper bath for a period of time ranging from 1/2 minute in a solution containing the full quantity of nitric acid to 2 minutes in a solution in which the nitric acid is nearing depletion. Usually a one minute dip will be sufficient, in a properly controlled bath. After the immersion period, the parts are to be held above the tank for 5 to 30 seconds. This allows the adhering solution to drain off and produce a better coloured coating. The parts must then be washed in cold running water followed by a dip in hot water to facilitate drying, or by exposure to heated air.

158 Magnesium die castings and aged sand castings are to be given a 15 to 30 second hot water dip followed immediately by a 10 second dip in the solution specified in Paragraphs 162 or 163, following, which is to be operated at 120° to 140°F. Excessive treatment time results in a powdery coating and failure to pre-heat the castings in hot water results in practically no coating in 10 seconds.

159 Sand castings in the solution heat-treated condition can be chrome-pickled with these solutions at room temperature. After dipping, parts are to be rinsed as described in Paragraph 157, preceding. Chrome-pickle solutions may remove as much as 0.0006 inch of metal per surface during treatment and, therefore, cannot be used on machined surfaces unless tolerances will permit or proper allowances have been made.

160 Magnesium parts containing steel or brass inserts can be given the Type I treatment.

161 The most desirable base for painting is a matt grey to yellow-red, irridescent coating, which exhibits a network of pebbled etch finish as viewed under magnification. Bright brassy coatings, which show a relatively smooth surface with only occasionally rounded pits when examined with magnification, are unsatisfactory where the treatment is used as a paint base, but are acceptable for protection during shipping and storage. This shade indicates an excess of nitric acid or nitrate salt build-up in the bath.

162 The chrome pickle bath for treating wrought magnesium is as follows:

(a) Use a tank constructed of stainless steel or one lined with glass, ceramics, synthetic rubber or vinyl base materials. Mix 1.5 pounds sodium dichromate (Item 49) and 1.5 pints nitric acid (Item 20) in enough water to make 1 gallon.

(b) Immerse part for 30 seconds to 2 minutes, with an operating temperature of 70° to 90°F, followed by 5 seconds draining.

163 The chrome-pickle bath for treating magnesium sand, permanent mould and die castings, is as follows:

(a) Use a tank constructed of 316 stainless steel (preferred) or a tank lined with synthetic rubber of vinyl base materials. Mix 1.5 pounds sodium dichromate (Item 49), 1.0 to 1.5 pints nitric acid (Item 20), and 2 ounces sodium acid fluoride (Item 50) with enough water to make 1 gallon.

(b) Immerse part for 1/2 to 2 minutes at an operating temperature of 70° to 140°F, followed by 5 seconds draining.

Brush Application

164 Articles too large to be immersed must be carefully brushed with a generous amount of fresh solutions specified in Paragraphs 162 and 163, preceding. The solution is to be allowed to remain on the surface for at least 1 minute while brushing and then washed off immediately with plenty of cold running water. The coating thus formed is less uniform in colour than that produced by immersion but is equally good as a paint base. Powdery coatings are not satisfactory as paint bases and indicate poor rinsing or failure to keep the surface wet with solution during the 1 minute treatment time by continuous brushing over the same area. In treating rivetted assemblies, care must be taken to avoid entrapping solution in the joints. Brush application is suitable for touch-up of Type I, II, and III treatments which have been damaged by handling or removed by abrasion during paint stripping.

Operational Difficulties

165 A brown, non-adherent, powdery coating may be encountered during chrome pickling. This may be caused by:

(a) The part being in the air too long before rinsing. The air interval must be as specified in Paragraph 157, preceding.

(b) The ratio of acid concentration to sodium dichromate content may have been too high.

(c) The solution may have been too hot.

(d) The metal was not properly degreased. Brown powder will occur at spots where oil exists.

166 To reduce intergranular corrosion of some alloys in the chrome pickle baths, magnesium sulphate (Item 51) may be added to the chrome pickle solution specified in Paragraphs 162 and 163 to the extent of 0.2 pound per gallon for use in Type I treatments for temporary storage and shipment where the coating will not be used as a base for painting. The addition of magnesium sulphate to chrome-pickle solutions used in the Type II treatment is not permitted.

Type II Treatment

167 The Type II treatment is a combination of the chrome-pickle treatment and the dichromate treatment and is commonly known as the sealed chrome pickle. All the requirements for the chrome pickle treatment as specified in Paragraph 157, preceding, shall be effective for the Type II treatment, except that the parts do not need to be dried after rinsing. The dichromate treatment must not be applied to an old chrome pickle film. Old chrome pickle film is to be removed as specified in Part 20, preceding and the part re-treated.

Dichromate Treatment

168 For the dichromate treatment, proceed as follows:

(a) The freshly chrome-pickled parts must be immersed in the bath as follows:

(1) Using a steel tank, mix 1 to 1.5 pounds sodium dichromate (Item 49) and 1/3 ounce of magnesium fluoride (Item 52) with enough water to make 1 gallon. With temperature at boiling, immerse parts for 30 minutes.

(b) After the treatment, the parts are to be thoroughly rinsed in cold water followed by a dip in hot water to facilitate drying, or dried by exposure to heated air.

(c) The specified paint coating is to be applied as soon as practical after the treated parts are thoroughly dry.

Type III Treatment

169 The Type III treatment or dichromate treatment provides satisfactory paint base and protective qualities on all standard alloys except those containing 1.5% or more manganese only and rare earth metal alloys similar to EK 30 and EK 31. The treatment effects no appreciable dimensional changes and normally is applied after machining. Castings and other parts containing bearings, studs and inserts of brass, bronze, cadmium plate and steel may be treated since these metals are not affected by the treatment. Aluminum, however, is rapidly attacked during the hydrofluoric acid dip which is an important step in this treatment. Where aluminum inserts are used or wrought parts are assembled with aluminum rivets, the acid fluoride dip must be used in place of the hydrofluoric acid dip. Close control of the Type III treatment is essential when applying this treatment to the alloy containing 3% aluminum and 1% zinc.

Hydrofluoric Acid Solution

170 To make up hydrofluoric acid solution, use a lead, rubber, or synthetic rubber lined tank. Mix 24 fluid ounces of hydrofluoric acid (Item 48) with enough water to make 1 gallon. Maintain solution at 70° to 90° F.

171 After parts have been cleaned, they are to be pickled in the hydrofluoric acid solution. This operation both cleans and activates the magnesium surface. It is recommended that wrought alloy containing 3% aluminum and 1% zinc to be immersed for 30 seconds and that all other wrought alloys and castings be immersed for 5 minutes. After the immersion period, the parts must be thoroughly rinsed in cold running water. Thorough rinsing is important in order to minimize fluoride carry-over which will make the dichromate bath inoperative.

Acid Fluoride Solution

172 To make up the acid fluoride solution, use a lead, rubber, or synthetic rubber lined tank. Mix 6-2/3 ounces of sodium acid fluoride (Item 50) with 1 gallon of water. This solution is to be used for all parts containing aluminum inserts, rivets, etc. and is used as an alternate treatment for Paragraph 170, preceding. Immerse parts in solution for 5 minutes minimum, with the operating temperature at 70° to 90°F. After immersion, the parts must be thoroughly rinsed in cold running water.

Dichromate Treatment

173 After the parts have been given the fluoride treatment in the solution specified in either Paragraph 170 or 172, preceding, they must be boiled for 30 minutes in the solution specified in Paragraph 168, preceding. Properly applied coatings vary from light to dark brown, depending upon alloy. After the immersion period, the parts are to be rinsed in cold running water followed by a hot water dip to facilitate drying, or dried by exposure to heated air. The specified paint coating must be applied as soon as practical after the treated parts are thoroughly dry.

Operational Difficulties

174 Abnormally heavy and loose, powdery coatings, failure to coat, or non-uniform coatings may be encountered during application of the Type III treatment. These faults may be caused as follows:

(a) The hydrofluoric acid or acid fluoride bath is too dilute.

(b) The pH of the dichromate bath is too low.

(c) Treatment of oxidized, corroded or flux-contaminated parts result in grey to yellow coatings of a loose nature. Parts are to be cleaned as specified in Part 20, preceding.

175 Failure to coat or non-uniform coatings may be caused by:

(a) The pH of the dichromate bath is too high.

(b) The dichromate concentration is too low in the bath.

(c) Oily matter has not been properly removed, resulting in a spotted coating where some areas are coated and others are not.

(d) Previous chrome pickle coating was not completely removed. Use of either solution specified in Paragraphs 147 or 149, preceding, to supplement the alkaline cleaning may be required.

(e) The part was not fluoride treated.

(f) Alloy treated is one that contains 1.5% manganese only. The Type III treatment is not suitable for this alloy.

(g) Too long a hydrofluoric acid dip with low aluminum-containing alloys produces a fluoride film that does not break down evenly in the normal time, producing a spotty coating. For these alloys, treatment time should be 1/2 to 1 minute.

(h) The bath was not kept boiling during the treating period. This is particularly important when processing low aluminum-containing alloys. Minimum bath temperature is 200°F.

Type IV Treatment

176 The Type IV treatment or galvanic anodizing treatment may be applied to all alloys. It causes no dimensional change and may be applied after machining operations. After parts have been cleaned, refer to Part 20, preceding, they are to be treated in hydrofluoric acid solution specified in Paragraph 170, preceding or in the acid fluoride solution specified in Paragraph 172, preceding.

Galvanic Anodizing Solution

177 After the treatment in a fluoride solution, the work must be galvanically anodized for at least 10 minutes and for as long as 30 minutes in the galvanic anodizing solution. The steel tank is to be the cathode. If the tank is made of non-metallic material, steel cathode plates must be used. The magnesium parts must be electrically connected with the tank or the cathode plates, care being taken that the work does not make contact with the tank except by an external connection. An ammeter and rheostat should be in the electric circuit. The current density must not exceed 10 amperes per square foot of anode area at any time. A minimum of 70 ampere-minutes per square foot of anode must be maintained to secure a uniform coating. Ordinarily 70 to 150 ampere-minutes per square foot will be sufficient. After the immersion period, the parts are to be rinsed in cold running water, followed by a hot water dip to facilitate drying, or dried by exposure to heated air. The specified paint coating must be applied as soon as practical after the treated parts are thoroughly dry.

178 The solution composition and operation is as follows:

(a) Using a steel tank, mix 4 ounces of ammonium sulphate (Item 53), 4 ounces sodium dichromate (Item 49), 1/3 fluid ounce ammonium hydroxide (Item 54) with enough water to make 1 gallon. Operating temperature is to be 120° to 140°F.

179 A properly applied Type IV treatment usually produces a coating that is uniformly black. Time of treatment, condition of bath and composition of the alloy influence the colour of the coating. Grey and non-uniform coatings indicate that articles were not properly cleaned before treatment or that the solution was depleted. An increase in time

required to secure a uniform coating also indicates a depletion of the solution.

Type V Treatment

180 The Type V treatment or caustic anodizing treatment is an anodic treatment employing an alkaline bath in which either direct or alternating low-voltage current produces a hard abrasion-resistant coating varying from light grey to light tan in colour, depending on the alloy and the type of current. The treatment can be applied to all alloys and forms. The coating produced can be painted after it is given a treatment in a neutralizing bath to counteract the effect of the free alkali remaining in the pores.

Anodic Treatment

181 Parts to be given the anodic treatment must be cleaned and suspended in the anodizing solution from 3 to 5 minutes before the current is applied. This further removes traces of foreign material from the surface and makes it more receptive to the anodic coating. If direct current is used, parts can be cathodically cleaned in the anodizing bath during this period by reversing the current, making the magnesium parts the cathode. The parts are to be made the anode and the current applied must be 10 to 20 amperes per square foot at 6 to 24 volts a. c. or 6 volts d. c. The anodizing time is to be 15 to 25 minutes. When maximum abrasion resistance and protection are required, the longer treating period is to be used. The lower current density is to be used when treating an alloy containing 1.5 percent manganese only. When the current is turned off after treating, the parts must be left in the bath at least 2 minutes to stabilize the coating. Parts are then removed and rinsed in cold running water for at least 5 minutes. The parts are then dipped in hot water to facilitate drying or exposed to heated air, unless the parts are to be painted, in which case the parts are to be immersed in a neutralizing bath for 5 minutes as specified in Paragraph 183, following. Dissimilar metals on any parts must be masked off before treatment. Vinyls are stable in this solution.

182 The solution composition is made up as follows:

(a) Using a steel or magnesium tank, mix 32 ounces sodium hydroxide (Item 39), 0.55 pint ethylene glycol (Item 55), and 1/3 ounce sodium oxalate (Item 56) with enough water to make 1 gallon. The operating temperature to be 165° to 175°F.

Neutralizing Bath

183 The Type V coating must not be painted immediately after treatment because of the free alkali that remains in the pores after rinsing. Since such free alkali interferes with paint adhesion, a neutralizing bath must be used to counteract such alkali. The treatment causes the coating to acquire a pale yellow colour due to chromate absorption. After treatment, the parts are to be thoroughly rinsed in cold running water followed by a hot water dip or exposure to heated air to facilitate drying. The specified paint coatings must be applied as soon as practical after the parts are thoroughly dry.

184 Solution composition is made by mixing 6-2/3 ounces sodium acid fluoride (Item 50) and 6-2/3 ounces sodium dichromate (Item 49) with enough water to make 1 gallon.

Racks for the Type V Treatment

185 Racks made of high aluminum content magnesium alloys such as one containing 9% aluminum, 2% zinc, and 0.15% manganese or aluminum alloys containing more than 8% magnesium should be used in applying the Type V treatment. Rubber or synthetic rubber covered steel racks may be used. Design of the rack must ensure very firm contacts at the bus-bar and to the part. The portion of the rack contacting the bus-bar is to be made of copper, bronze or brass which can be bolted to the lower part of the rack. The rack must make good contact with the magnesium parts. Steel racks may be exposed only at the point where contact is made to the parts. Since the oxide coating acts as an insulator, magnesium racks must be stripped of this oxide at the contact points by use of the chromic-nitrate pickle specified in Paragraphs 149 and 150, preceding, or by sanding prior to each use.

Material Specifications

186 For table showing item numbers, materials, specifications and manufacturers, see Figure 23-6.

Item No.	Material	RCAF Ref.	Specification	Manufacturer
1	Cleaner	33C/182	3-GP-8	
2	Compound, Turco Red-X			B.W. Deane & Co. 3620 Namur, Montreal
3	Bon Ami	33C/666		Bon Ami Ltd Montreal
4	Paper, Abrasive	29/1869		
5	Wool, Aluminum	29/1162		
6	Acid, Chromic	33C/494	O-C-303	
7	Primer, Zinc Chromate	33A/462	MIL-P-6889	
8	Lacquer, Aluminized		MIL-L-7178	
9	Compound, Corrosion Preventive		AN-C-52, Type 1	
10	Oil, Linseed, Raw		JJJ-0-336	
11	Compound, Corrosion Preventive		AN-C-52 Type 2	
12	Cord, Cotton, Wrapping		MIL-C-2520	
13	Sodium Bicarbonate	33C/88		Technical Grade
14	Lacquer, Stop-off, Unichrome No. 324			Canadian Hanson and Van Winkle Co. 15 Murrow Ave. Toronto, Ont.
15	Tape, Masking	32B/96, 59, 60		Commercial Grade
16	Methyl Ethyl Ketone	33C/520	MIL-T-6094	
17	Ammonium Nitrate			Technical Grade
18	Compound, Unichrome CR-110 SRHS			Canadian Hanson and Van Winkle Co. 15 Murrow Ave. Toronto Ont.
19	Acid, Sulphuric Sp. Gr. 1.84	33C/4	15-GP-8a	
20	Acid, Nitric Sp. Gr. 1.42	33C/2		

Figure 23-6 (Sheet 1 of 3) Table of Material Specifications

Item No.	Material	RCAF Ref.	Specification	Manufacturer
21	Acid, Hydrochloric	33C/1		
22	Lacquer, Unichrome, Stop-off No.323			Canadian Hanson and Van Winkle Co., 15 Murrow Ave., Toronto Ont.
23	Compound, Parco, (liquid)			Parker Rustproof Co., Detroit Mich.
24	Abrasive, Sand for sandblasting	29/2342		
25	Blastite, Aluminum oxide grit			Can. Carborundum Co., Niagara Falls Ont.
26	Potassium Dichromate	33C/308		Technical Grade
27	Putty, Metal, for patching			Minnesota Mining and Manufacturing Co., London Ont.
28	Remover, Paint		1-GP-78	
29	Presstite 217.5			Minnesota Mining and Manufacturing Co., London Ont.
30	Varnish		1-GP-20	
31	Potassium Bichromate			Technical Grade
32	Acid, Phosphoric	33C/3		
33	Alcohol, Butyl			Technical Grade
34	Alcohol, Isopropyl	34A/214	3-GP-525	
35	Alcohol, Denatured, Ethyl	34A/216	3-GP-530	
36	Nacconal NR	33C/728		
37	Paper, Abrasive, No. 400 grit	29/1867		
38	Kerosene	34A/217	3-GP-3	
39	Sodium Hydroxide	33C/672	15-GP-7	Technical Grade
40	Trichlorethylene	33C/163	MIL-T-7003	

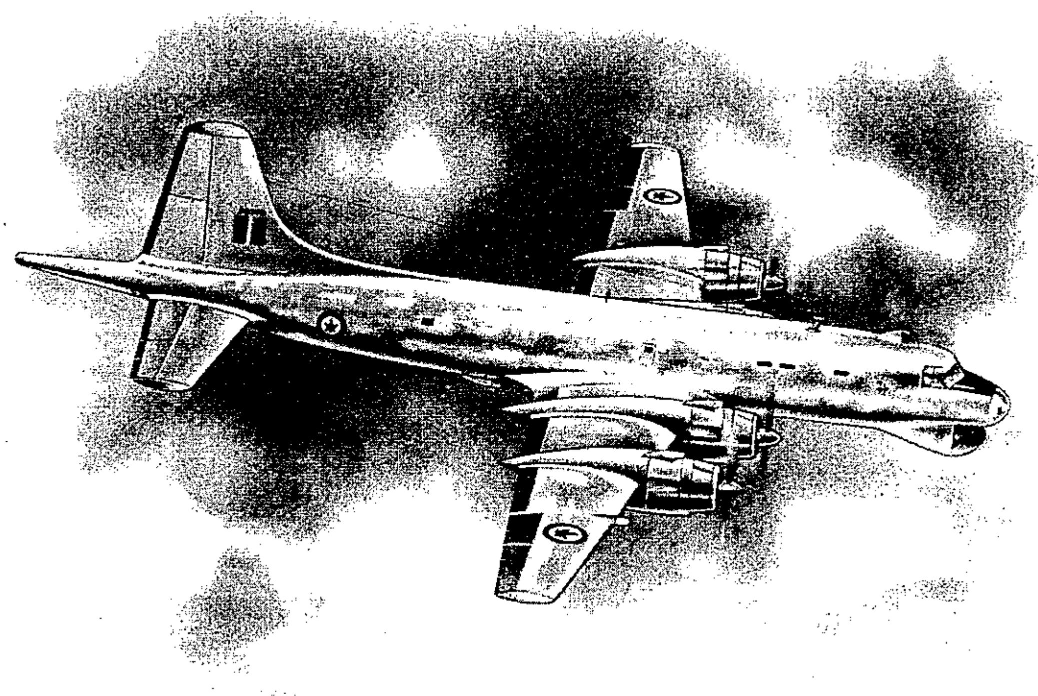
Figure 23-6 (Sheet 2 of 3) Table of Material Specifications

Item No.	Material	RCAF Ref.	Specification	Manufacturer
41	Liquid, Alodine No. 500			American Chemical Paint Co., Ambler, Penn.
42	Powder, Alodine make-up No. 5			American Chemical Paint Co., Ambler, Penn.
43	Etchant, W0 No. 1			B. W. Deane and Co., 3620 Namur, Montreal
44	Paper, Hydrion			Technical Grade
45	Indicator, Gramercy Universal			Technical Grade
46	Sodium Nitrate	33C/226		
47	Acid, Acetic, Glacial	14B/27		
48	Acid, Hydrofluoric			Technical Grade
49	Sodium Dichromate			Technical Grade
50	Sodium Acid Fluoride			Technical Grade
51	Magnesuim Sulphate			Technical Grade
52	Magnesium Fluoride			Technical Grade
53	Ammonium Sulphate			Technical Grade
54	Ammonium Hydroxide	33C/736	O-A-451d	
55	Ethylene Glycol	34A/172	3-GP-850	
56	Sodium Oxalate			Technical Grade
57	Oil.		3-GP-335A	

Figure 23-6 (Sheet 3 of 3) Table of Material Specifications

PART 24

TYPICAL METAL REPAIRS



PART 24

TYPICAL METAL REPAIRS

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LIST OF ILLUSTRATIONS

(Continued)

PART 24

TYPICAL METAL REPAIRS

TYPICAL METAL REPAIRS

General

1 Repairs must be planned with great care. Frequently more than one repair plan is available and various factors must be considered in making the right selection, such as equipment and materials available, level of skill, weight economy, etc. For example, Figures 24-1 and 24-2 are typical of various approaches to a skin damage repair where a stringer crosses the area of damage.

Control of Weight and Drag in Repairs

2 The primary consideration in planning repairs is the restoration of the part to its original strength. Secondary considerations are weight control and, where applicable, aerodynamic cleanness.

3 Repairs almost always necessitate an increase in weight and this increase must be kept to a minimum, consistent with good repair practice. In control surfaces, weight increases become critical since, unless they occur along the axis of rotation, they tend to unbalance the control surface thus creating a danger of flutter. In practice, repairs are most frequently made at or near the trailing edge, thus aggravating the possibility of unbalance.

4 Repaired control surfaces must be rebalanced by adding sufficient weight on the side opposite the repair so that the new weight multiplied by the distance to the axis of rotation equals the added repair weight multiplied by the distance to axis of rotation, (see Figure 24-3). Lead washers are a convenient means of adding the required weight, and should be added as near as possible to the

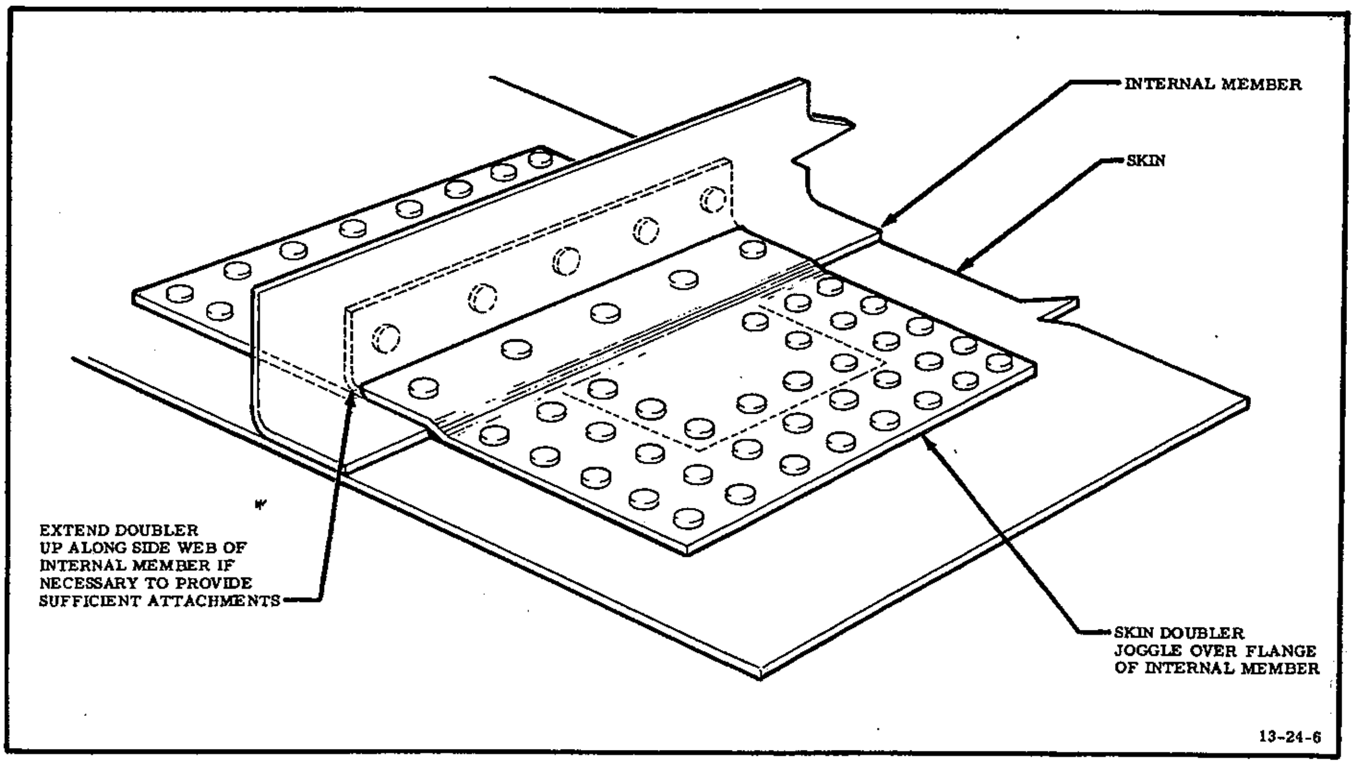


Figure 24-1 Repair Plan - Skin Only

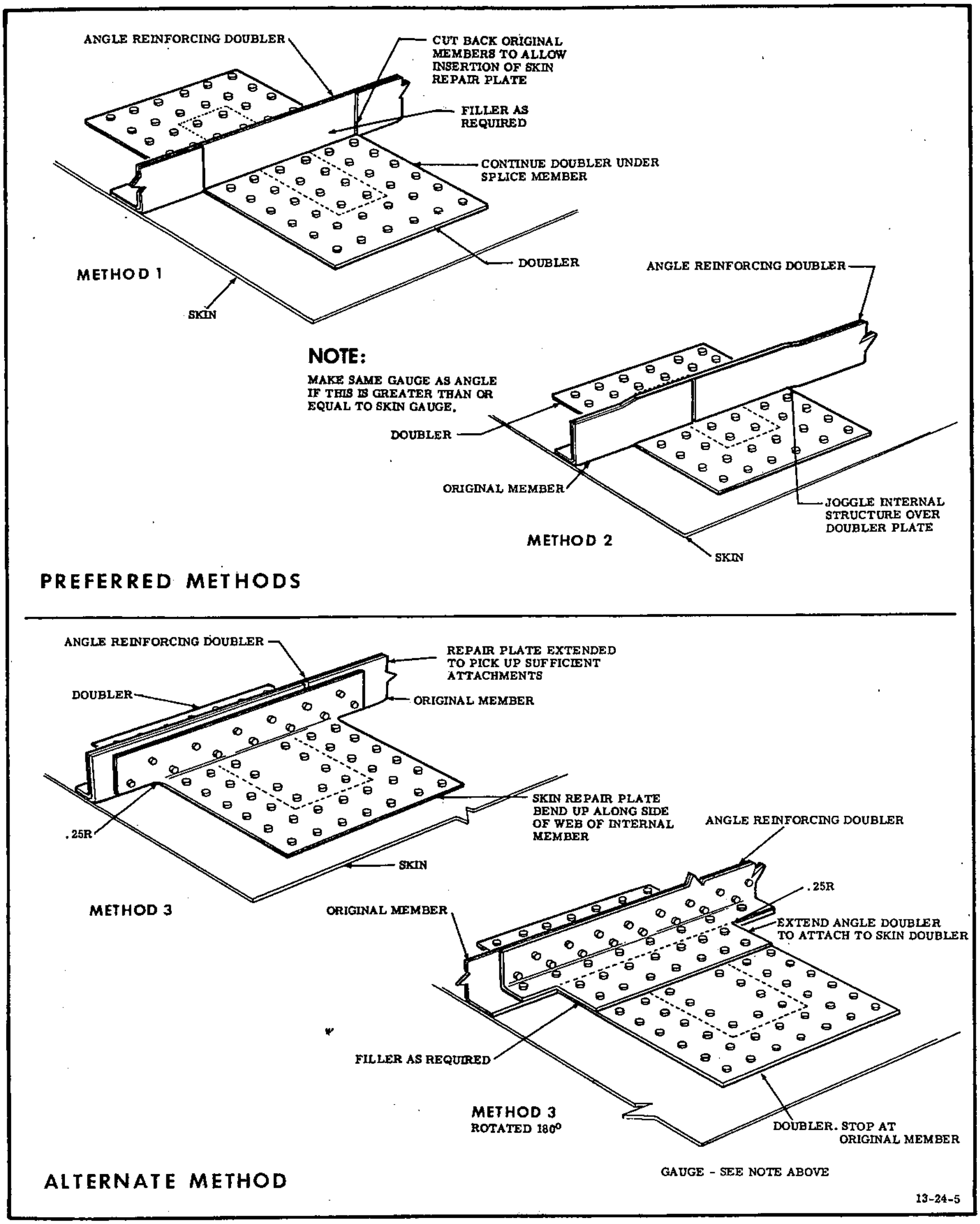
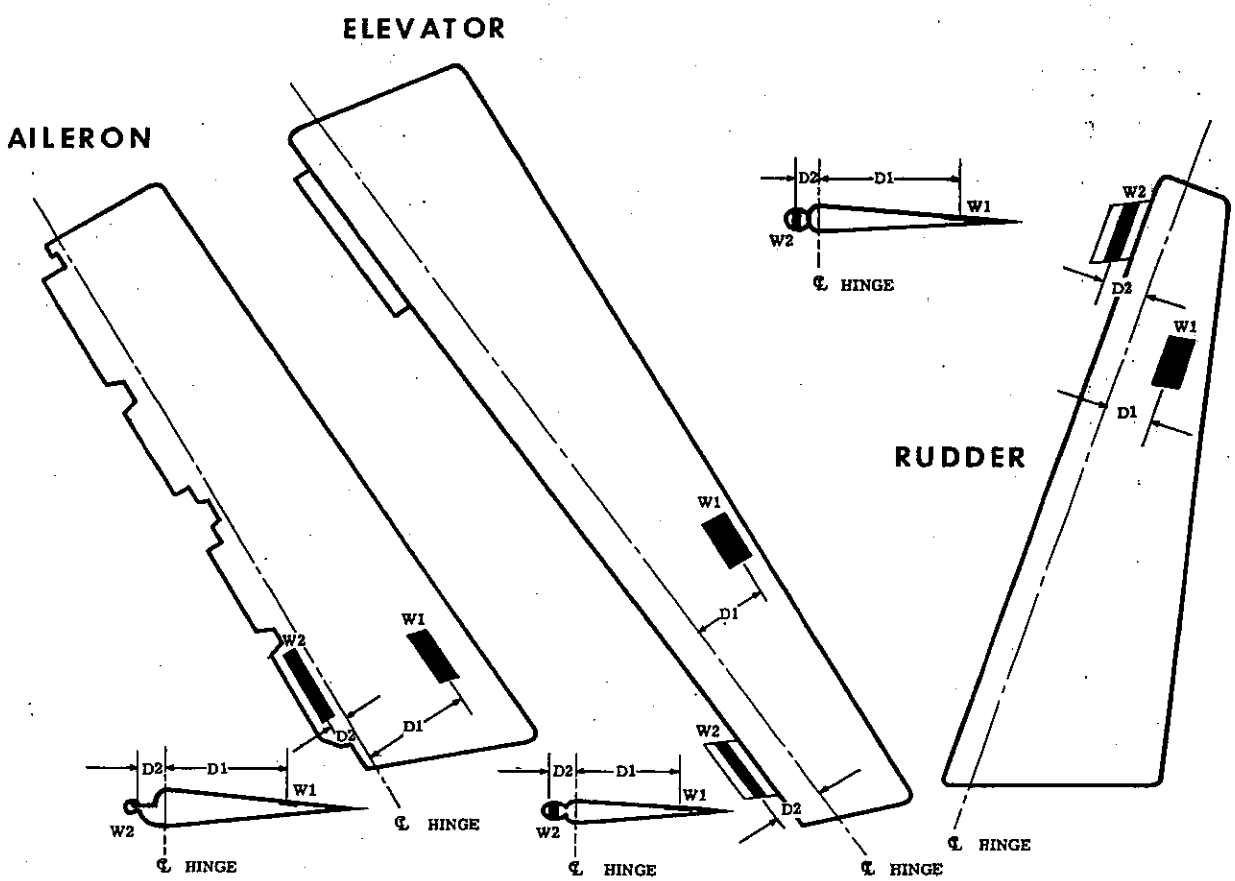


Figure 24-2 Repair Plans - Skin and Stringer



D1 DISTANCE IN INCHES FROM CENTROID OF REPAIR TO HINGE CENTRE LINE.

D2 DISTANCE IN INCHES FROM CENTROID OF REBALANCING WEIGHT TO HINGE CENTRE LINE.

W1 NET WEIGHT OF REPAIR MATERIALS (GROSS WEIGHT OF REQUIRED REPAIR MATERIALS MINUS WEIGHT OF REMOVED DAMAGED MATERIAL).

W2 REQUIRED REBALANCING WEIGHT.

1. DETERMINE EFFECT OF REPAIR BY MULTIPLYING D1 x W1.

FOR EXAMPLE D1= 8 INCHES
W1=.25 POUND
EFFECT OF REPAIR= 8 x .25 = 2 INCH-POUNDS UNDERBALANCE

NOTE: ADDITIONAL REBALANCING WEIGHT IS NECESSARY IF THE EFFECT OF THE REPAIR CAUSES UNDERBALANCE.

2. IF THE EFFECT OF THE REPAIR CAUSES UNDERBALANCE, SUBSTITUTE IN THE FOLLOWING EQUATION TO DETERMINE THE REQUIRED REBALANCING WEIGHT.

$$W2 = \frac{W1 \times D1}{D2}$$

FOR EXAMPLE W1 = 1 POUND
D1 = 12 INCHES
D2 = 4 INCHES

SUBSTITUTING $W2 = \frac{1 \times 12}{4}$ = 3 POUNDS REQUIRED REBALANCING WEIGHT.

13-24-3

Figure 24-3 Mathematical Balance Check of Control Surfaces plane of the repair. For a method of measuring static unbalance of control surfaces, refer to Part 18, preceding.

5 Aerodynamic cleanness is of major importance in the performance of an aircraft, and great progress has been achieved in design and manufacture. On a recent four engine passenger aircraft, the parasitic drag of the entire aircraft is equal to the drag of a rod 2-1/2 inches in diameter, length equal to the wingspan, placed normal to the airflow.

6 When planning a repair on any part of the aircraft exposed to the airflow, keep any drag increase to the lowest possible level. Figure 24-4 shows some comparisons and proportions of drag caused by air leakage, protruding drain pipes and non-flush patches.

Typical Repair Instructions

7 In the repairs in this section, observe the following:

(a) Callouts of blind rivets, Hi-Shear rivets, bolts, screws, etc. are qualified by the limitations in Parts 5 and 6, preceding.

(b) Where flush rivetting is required, see Part 5, preceding, for gauge limitations of dimpling and countersinking.

(c) Protruding head rivets (AN470) are to be used wherever possible.

(d) When any part of the assembly is made of magnesium, 56S rivets (B rivets) must be used.

(e) Existing rivet holes are to be picked up in all cases unless otherwise noted.

(f) Rivet heads must not encroach on any radii.

(g) Where bolts or other steel fasteners are used in a repair along with light alloy rivets, the bolt holes must be reamed.

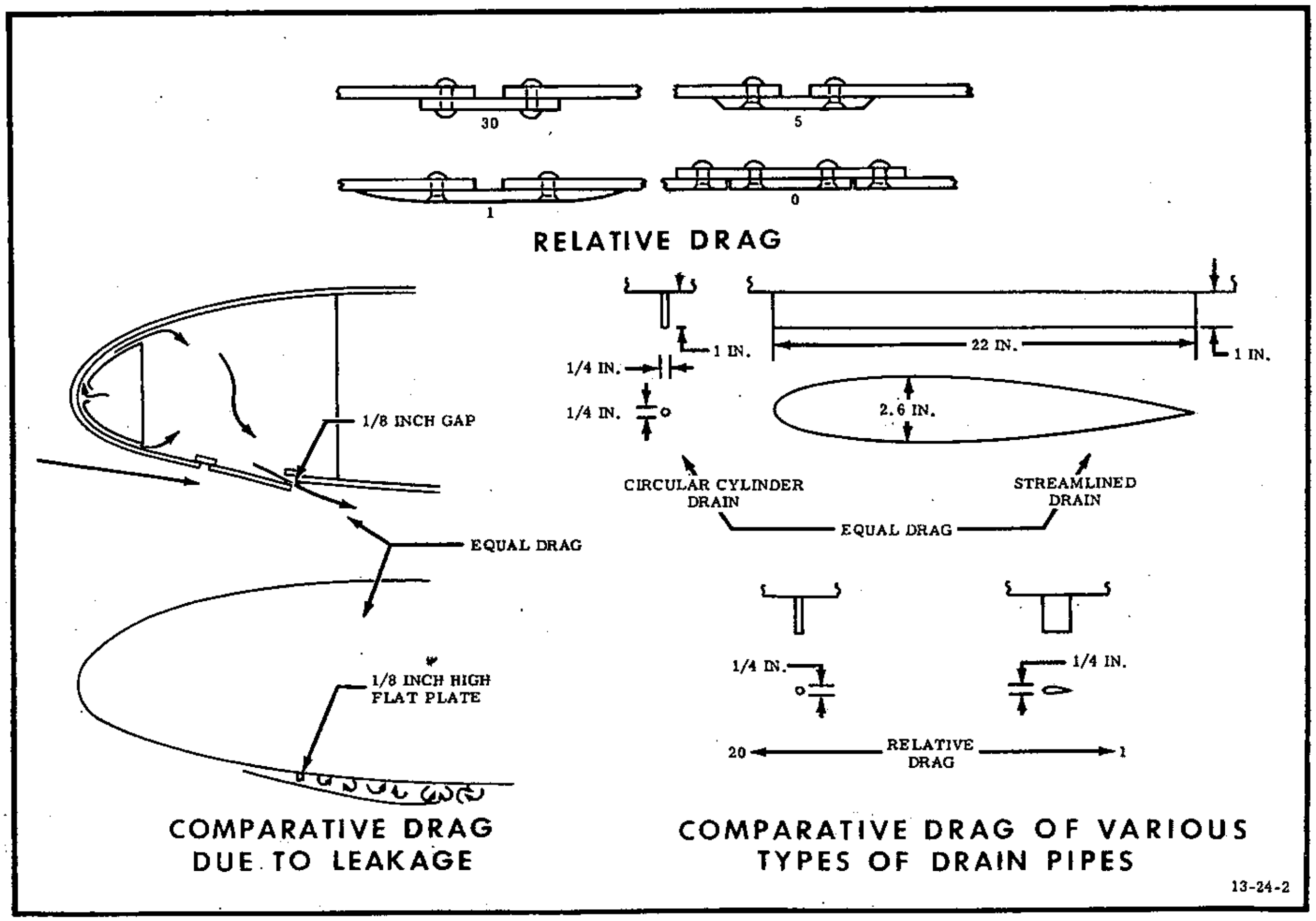


Figure 24-4 Comparative Drag Types

(h) Repair material, gauge and heat-treat are the same as the original part, unless otherwise noted.

(j) All parts must be suitably treated against corrosion, (refer to Part 23, preceding), and have the original finish restored (refer to Part 20, preceding). In most cases, two coats of zinc chromate will furnish sufficient protection for doublers and similar non-exposed repair parts.

(k) Cleaning-up operations must always consist of metal removal only. Care must be taken to avoid burnishing (cold flow), even in minute amounts, because of the danger of trapping moisture.

(m) Stop drilling is done with a No. 40 (.098 inch) drill. Make certain that the drill hole engages the extremity of the crack.

(n) Adequate support must always be provided for the part being repaired.

(p) Symbol ~~S~~ means number of equal spaces.

(q) The term developed length means the total length in the section of a member. Thus, the developed length of a C-channel section would be the sum of the width of the upper and lower flanges and the web depth. Use a flexible steel tape to take this measurement.

(r) Oversize holes for conventional driven rivets may be used as is if they are not more than 15% oversize, since the rivet will expand sufficiently to fill the hole. This rule applies only to protruding head rivets and to the cylindrical portion of the hole for flush rivets. It does not apply to the countersunk portion of a hole. A table of 15% oversize hole diameters is provided for reference.

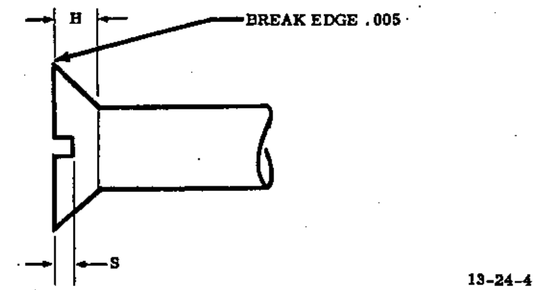
Rivet size	3/32*	1/8	5/32	3/16	1/4
Maximum hole dia.	.115	.150	.186	.223	.300

Screw Replacement for Flush Hi-Shear Rivet

8 Whenever it is necessary to substitute a screw for a flush Hi-Shear rivet when the hole and countersink are not oversize, a special screw is to be used. This special screw is made from a standard AN509 screw and must conform to all dimensions of the latter except as shown in Figure 24-5. The use of the slotted or recessed type head is optional.

Negligible Damage

9 Damage as outlined in Figures 24-6 to 24-10 inclusive may be regarded as negligible



Size	Make From	H	S (max.)
3/16	AN509-10	.047-.045	.036
1/4	AN509-416	.061-.059	.036
5/16	AN509-516	.068-.066	.045
3/8	AN509-616	.078-.076	.045

Same as Hi-Shear rivet.

NOTE

(1) The head of the special screw must be stamped SPL.

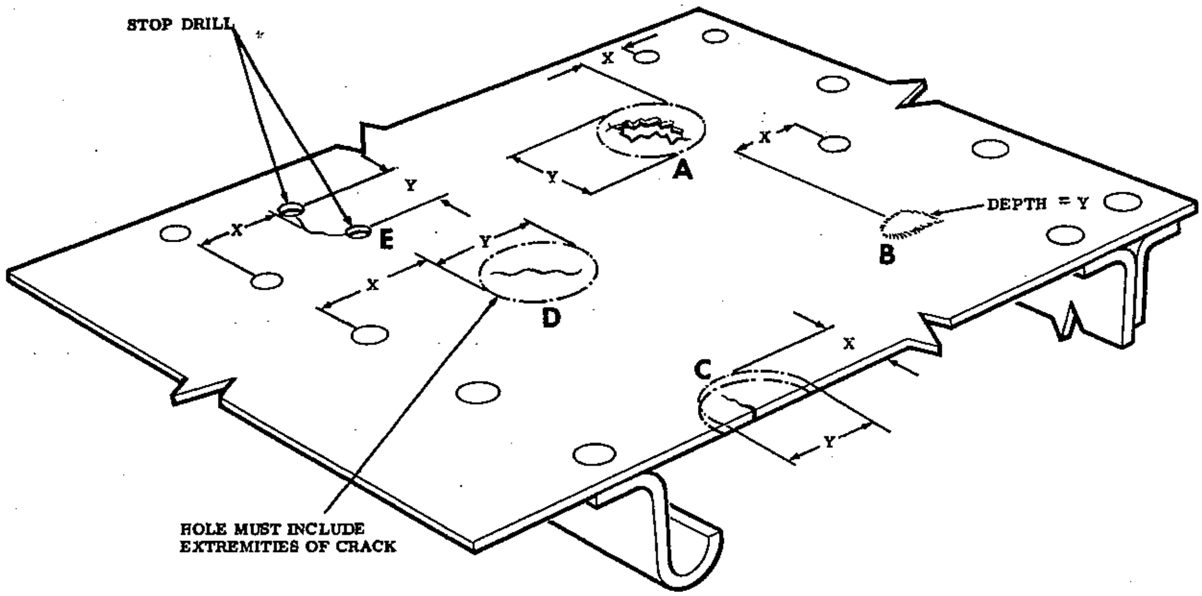
(2) There must be sufficient clearance and a flat seat for the nut. Where a flat seat does not already exist, spotfacing is not permitted.

(3) After machining to the above dimensions, the screw must be stripped of old plating and cadmium plated, (refer to Part 23, preceding).

(4) If there is insufficient tool grip after machining a recessed type head, and it is found necessary to install a standard AN509 screw first and then mill down the head, the newly exposed surface of the head must be spotplated to prevent corrosion.

(5) If a small number of screws are involved, the heads can be conveniently protected with soft solder, (refer to Part 20, preceding).

Figure 24-5 Screw Replacement Details



A SKIN PUNCTURE CLEANED UP WITH A CLEAN, ROUND HOLE

B SMALL INDENTATION FREE FROM CRACKS AND ABRASIONS

C DAMAGE AT EDGE OF SHEET CLEANED UP TO SMOOTH CONTOUR

D CRACK CLEANED UP WITH A CLEAN, ROUND HOLE

E CRACK STOP DRILLED AT EXTREMITIES

	A		B		C		D		E	
	X	Y	X	Y	X	Y	X	Y	X	Y
* WING	1-1/2	1/2	1-1/2	1/32	1/4	1/2	1-1/2	1/2	1-1/2	1/2
WING TIPS, AILERONS & FLAPS	NONE		1-1/2	1/32	NONE		NONE		NONE	
** FUSELAGE	1-1/2	1/2	1-1/2	1/32	1-1/2	1/2	1-1/2	1/2	1-1/2	1/2
*** DIVE FLAPS	1-1/2	3/4	1-1/2	1/32	1/4	1/2	1-1/2	3/4	1-1/2	3/4
FILLETS	NONE		1-1/2	1/32	NONE		NONE		NONE	
* STABILIZER & FIN	1-1/2	1/2	1-1/2	1/32	1-1/2	1/2	1-1/2	1/2	1-1/2	1/2
ELEVATOR & RUDDER	NONE		1-1/2	1/32	NONE		NONE		NONE	
*** L G DOORS	1-1/2	1/2	1-1/2	1/32	1-1/2	1/2	1-1/2	1/2	1-1/2	1/2
TAIL PIPE	1-1/2	1	1-1/2	1/16	1-1/2	1	1-1/2	1	1-1/2	1

* AREA CONTAINED WITHIN THE FUSELAGE OR FILLETS ONLY i.e. THE COVERED CENTRE SECTION.

** TYPE A, C, D, OR E DAMAGES APPLY TO NON-CRITICAL FUSELAGE AREAS ONLY.

*** TYPE A, C, D, OR E DAMAGES APPLY TO INNER SKINS ONLY.

COVER HOLES WITH FABRIC PATCHES.

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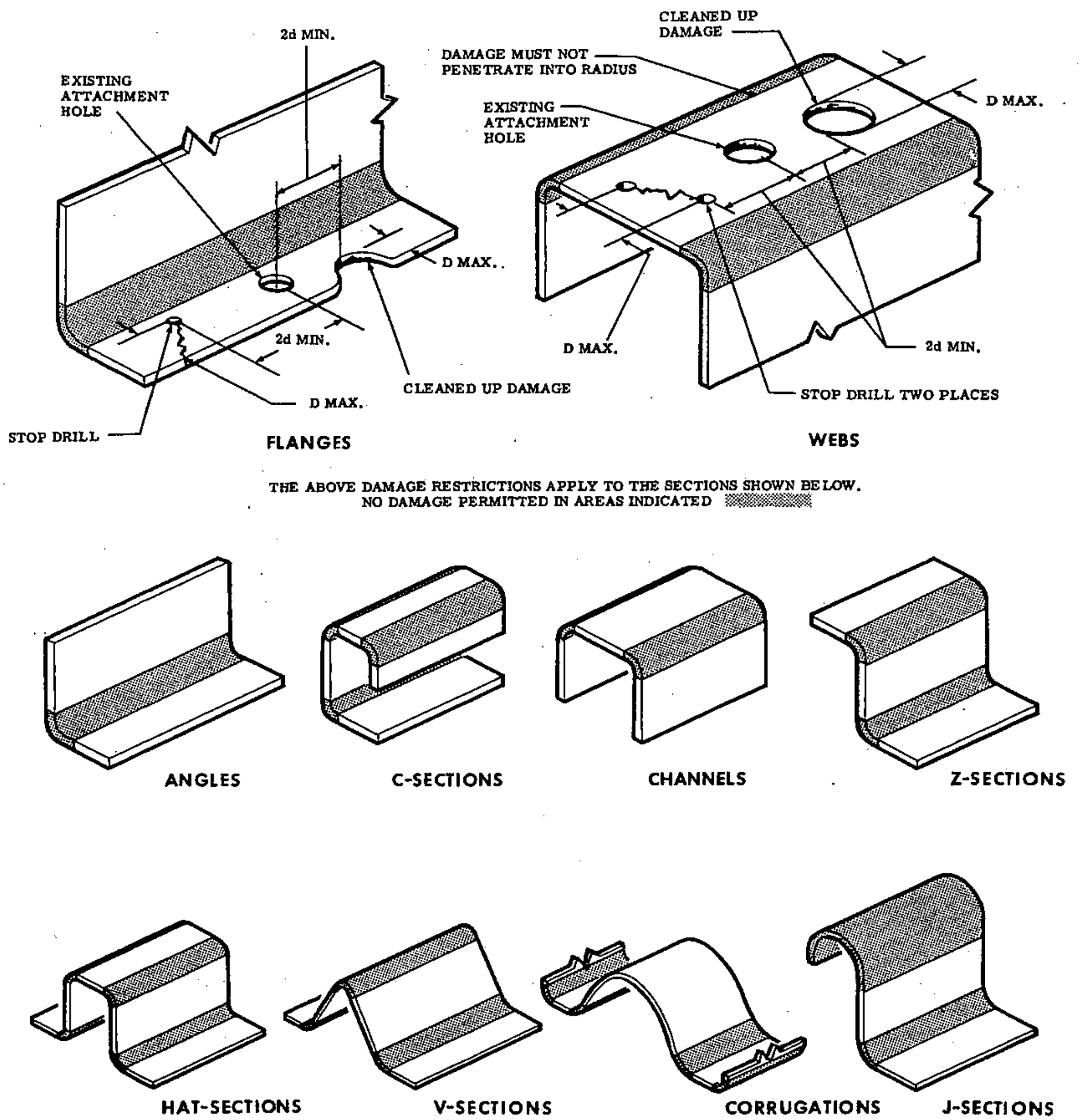
Figure 24-6 Skin - Negligible Damage



NOTES:

1 DAMAGE PERMITTED TO ONLY ONE COMPONENT IN ANY ONE CROSS SECTION.

2 NO REDUCTION IN SECTION PERMITTED IN COMPONENTS WHERE ORIGINAL DOES NOT CONTAIN ATTACHMENT HOLES.

3 ALL DAMAGE SHALL BE CLEANED UP TO A SMOOTH RADIUS OR STOP-DRILLED AS SHOWN.

4 D DENOTES THE DIAMETER OF THE LARGEST EXISTING ATTACHMENT HOLE IN THE DAMAGED COMPONENT.

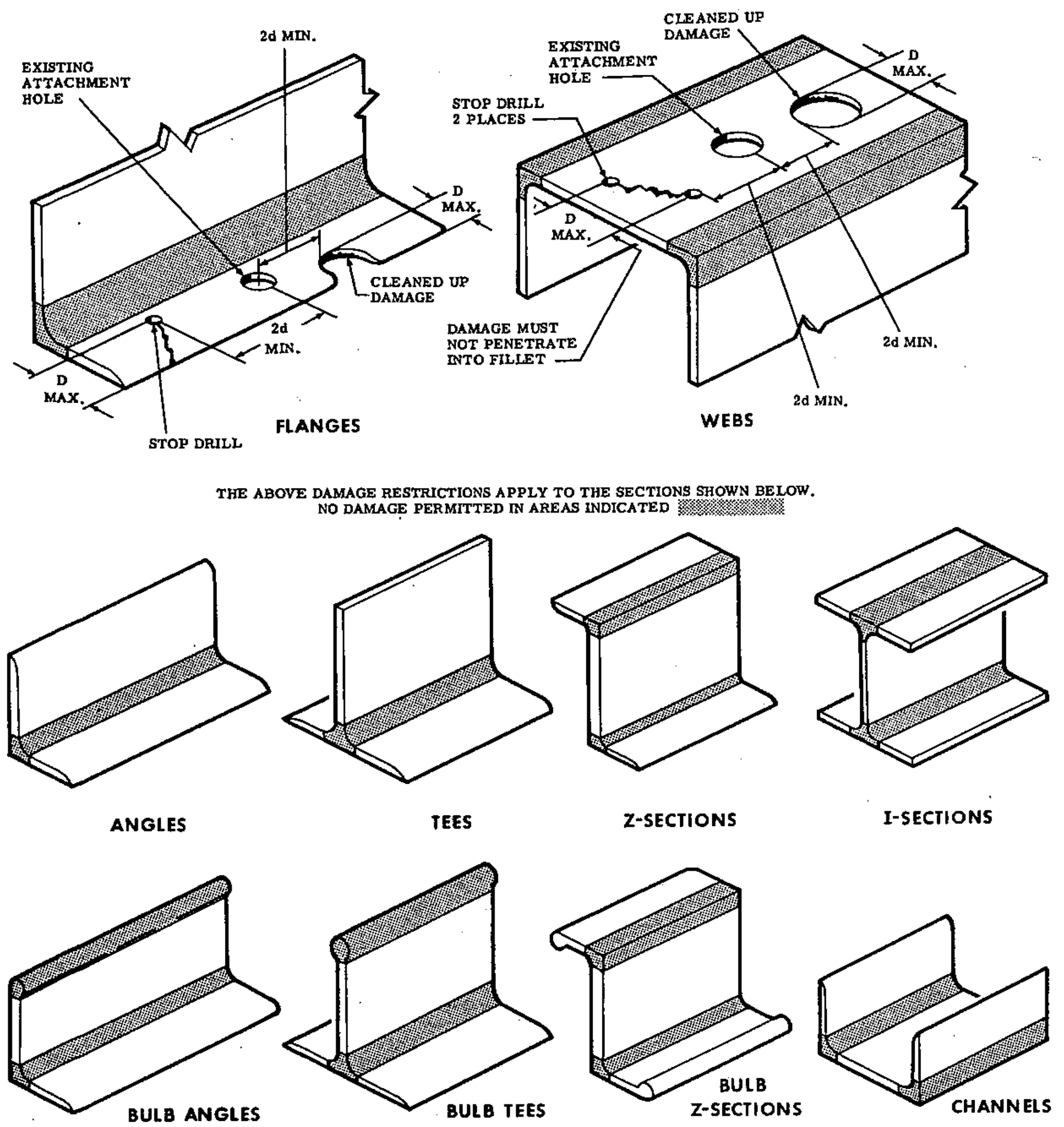
5 d DENOTES THE DIAMETER OF THE ATTACHMENT HOLE ADJACENT TO THE DAMAGE.

6 DENTS PERMITTED TO A DEPTH EQUAL TO t (THICKNESS OF THE MATERIAL).

7 NICKS AND SCRATCHES MUST BE SMOOTHED AND FAIRED INTO THE ADJACENT MATERIAL, REDUCTION IN CROSS-SECTIONAL AREA MUST NOT EXCEED D x t SQ. IN.

13-24-8

Figure 24-7 Sheet Metal Sections - Negligible Damage



NOTES:

1 DAMAGE PERMITTED TO ONLY ONE COMPONENT IN ANY ONE CROSS SECTION.

2 NO REDUCTION IN SECTION PERMITTED IN COMPONENTS WHERE ORIGINAL DOES NOT CONTAIN ATTACHMENT HOLES.

3 ALL DAMAGE SHALL BE CLEANED UP TO A SMOOTH RADIUS OR STOP-DRILLED AS SHOWN.

4 D DENOTES THE DIAMETER OF THE LARGEST EXISTING ATTACHMENT HOLE IN THE DAMAGED COMPONENT.

5 d DENOTES THE DIAMETER OF THE ATTACHMENT HOLE ADJACENT TO THE DAMAGE.

6 DENTS PERMITTED TO A DEPTH EQUAL TO t THICKNESS OF THE MATERIAL.

7 NICKS AND SCRATCHES MUST BE SMOOTHED AND FAIRED INTO THE ADJACENT MATERIAL. REDUCTION IN CROSS-SECTIONAL AREA MUST NOT EXCEED D x t SQ. IN.

13-24-9

Figure 24-8 Extruded Sections - Negligible Damage

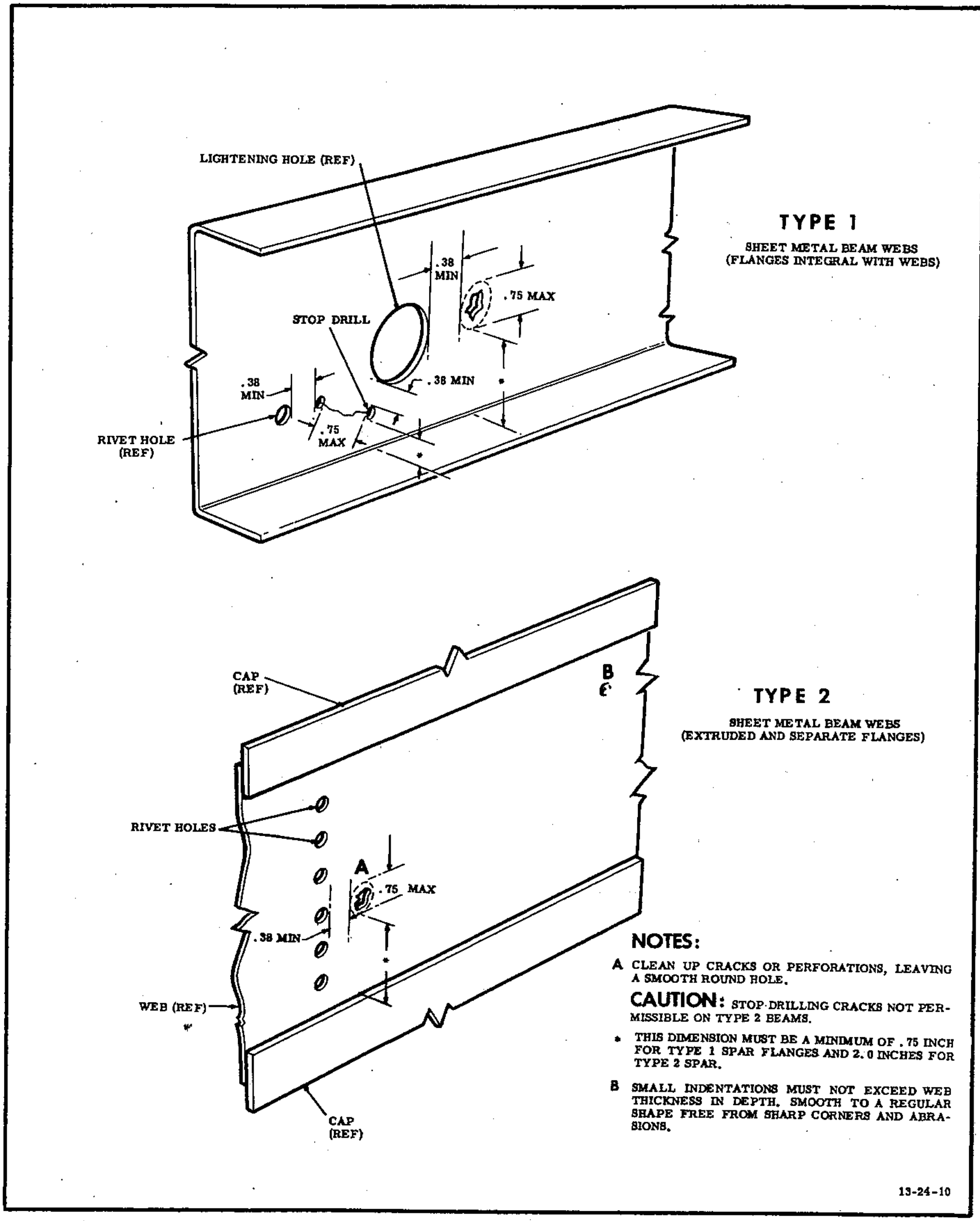
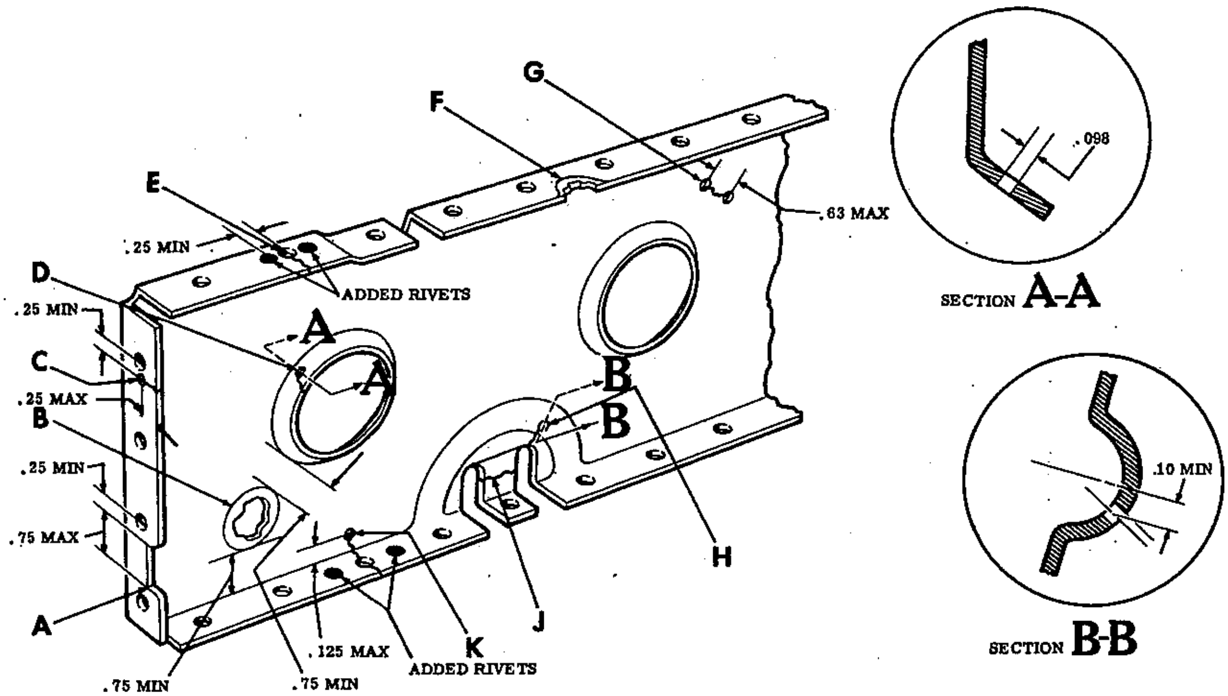


Figure 24-9 Spars - Negligible Damage



A DAMAGE TO END FLANGE - CLEAN UP TO A REGULAR CONTOUR WITH .12 CORNER RADII.

B DAMAGE TO WEB - CLEAN UP LEAVING A SMOOTH ROUND HOLE (.75 MAXIMUM DIAMETER).

C CRACK IN FLANGE NOT APPROACHING WITHIN .25 OF RIVET HOLE - STOP DRILL NO. 40 (.098).

D CRACK IN FLANGE OF LIGHTENING HOLE - STOP DRILLING MUST NOT ENCROACH IN RADIUS.(REF SECTION A-A).

E CRACK THROUGH RIVET HOLE TO EDGE OF FLANGE, OR CRACK WITHIN .25 OF RIVET HOLE - ADD RIVETS ON EITHER SIDE OF CRACK AS SHOWN.

F NICK IN FLANGE - CLEAN UP AND BLEND INTO SMOOTH CONTOUR.

G CRACK IN WEB - STOP DRILL.

H CRACK FROM CUTOUT IN BEAD - STOP DRILL IF .10 FROM CROWN OF BEAD. (REF SECTION B-B).

J BREAK AT THIS POINT - CLEAN UP DAMAGE BY BLENDING INTO SURROUNDING CONTOURS. REPLACE CLIP WITH NOT LESS THAN 4 RIVETS OF SAME SIZE AND STRENGTH AS USED IN FLANGE.

K CRACK THROUGH RIVET HOLE EXTENDS MAXIMUM OF .12 PAST BEND RADIUS - ADD RIVETS ON BOTH SIDES OF CRACK.

NOTES:

1 DAMAGE SUCH AS **B** OR **G** MUST BE AT LEAST SIX INCHES FROM SIMILAR DAMAGE.

2 DAMAGE SUCH AS **C D** OR **F** MUST BE AT LEAST TWO INCHES FROM ANY OTHER DAMAGE.

3 DEPTH OF **A** OR **F** MUST NOT EXCEED ONE-THIRD WIDTH OF FLANGE.

13-24-11

Figure 24-10 Channels - Negligible Damage and can be repaired by cleaning up, stop drilling, etc., as detailed. If it is necessary to plug the hole, a doped fabric patch will frequently be adequate. Proceed as follows:

(a) Cut the patch to overlap at least 1 inch past the cleaned-up hole, and clean the skin to the bare metal at least 1-1/4 inch past the hole.

(b) Apply a heavy coat of nitrate dope to the metal skin.

(c) Saturate a fabric patch with dope and place over hole. Smooth the patch flat.

(d) Apply 4 or 5 coats of dope over patch, allowing the dope to dry between each application. Smooth the surface between each coat with fine sandpaper.

(e) When last coat is dry and patch is drawn tight, apply finish lacquer to match adjacent paint.

NOTE

Dope must overlap edge of patch 1/4 inch to prevent edge from curling.

Typical Damage

10 Figures 24-11 to 24-38 inclusive show typical repairs to damages in various parts of stressed skin aircraft. Although the damage to be repaired will frequently not coincide with any single example shown, a careful study of related repairs should indicate the course to be followed. The general notes in Paragraph 7, preceding, should be adhered to where applicable.

CAUTION

Remember that an overstrength repair is usually harmless; an understrength repair can be disastrous.

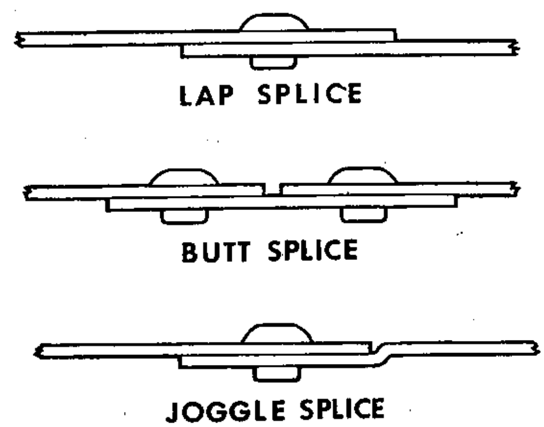
Sheet Splices

NOTE

The following does not apply to integrally stiffened sheets.

11 When sheet damage is extensive, it is frequently preferable to replace a panel rather than effect a number of individual patches. When possible, the repair seam should be made to lie along stiffening members, such as ribs, frames, etc. and each seam should be made an exact copy of the parallel manufactured seams at the edges of the original sheet. If the two manufactured seams are different, the stronger should be used. If, because of structural complexity or any other reason, the original seam is unsatisfactory as a pattern, splices should be made.

12 There are three types of splices in common use, the lap splice, the butt splice

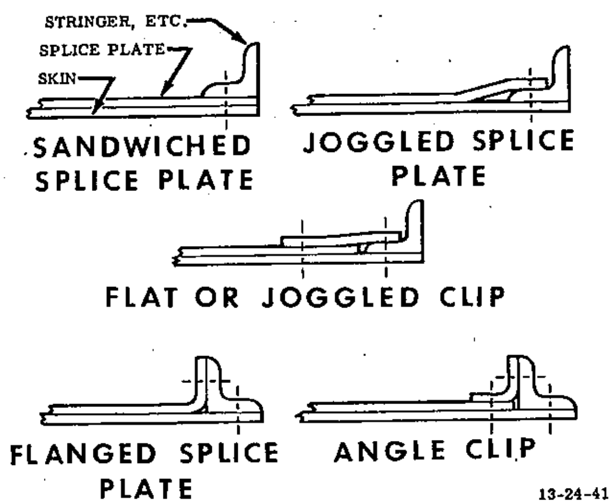


13-24-40

and the joggle splice. The lap splice is simpler, but sometimes cannot be used because of aerodynamic cleanness requirements or for structural reasons, as in the case of a spar web sandwiched between double spar cap angles.

13 When a butt splice is used, the splice plate must be made from the same type material and at least the same thickness as the sheets. In the case of relatively thin sheets, it is generally preferable to stiffen the splice plate either by flanging it or making it thicker than the sheets. The two edges of the splice plate crossing the line of separation between the sheets must be adequately attached to structural members normal to the splice. For example, chordwise wing skin splices must have the front and rear edges of the splice plates attached to stringers or spar caps. If the splice plate is cut into several pieces so that it is not

continuous across stringers or other intervening members, the same rule about end attachment applies to each piece. A few suggested types of end attachment are shown.



13-24-41

14 Of the types shown, the particular choice for any given situation will depend upon the circumstances. It should be noted, however, that since the sandwiched splice plate distorts the sheet to some extent, it should be used only for relatively thin gauges and then only when the consideration of aerodynamic cleanness will permit its use. It should never be used for relatively thick sheets where high axial loads in the sheet require that the sheet be free from local displacements from a smooth contour. Such local bumps in a sheet highly loaded in compression could cause an unstable condition resulting in failure. Recommended specifications for sheet splices are shown in Figure 24-39. When a sheet splice is to be made, the following general rules must be observed:

(a) The replacement section of the sheet must be made from the same gauge and material as the original sheet.

(b) No splice may be made in the same bay as the end of the sheet.

(c) No rivet in the splice may have an edge distance in the splice plate or in either sheet less than that called in the appropriate sheet splice table. (See Figure 24-39.)

(d) In the case of butt splices, the gauge of the splice plate must be at least as great as the gauge of the sheets, except as noted in the sheet splice tables. (See Figure 24-39.)

(e) In the case of butt splices, the splice plate must be made either from the same material as the sheets or from one of the acceptable substitutes listed:

(1) When splicing sheets, the splice plate may be made from any of the materials listed above the basic sheet material:

75S-T6 Bare
75S-T6 Clad
24S-T3 Bare
24S-T3 Clad
24S-T4 Bare
24S-T4 Clad

(2) There is no acceptable substitute for FS-1H magnesium sheet.

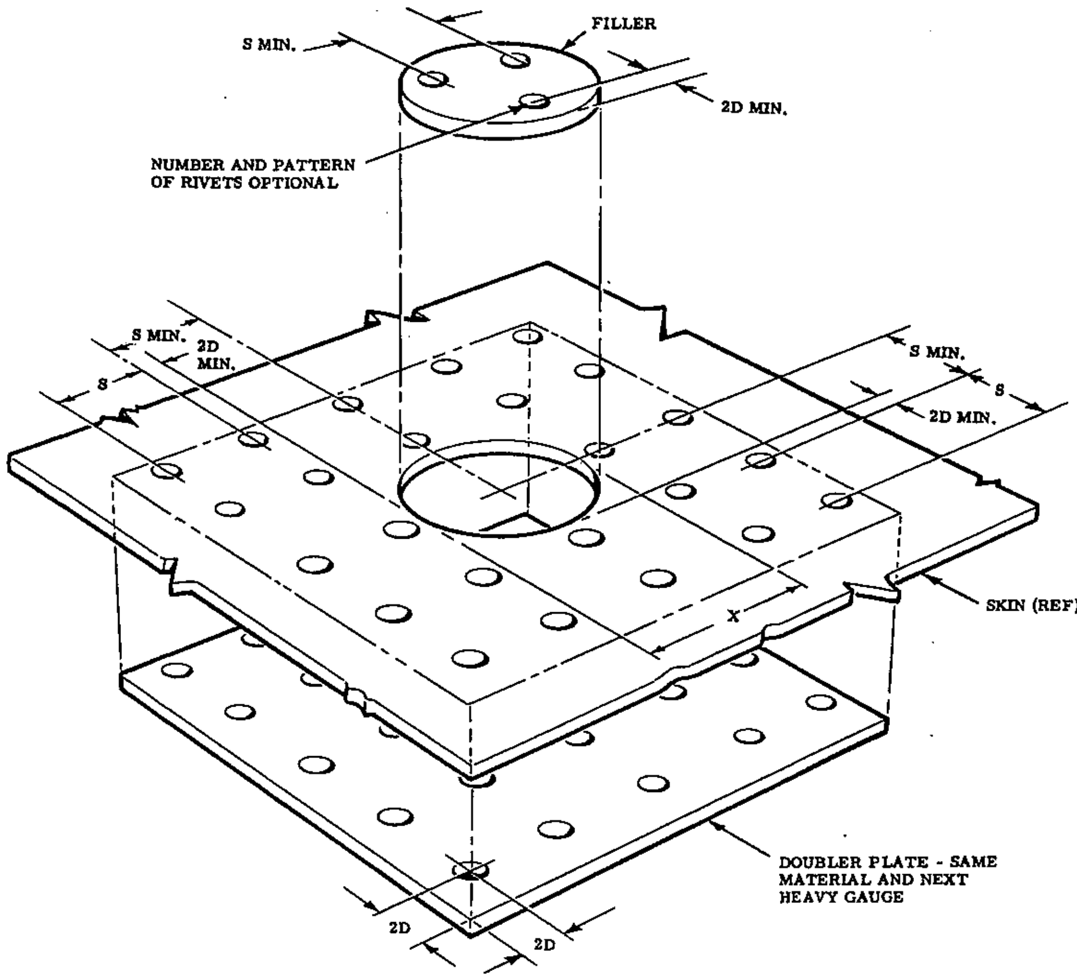
(3) 1/2 hard corrosion resistant steel sheet may be substituted for annealed corrosion resistant steel sheet.

(f) When protruding head Hi-Shear rivets are called out in Figure 24-39, AN3 series bolts may be substituted. Flush screws may not be substituted for flush Hi-Shear rivets, except as specified in Paragraph 8, preceding.

(g) The indicated number of rows of rivets is required on each side of a butt splice. For lap and joggle splices the indicated number of rows is the total for the splice. The edge distance specified in Figure 24-39 is to be maintained in both sheets and in the splice plate.

(h) Flush rivet installation is coded as follows:

Code	Butt Splice	Lap and Joggle Splice
D2	Dimple sheet and splice plate.	Dimple both sheets.
DC	Dimple sheet, subcountersink splice plate.	
C	Countersink sheet.	Countersink top sheet.



NOTES:

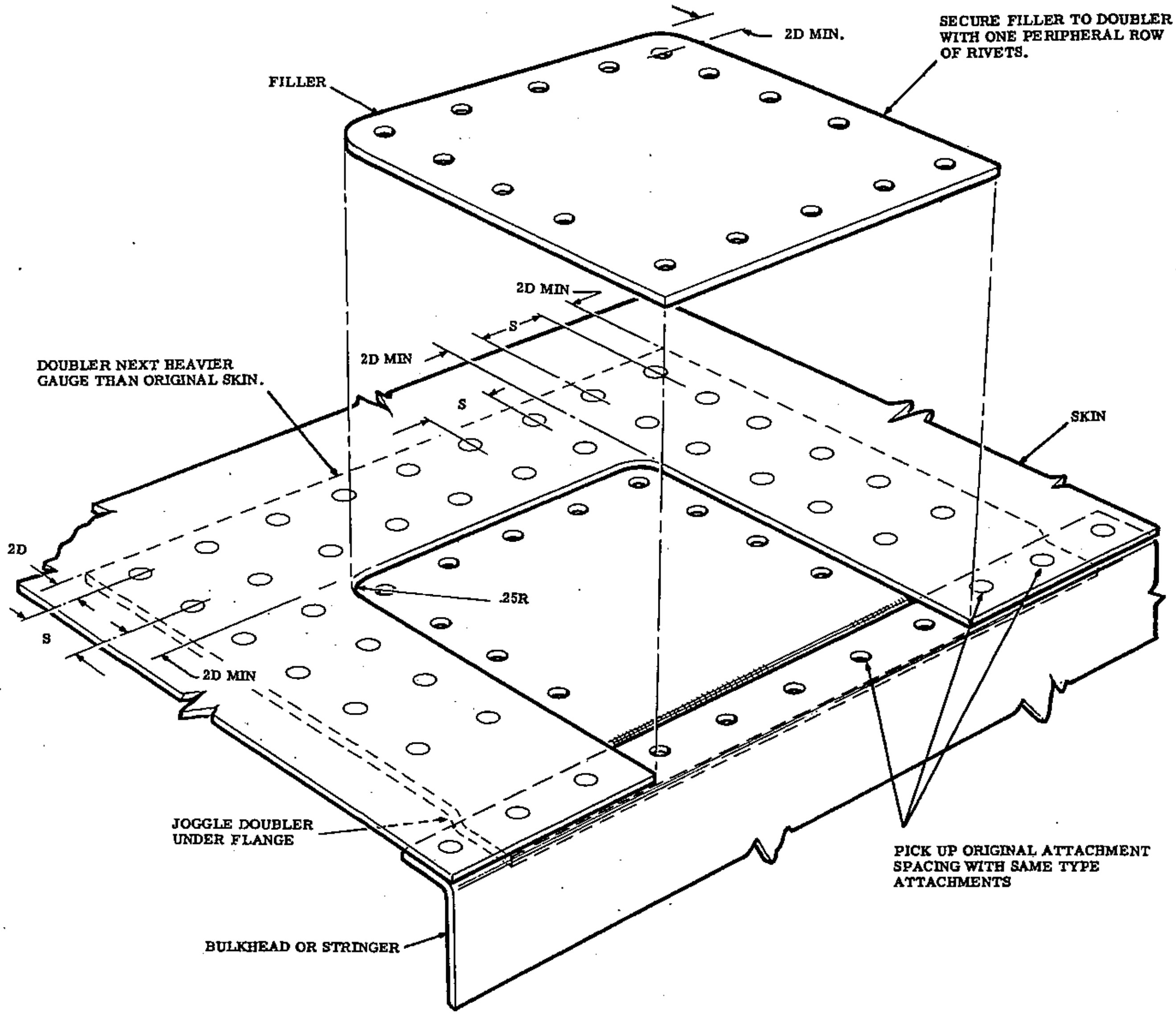
1 CLEAN UP DAMAGED AREA TO A CLEAN ROUND HOLE.

2 NOT SUITABLE FOR STAINLESS STEEL SKINS.

RIVET REQUIREMENTS				
SKIN GAUGE	MAXIMUM PERMISSIBLE DAMAGE DIAMETER (X)	TYPE OF RIVETS REQUIRED	RIVET SPACING (S)	EDGE DISTANCE (2D)
.016 TO .025 ²	1.06	AN426 AD3	.41	.19
.032	1.56	AN426 AD4	.55	.25
.040	1.40	AN426 AD4	.55	.25
.051	1.48	AN426 AD5	.67	.31
.064	1.10	AN426 AD6	1.11	.38
.072	1.06	AN426 AD6	1.07	.38
.081	1.27	AN426 DD6	1.03	.38
.091	1.19	AN426 DD6	1.00	.38

13-24-12

Figure 24-11 Small Skin Patch in Open Areas



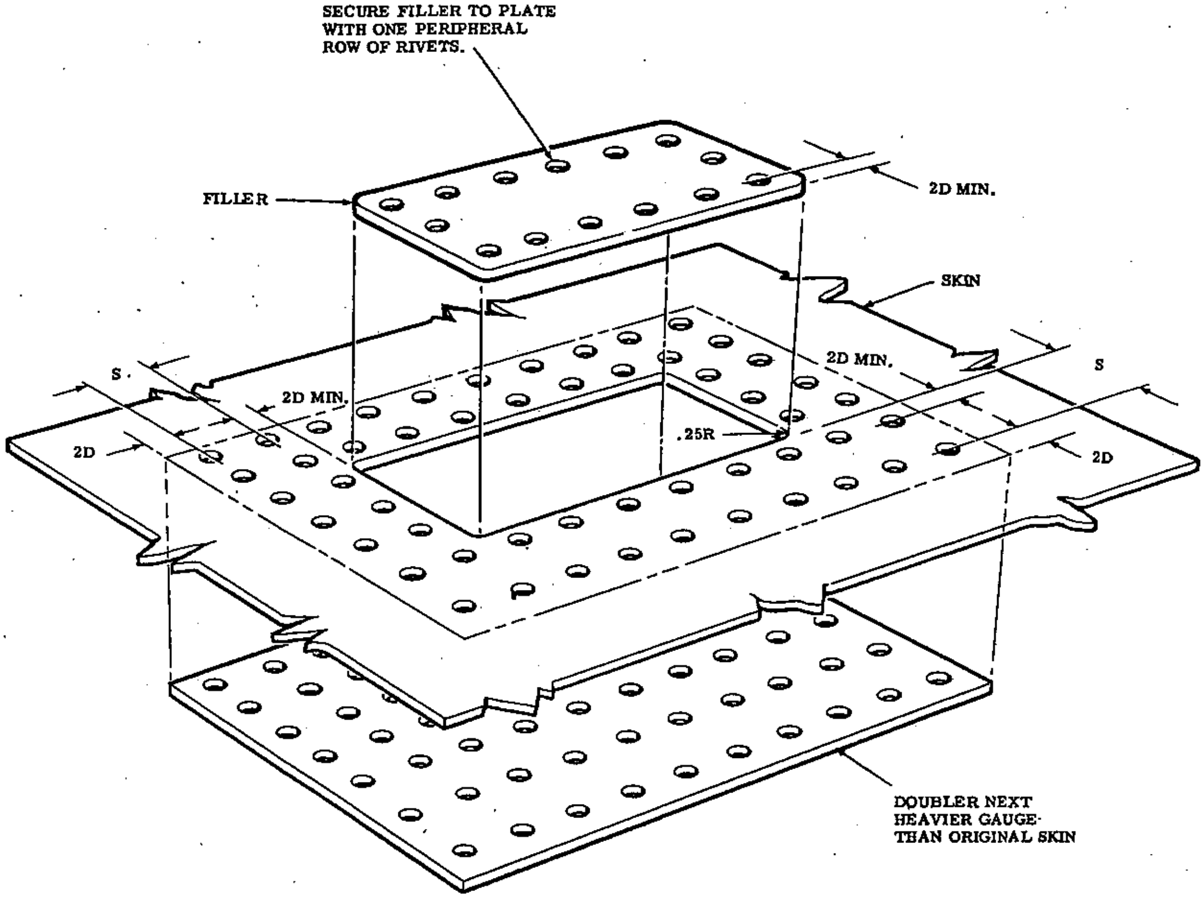
NOTE: NOT SUITABLE FOR STAINLESS STEEL SKINS

RIVET REQUIREMENTS

GAUGE	NUMBER OF ROWS REQUIRED			RIVET SIZE REQUIRED			SPACING (S)			EDGE DISTANCE (2D)		
	AD	DD	BLIND	AD	DD	BLIND	AD	DD	BLIND	AD	DD	BLIND
.016	2			3			.41			.19		
.020	3			3			.50			.19		
.025	3		3	3		4	.46		.55	.19		.25
.032	3		4	3		4	.42		.56	.19		.25
.040	3		4	4		5	.63		.70	.25		.31
.051	3		5	5		5	.71		.73	.31		.31
.064	6	5	7	6	6	6	1.11	1.13	1.11	.38	.38	.38
.072	7	5	8	6	6	6	1.14	1.11	1.13	.38	.38	.38
.081	7	5	8	6	6	6	1.08	1.04	1.04	.38	.38	.38
.091	7	5	8	6	6	6	1.04	1.00	1.06	.38	.38	.38

13-24-13

Figure 24-12 Skin Patch at Edge

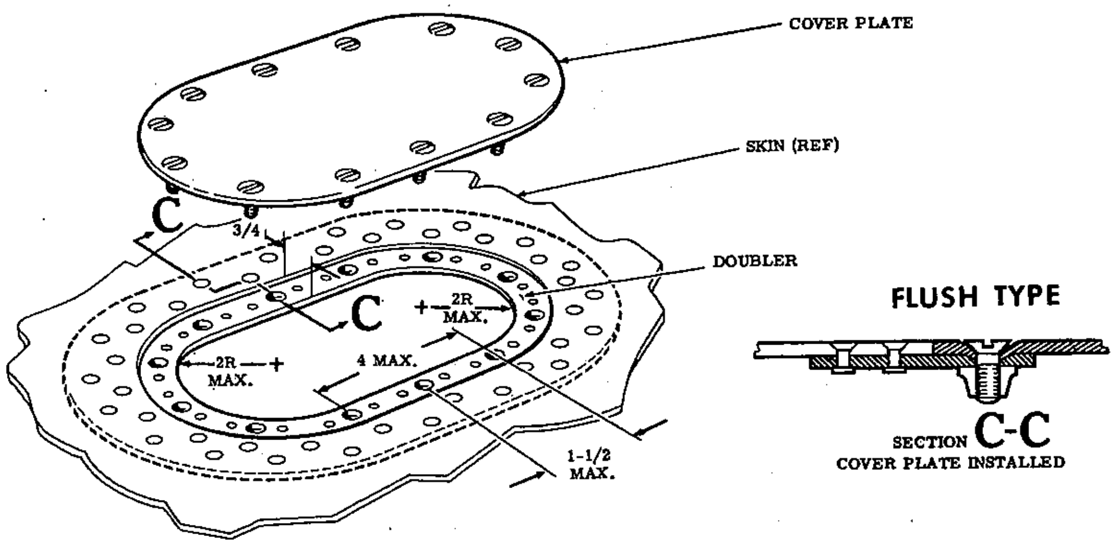


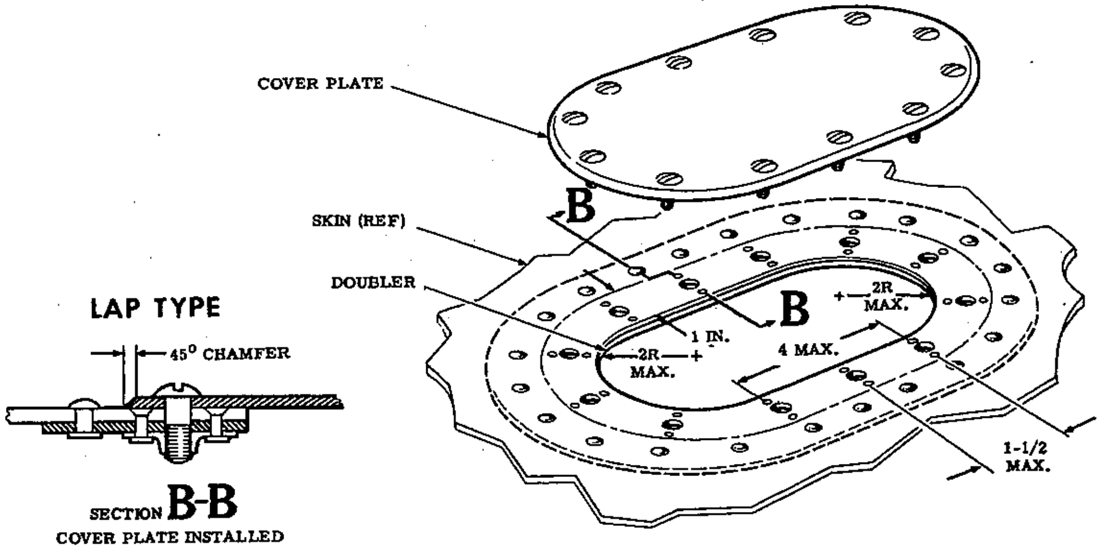
NOTE:
NOT SUITABLE FOR STAINLESS STEEL SKINS.

RIVET REQUIREMENTS												
GAUGE	NUMBER OF ROWS REQUIRED			RIVET SIZE REQUIRED			SPACING (S)			EDGE DISTANCE (2D)		
	AD	DD	BLIND	AD	DD	BLIND	AD	DD	BLIND	AD	DD	BLIND
.016	2			3			.41			.19		
.020	3			3			.50			.19		
.025	3		3	3		4	.46		.55	.19		.25
.032	3		4	3		4	.42		.56	.19		.25
.040	3		4	4		5	.63		.70	.25		.31
.051	3		5	5		5	.71		.73	.31		.31
.064	6	5	7	6	6	6	1.11	1.13	1.11	.38	.38	.38
.072	7	5	8	6	6	6	1.14	1.11	1.13	.38	.38	.38
.081	7	5	8	6	6	6	1.08	1.04	1.04	.38	.38	.38
.091	7	5	8	6	6	6	1.04	1.00	1.06	.38	.38	.38

13-24-14

Figure 24-13 Flush Skin Patch





RIVET REQUIREMENTS			
MATERIAL GAGE	RIVET DIA. (D)	(3D) EDGE DISTANCE	(6D) RIVET SPACING
.025	1/8	3/8	3/4
.032	1/8	3/8	3/4
.040	5/32	15/32	15/16
.051	5/32	15/32	15/16
.064	3/16	9/16	1-1/8

NOTES:

1 USE SCREWS AN509 OR AN525 AND NUTS AN373 OR AN366 OR EQUIVALENT. REFER TO PART 6.

2 DOUBLER TO BE NEXT GAUGE HEAVIER THAN SKIN.

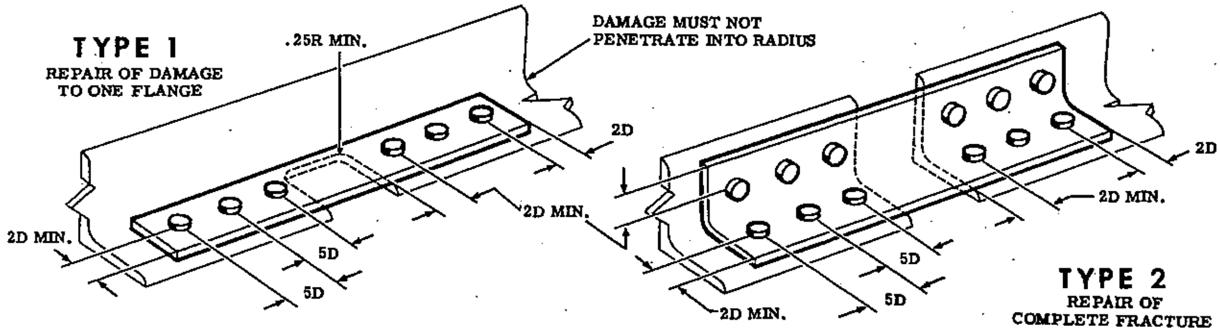
3 FLUSH COVER PLATE SAME GAUGE AS SKIN.

4 LAP COVER PLATE SAME OR NEXT GAUGE HEAVIER.

5 CHAMFER EDGES OF LAP COVER PLATE.

13-24-15

Figure 24-14 Installation of Access Panels



NOTES:

1 REPAIR MEMBER TO BE NEXT HEAVIER GAUGE THAN ORIGINAL ANGLE.

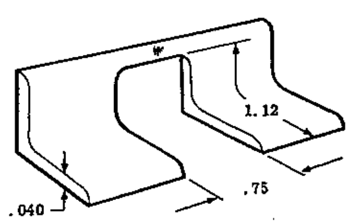
2 USE EXISTING ATTACHMENT SPACING WHERE FLANGES WERE ORIGINALLY ATTACHED OTHERWISE USE INDICATED SPACING.

3 BLIND SELF-PLUGGING RIVETS MAY BE SUBSTITUTED FOR SAME DIAMETER SOLID RIVETS PROVIDED THE NUMBER OF RIVETS IS INCREASED AT A RATIO OF 3 TO 2.

RIVET REQUIREMENTS

NUMBER OF RIVETS REQUIRED ON EACH SIDE OF DAMAGED AREA. INTERPOLATE FOR INTERMEDIATE VALUES

ANGLE GAUGE	TYPE OF RIVETS REQUIRED	LONGITUDINAL SPACING (5D)	MINIMUM EDGE DISTANCE (2D)	NUMBER OF RIVETS REQUIRED WHEN EXTENT OF DAMAGE ACROSS ANGLE IS									
				.50	.75	1	1.25	1.50	1.75	2	2.50	3	4
.025	AN470AD4	.63	.25	3	4	5	6	7	8	9	12	14	18
.032	AN470AD4	.63	.25	3	4	6	7	8	10	11	14	16	22
.040	AN470AD5	.78	.31	3	4	5	6	7	8	9	11	13	18
.051	AN470AD5	.78	.31	3	4	6	6	8	10	11	14	16	22
.064	AN470AD5 AN470DD6	.78 .94	.31 .38	4 2	5 3	7 4	9 5	10 5	12 6	14 7	17 9	20 11	27 14
.072	AN470AD5 AN470DD6	.78 .94	.31 .38	4 2	6 3	8 4	10 5	12 6	14 7	15 8	19 10	23 12	30 15
.081	AN470AD6 AN470DD6	.94 .94	.38 .38	3 3	5 4	6 5	8 6	9 7	10 8	12 9	15 11	18 13	23 17
.091	AN470AD6 AN470DD6	.94 .94	.38 .38	4 3	5 4	7 5	9 6	10 8	12 9	13 10	17 12	20 15	27 19
.102	AN470AD8 AN470DD8	1.25 1.25	.50 .50	2 2	3 3	4 3	6 4	7 5	8 6	9 6	11 8	13 9	17 12
.125	AN470AD8 AN470DD8	1.25 1.25	.50 .50	3 2	4 3	5 4	7 5	8 6	9 7	10 8	13 10	15 11	20 15
.156	AN470AD8 AN470DD8	1.25 1.25	.50 .50	4 3	5 4	7 5	8 6	10 7	11 9	13 10	16 12	19 14	25 19
.188	AN470AD8 AN470DD8	1.25 1.25	.50 .50	4 3	6 5	8 6	10 7	12 9	14 10	15 11	19 14	23 17	30 22



EXAMPLE

ASSUME A DAMAGE WHEN CLEANED UP IS .75 INCH WIDE AND EXTENDS 1.12 INCHES ACROSS A .040 ANGLE. APPLY TYPE 2 REPAIR. DETERMINE THE NUMBER OF AN470AD5 RIVETS REQUIRED BY INTERPOLATING BETWEEN .040 - 1 INCH AND .040 - 1.25 INCHES, WHICH GIVES 5-1/2 RIVETS REQUIRED. USE 6 RIVETS. ALWAYS INTERPOLATE TO HIGHEST VALUE. NUMBER OF BLIND RIVETS IS 3/2 x 6=9 RIVETS REQUIRED ON EACH SIDE OF DAMAGE. SINCE DAMAGE LENGTH EXCEEDS .50, A .040 FILLER WILL BE REQUIRED.

13-24-16

Figure 24-15 Angle Repair

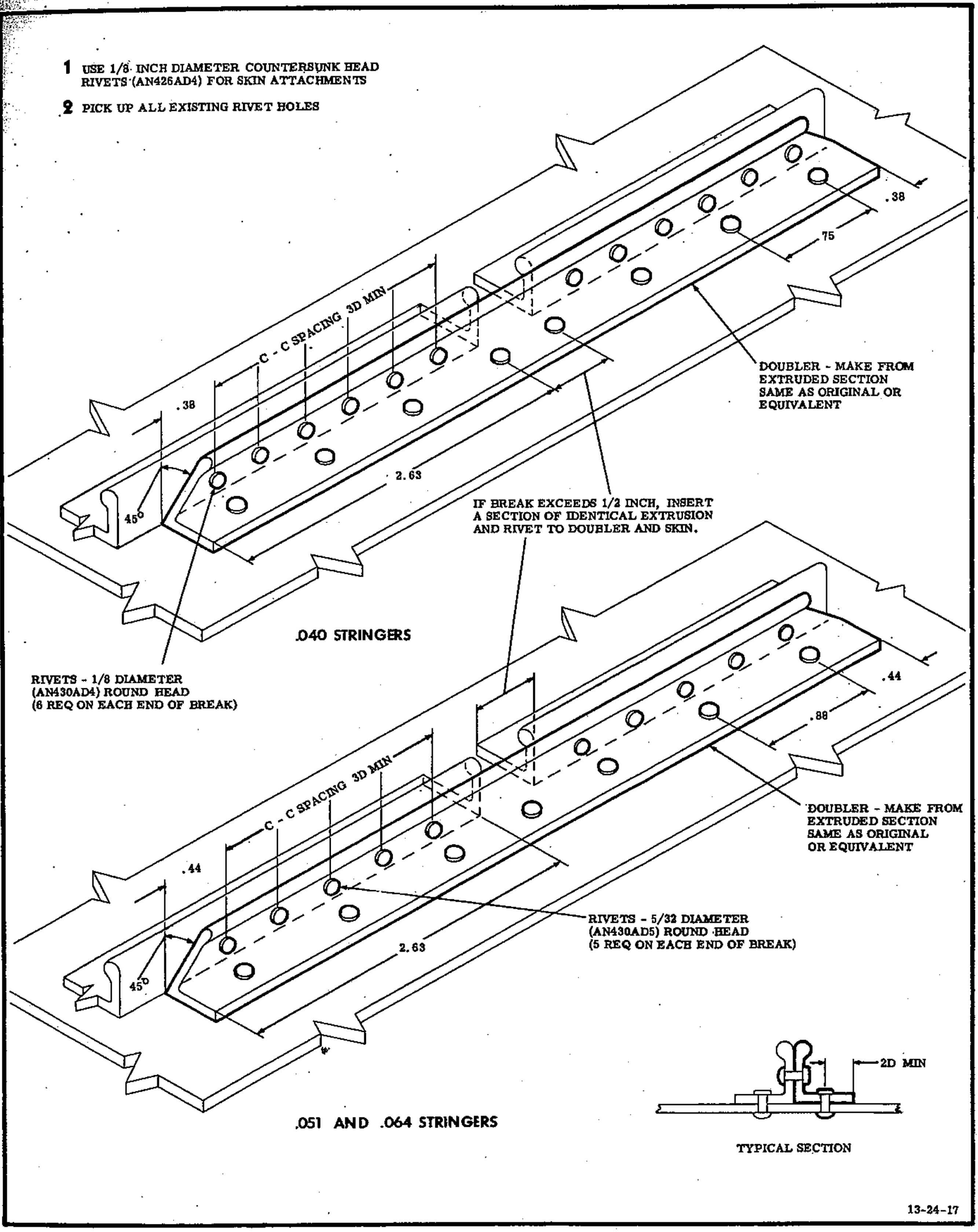


Figure 24-16 Extruded Bulb Angle Repair

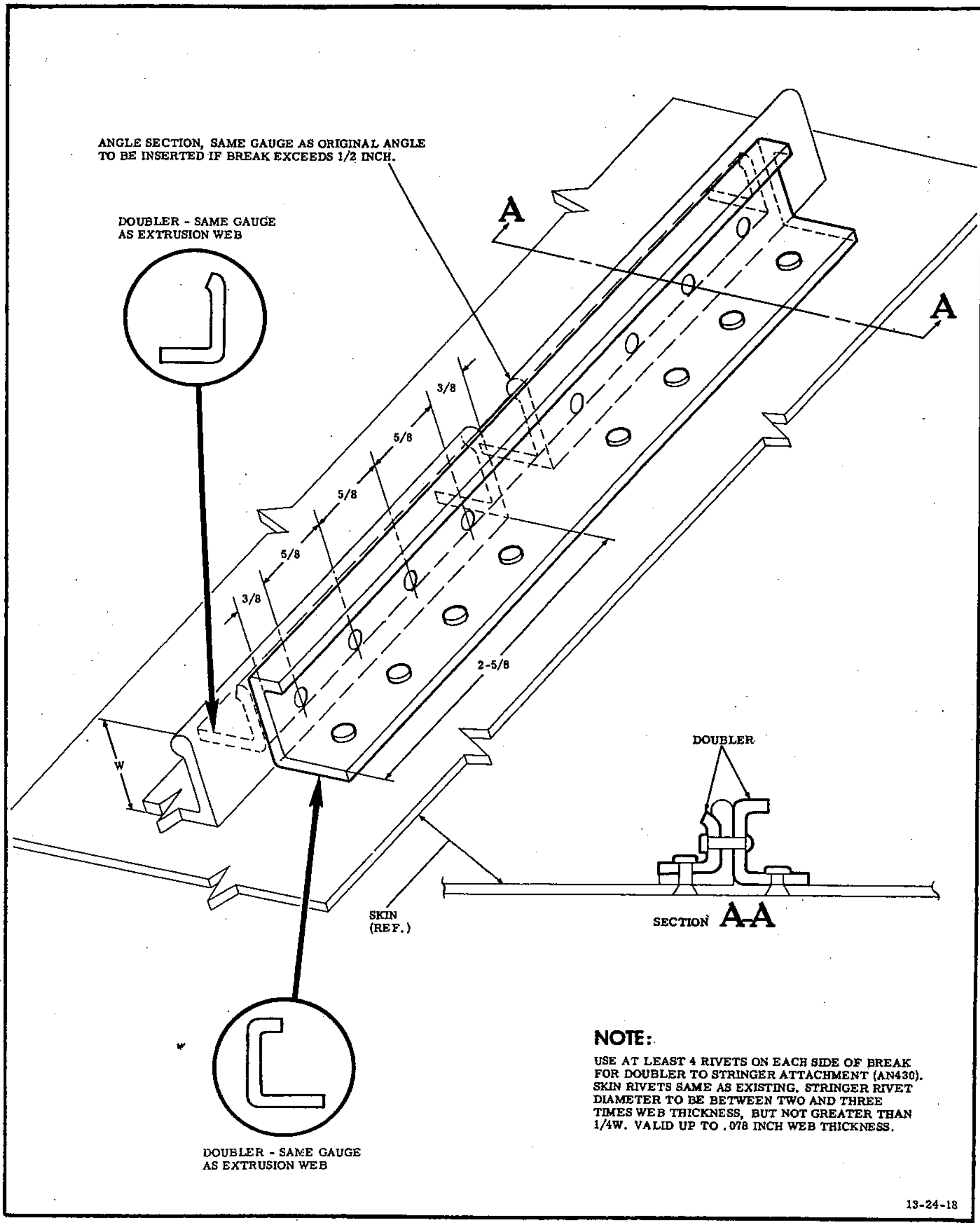
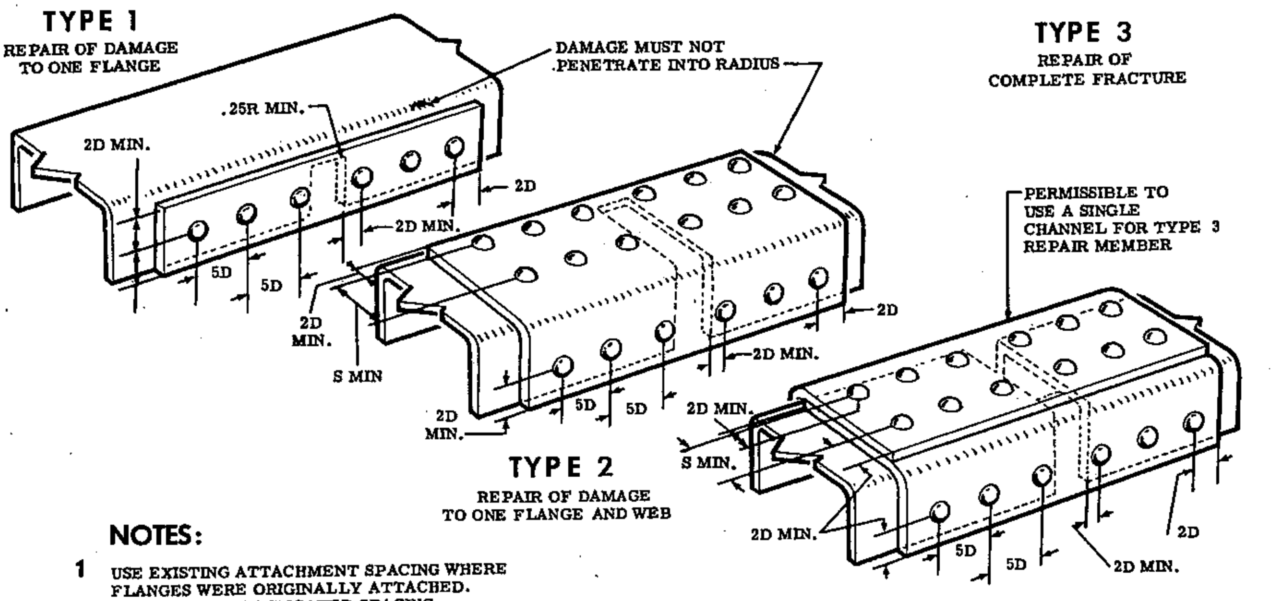


Figure 24-17 Extruded Bulb Angle Repair - Sheet Metal



NOTES:

1 USE EXISTING ATTACHMENT SPACING WHERE FLANGES WERE ORIGINALLY ATTACHED. OTHERWISE USE INDICATED SPACING.

2 USE SAME GAUGE AS ORIGINAL IF REPAIR IS APPLIED TO OUTSIDE OF CHANNEL. REPAIR MEMBERS TO BE NEXT HEAVIER GAUGE IF APPLIED TO INSIDE OF CHANNEL.

3 BLIND SELF-PLUGGING RIVETS MAY BE SUBSTITUTED FOR SAME DIAMETER SOLID RIVETS PROVIDED THE NUMBER OF RIVETS IS INCREASED AT A RATIO OF 3 TO 2.

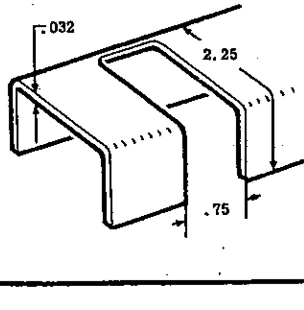
4 FOR SKIN ATTACHMENT USE FLUSH HEAD OR BLIND FLUSH HEAD RIVETS.

5 IF DAMAGED LENGTH EXCEEDS .50 INCH USE FILLER.

RIVET REQUIREMENTS

NUMBER OF RIVETS REQUIRED ON EACH SIDE OF DAMAGED AREA. INTERPOLATE FOR INTERMEDIATE VALUES.

CHANNEL GAUGE	TYPE OF RIVETS REQUIRED	LONGITUDINAL SPACING (5D)	MINIMUM TRANSVERSE SPACING (S)	MINIMUM EDGE DISTANCE (2D)	NUMBER OF RIVETS REQUIRED WHEN EXTENT OF DAMAGE ACROSS CHANNEL IS									
					.50 IN.	1 IN.	1.50 IN.	2 IN.	2.50	3	4	5	6	7
.025	AN470AD4	.63	.55	.25	3	5	7	9	12	14	18	22	27	31
.032	AN470AD4	.63	.55	.25	3	6	8	11	14	16	22	27	32	38
.040	AN470AD5	.78	.67	.31	3	5	7	9	11	13	18	22	26	30
.051	AN470AD5	.78	.67	.31	3	6	8	11	14	16	22	27	32	37
.064	AN470AD5 AN470DD6	.78 .94	.67 1.07	.31 .38	4 2	7 4	10 5	14 7	17 9	20 11	27 14	34 17	40 21	47 24
.072	AN470AD5 AN470DD6	.78 .94	1.07 1.07	.31 .38	4 2	8 4	12 6	15 8	19 10	23 12	30 15	38 19	45 23	53 27
.081	AN470AD6 AN470DD6	.94 .94	1.07 1.07	.38 .38	3 3	6 5	9 7	12 9	15 11	18 13	23 17	29 22	35 26	41 30
.091	AN470AD6 AN470DD6	.94 .94	1.07 1.07	.38 .38	4 3	7 5	10 8	13 10	17 12	20 15	27 19	33 24	40 29	46 34
.102	AN470AD8 AN470DD8	1.25 1.25	1.07 .81	.50 .50	2 2	4 3	7 5	9 6	11 8	13 9	17 12	21 15	25 18	29 21
.125	AN470AD8 AN470DD8	1.25 1.25	.67 .81	.50 .50	3 2	5 4	8 6	10 8	13 10	15 11	20 15	25 19	30 22	35 26
.156	AN470AD8 AN470DD8	1.25 1.25	.81 .81	.50 .50	4 3	7 5	10 7	13 10	16 12	19 14	25 19	32 24	38 28	44 33
.188	AN470AD8 AN470DD8	1.25 1.25	.81 .81	.50 .50	4 3	8 6	12 9	15 11	19 14	23 17	30 22	38 28	45 33	53 39



EXAMPLE

ASSUME A CLEANED-UP DAMAGE IS .75 INCH WIDE AND EXTENDS 2.25 INCHES ACROSS A CHANNEL, .032 INCH THICK. APPLY TYPE 2 REPAIR. DETERMINE THE NUMBER OF AN470AD4 RIVETS REQUIRED ON EACH SIDE OF DAMAGE BY INTERPOLATING BETWEEN .032 - 2 AND .032 - 2.50 ON THE TABLE. THE NUMBER OF RIVETS REQUIRED IS 13. THE NUMBER OF BLIND RIVETS WOULD BE 3/2 x 13=20. SINCE DAMAGE LENGTH EXCEEDS .50 INCH, A FILLER WILL BE REQUIRED, .032 INCH THICK.

13-24-19

Figure 24-18 Channel Repair

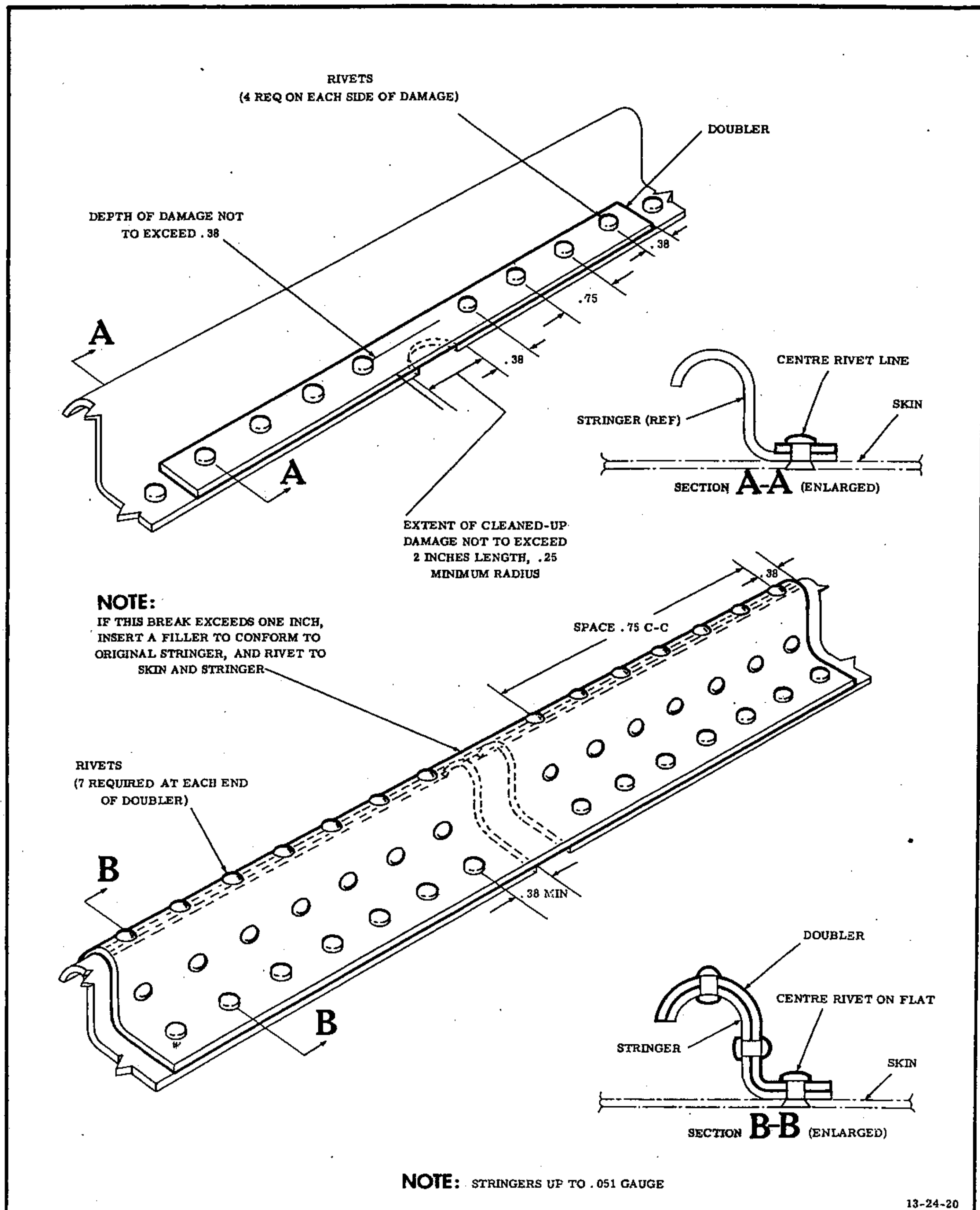
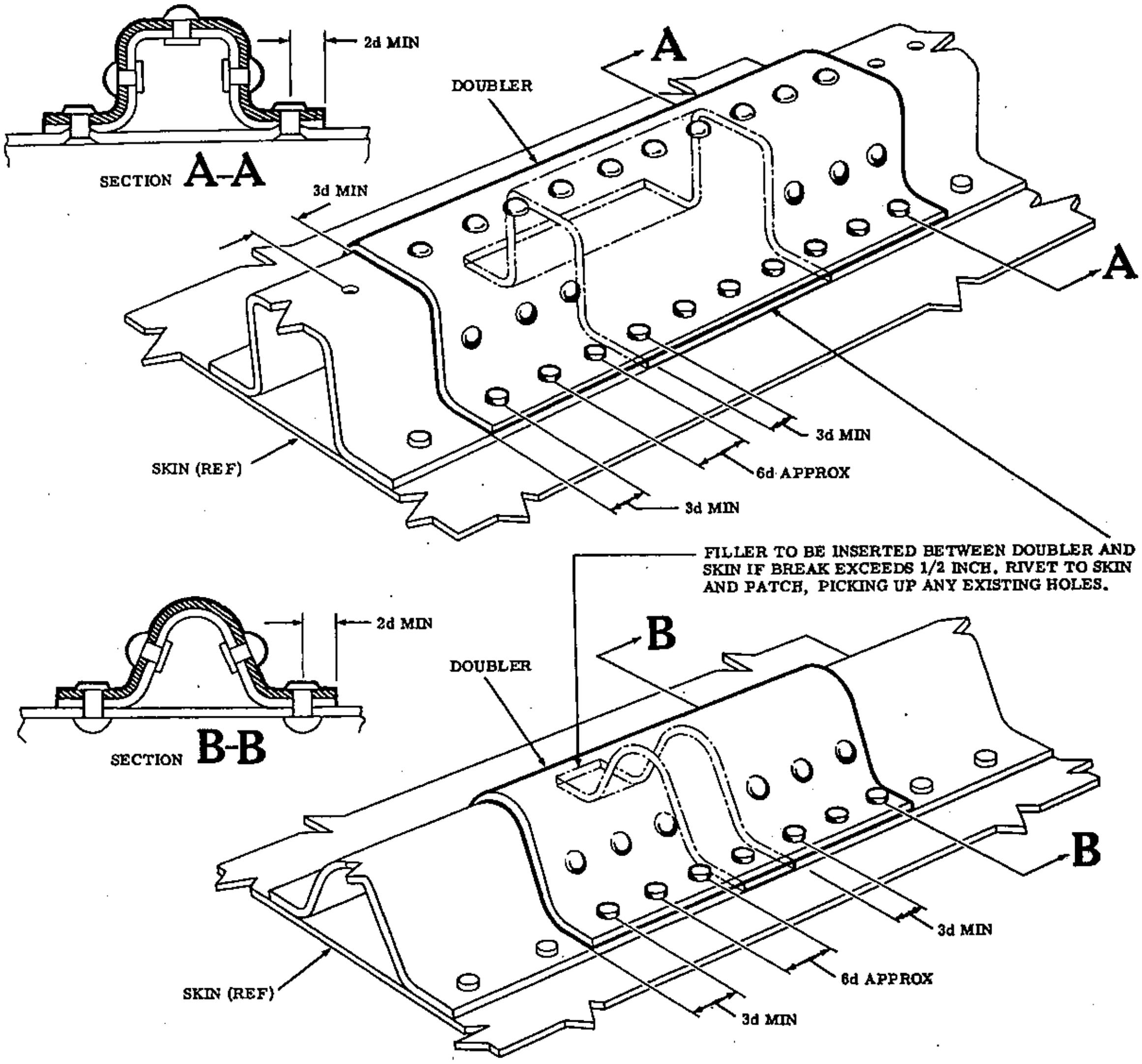


Figure 24-19 J-Section Repair



RIVET REQUIREMENTS									
MATERIAL GAUGE	RIVET DIAMETER			3d EDGE DISTANCE			6d RIVET SPACING		
	AD	DD	CHERRY	AD	DD	CHERRY	AD	DD	CHERRY
.025	1/8		1/8	.375		.375	.750		.750
.032	1/8		1/8	.375		.375	.750		.750
.040	5/32		5/32	.469		.469	.938		.938
.051	3/16	5/32	3/16	.563	.469	.563	1.125	.938	1.125
.064	1/4	3/16	*3/16	.750	.563	.563	1.50	1.125	1.125

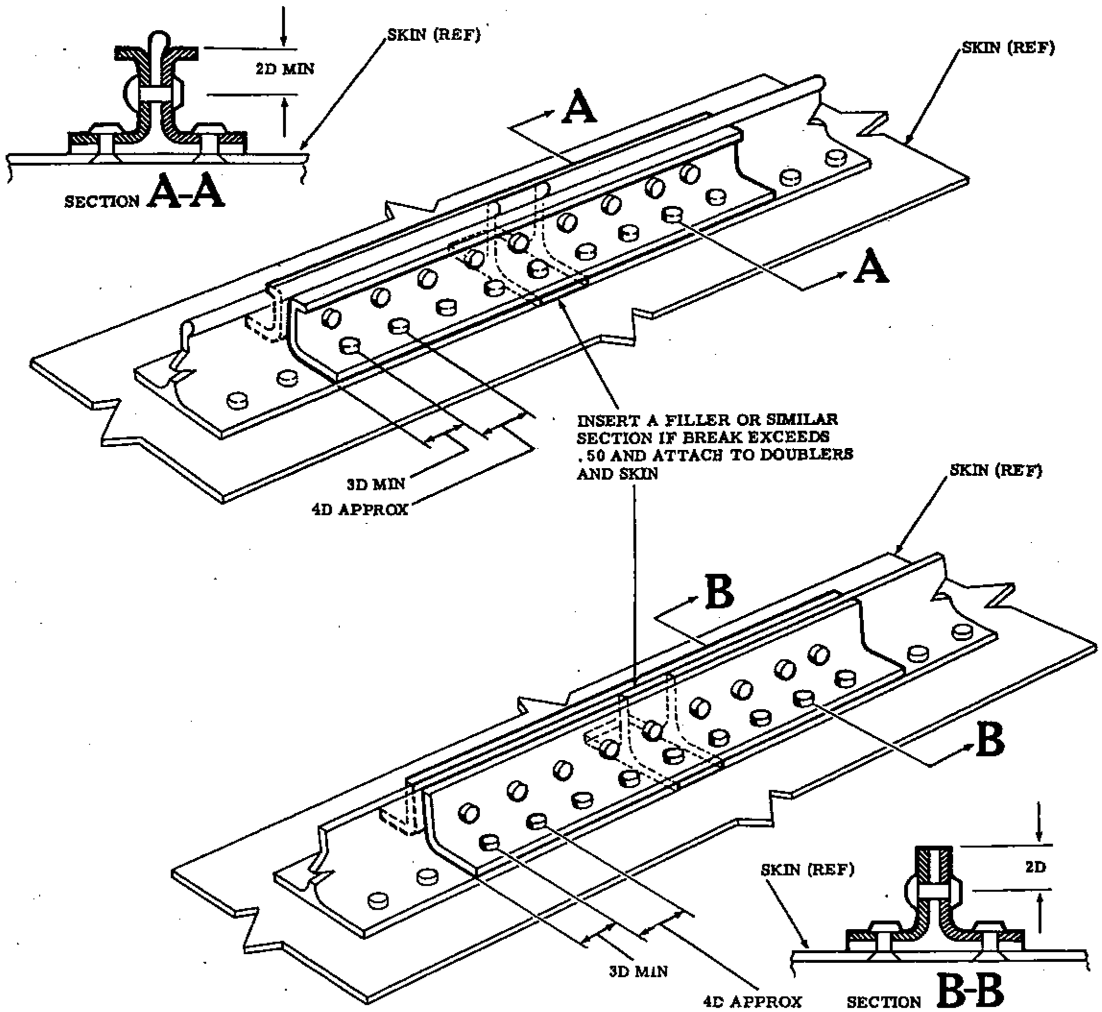
*ADD ADDITIONAL CHERRY RIVETS AT THE RATIO OF 7-5

NOTE:
d INDICATES SHANK DIAMETER OF RIVET.

EXAMPLE
3d (FOR 1/8 INCH DIAMETER RIVET) INDICATES 3/8 INCH.

13-24-21

Figure 24-20 Hat-Section and V-Section Repairs



RIVET REQUIREMENTS						
MATERIAL GAUGE	RIVET DIAMETER		3D EDGE DISTANCE		4D RIVET SPACING	
	AD	DD	AD	DD	AD	DD
.032	1/8		.38		.50	
.040	1/8		.38		.50	
.051	5/32		.47		.63	
.064	5/32		.47		.63	
.072	3/16		.56	47	.75	.63
.081	3/16		.56	.47	.75	.63
.091	3/16		.56	.56	.75	.75
.102	1/4		.75	.56	1.00	.75
.125	1/4		.75	.56	1.00	.75
.156	1/4		.75	.75	1.00	1.00
.188	1/4		.75	.75	1.00	1.00

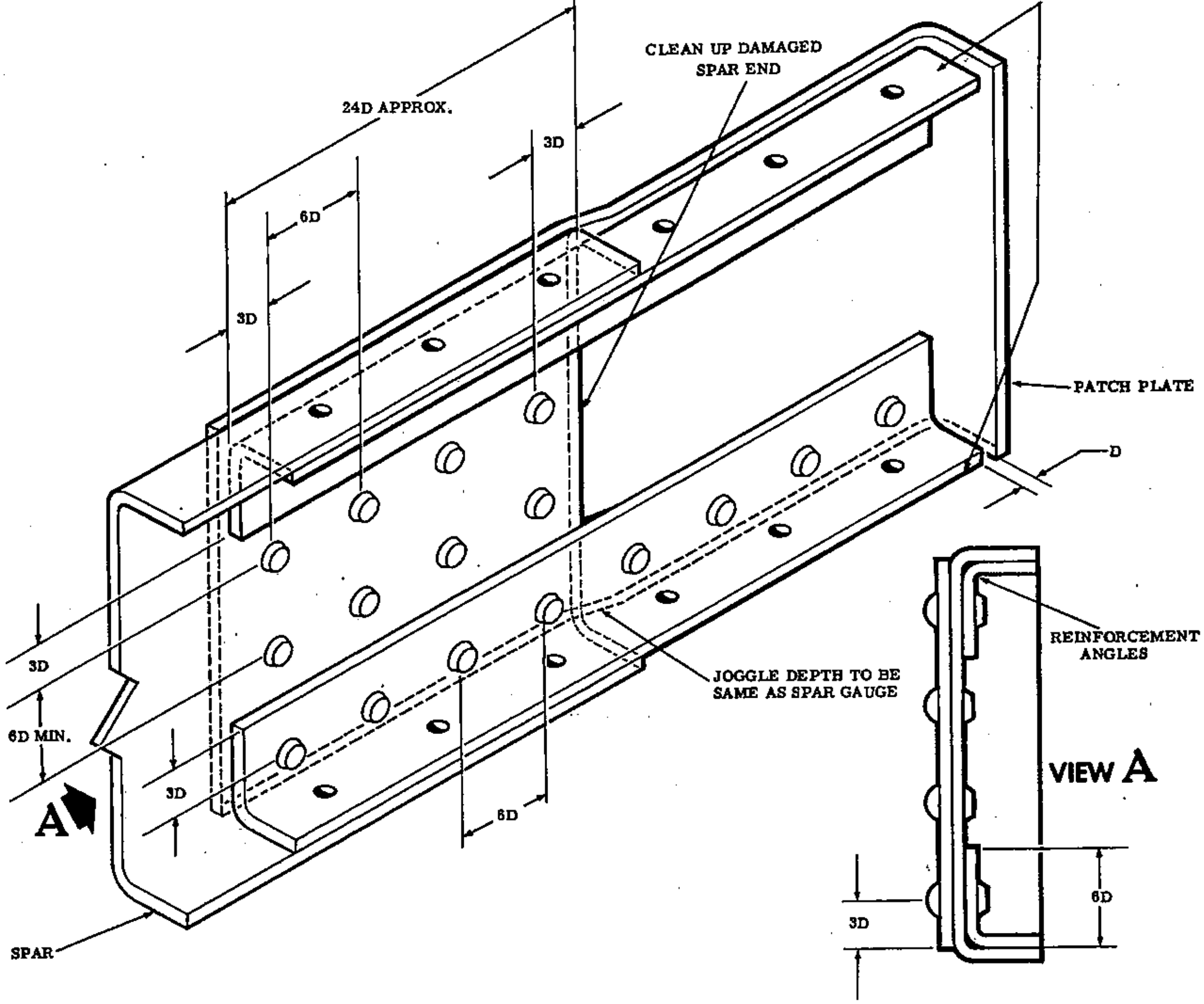
13-24-22

Figure 24-21 Extruded T-Section Repairs

NOTES:

1 ALL RIVETS TO BE SPACED 6D, CENTRE TO CENTRE, UNLESS OTHERWISE NOTED.

2 3D EDGE DISTANCE TO BE MAINTAINED FROM CENTRE OF RIVET TO EDGE OF SHEET IN ALL INSTANCES.

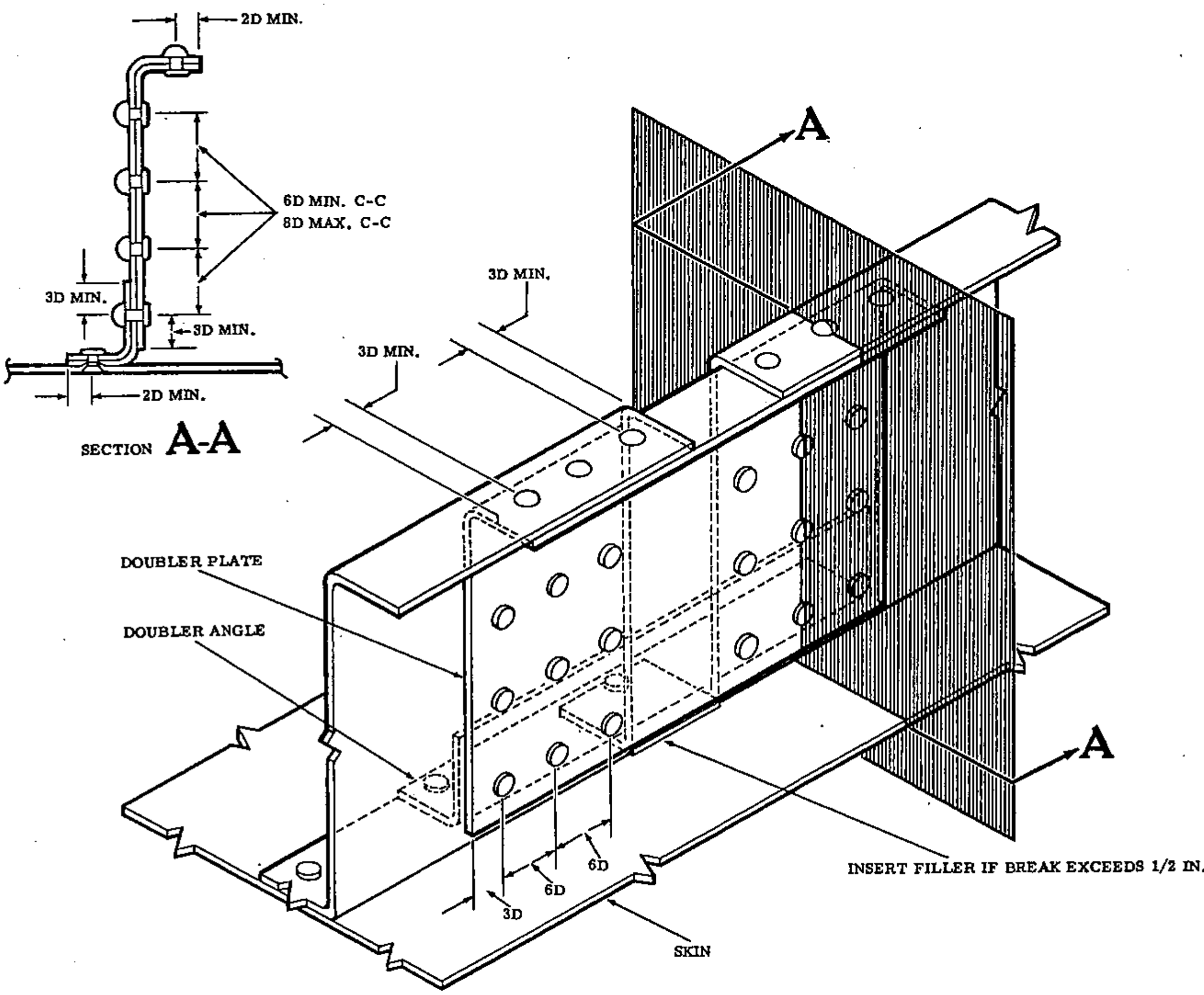


RIVET REQUIREMENTS									
MATERIAL GAUGE	RIVET DIAMETER			3D EDGE DISTANCE			6D RIVET SPACING		
	AD	DD	CHERRY	AD	DD	CHERRY	AD	DD	CHERRY
.025	1/8		1/8	.375		.375	.750		.750
.032	1/8		1/8	.375		.375	.750		.750
.040	5/32		5/32	.469		.469	.938		.938
.051	3/16*	5/32	3/16	.563	.469	.563	1.125	.938	1.125
.064	1/4	3/16	*3/16	.750	.563	.563	1.500	1.125	1.125

* ADD ADDITIONAL CHERRY RIVETS OF THE RATIO OF 7-5.

13-24-23

Figure 24-22 Channel Repair - Spar Ends

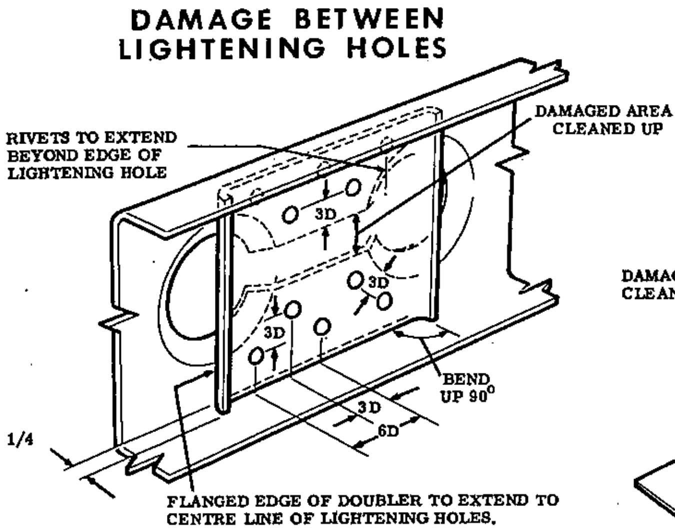


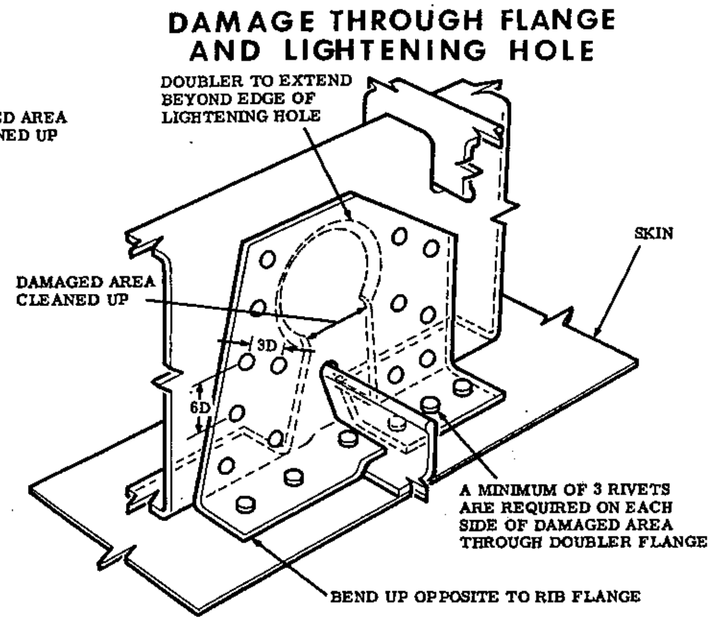
RIVET REQUIREMENTS									
MATERIAL GAUGE	RIVET DIAMETER			3D EDGE DISTANCE			6D RIVET SPACING		
	AD	DD	CHERRY	AD	DD	CHERRY	AD	DD	CHERRY
.025	1/8		1/8	.375		.375	.750		.750
.032	1/8		1/8	.375		.375	.750		.750
.040	5/32		5/32	.469		.463	.938		.938
.051	3/16	5/32	3/16	.563	.469	.563	1.125	.469	1.125
.064	1/4	3/16	* 3/16	.750	.563	.563	1.500	.563	1.125

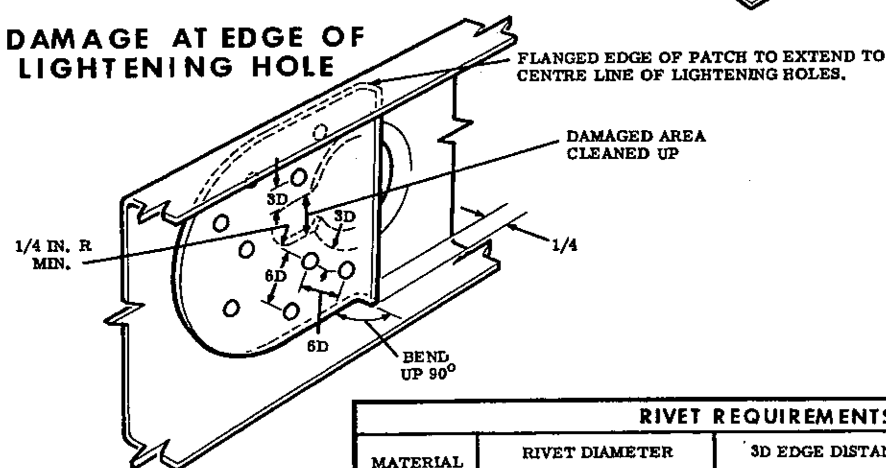
* ADD ADDITIONAL CHERRY RIVETS ON THE RATIO OF 7-5.

13-24-24

Figure 24-23 Z-Section Repair







RIVET REQUIREMENTS

MATERIAL GAUGE	RIVET DIAMETER			3D EDGE DISTANCE			6D RIVET SPACING		
	AD	DD	CHERRY	AD	DD	CHERRY	AD	DD	CHERRY
.025	1/8		1/8	.375		.375	.750		.750
.032	1/8		1/8	.375		.375	.750		.750
.040	5/32		5/32	.469		.463	.938		.938
.051	3/16	5/32	3/16	.563	.469	.563	1.125	.938	1.125
.064	1/4	3/16	*3/16	.750	.563	.563	1.500		1.125

* ADD ADDITIONAL CHERRY RIVETS AT THE RATIO OF 7-5.

NOTES:

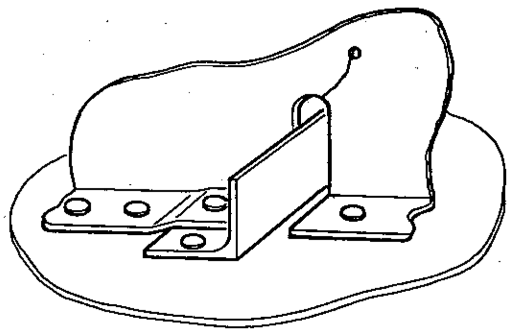
1 SPACE ALL RIVETS 6D CENTRE TO CENTRE UNLESS OTHERWISE NOTED.

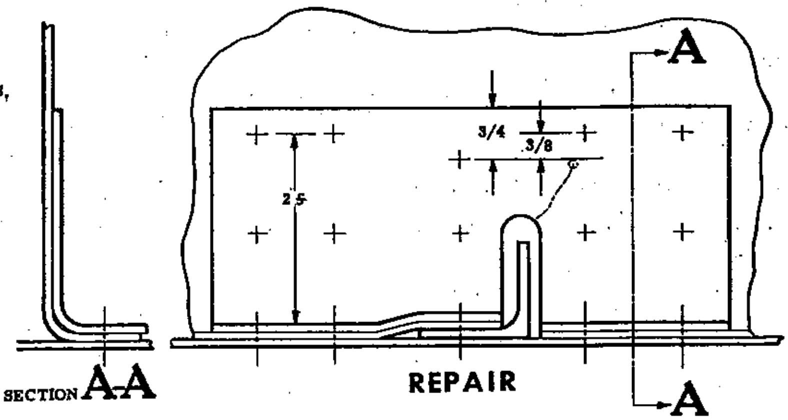
2 MAINTAIN 3D EDGE DISTANCE FROM CENTRE OF RIVET TO EDGE OF SHEET.

13-24-25

Figure 24-24 Rib Repair at Lightening Holes

FOR REPAIR OF CRACKS IN FORMERS AT STRINGER CUTOUTS, THE LENGTH OF CRACK IS LIMITED TO 20 TIMES THE SHEET THICKNESS (T). THE DISTANCE FROM STOP HOLE TO INNER EDGE OF FORMER MUST EXCEED 30T. THE REPAIR MAY BE MADE BY USING A FLANGED DOUBLER AS SHOWN.





NOTES:

1 DRILL STOP HOLE AT END OF CRACK.

2 FLANGED DOUBLER IS TO BE ONE GAUGE HEAVIER THAN WEB THICKNESS. FLANGE ON DOUBLER IS TO BE SAME SIZE AS FLANGE ON DAMAGED PART.

3 DOUBLER-TO-WEB RIVETS ARE TO BE IN TWO ROWS AT SAME SPACING AS EXISTING FLANGE RIVETS.

4 DOUBLER IS TO PICK UP A MINIMUM OF THREE (3) FLANGE RIVETS ON EITHER SIDE OF CUTOUT.

5 DOUBLER-TO-WEB RIVETS ARE TO BE THE SAME SIZE AS EXISTING FLANGE RIVETS.

13-24-26

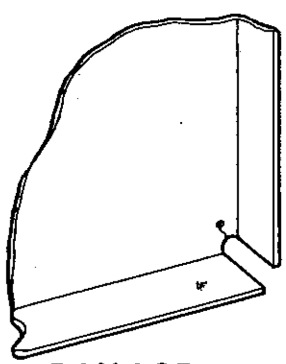
Figure 24-25 Damaged Stringer Cutout Repair

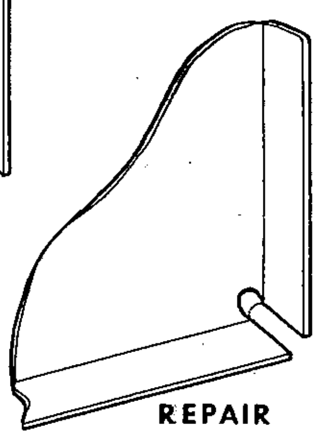
FOR REPAIR OF A CRACK IN THE CORNER OF A DOUBLE FORMED FLANGE, USE THE FOLLOWING APPLICATIONS:

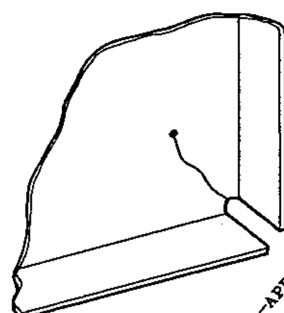
1 FOR A LENGTH OF CRACK LIMITED TO EIGHT TIMES THE SHEET THICKNESS.

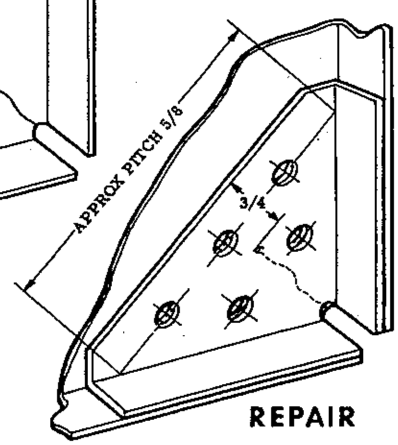
(a) DRILL STOP HOLE AT END OF CRACK.

(b) REMOVE AREA OUTWARD FROM DRILLED HOLE AS SHOWN IN SKETCH WITH MINIMUM NOTCH RADII OF .125 IN. AND SMOOTH TO REMOVE BURRS.









2 FOR A LENGTH OF CRACK LIMITED TO TWENTY-FIVE TIMES THE SHEET THICKNESS:

(a) DRILL NO.40 STOP HOLE AT END OF CRACK.

(b) ADD FLANGED DOUBLER AS SHOWN

(c) DOUBLER IS TO BE SAME MATERIAL AND THICKNESS AS DAMAGED PART. DOUBLER FLANGES ARE TO BE IDENTICAL TO DAMAGED PART.

(d) RIVETS ARE TO BE AS INDICATED IN SKETCH AND OF THE SAME SIZE AS EXISTING FLANGE RIVETS.

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Figure 24-26 Double-formed Flange Repair

(j) The minimum splice plate gauges, where called, are a sub-countersinking requirement. Where a splice plate gauge is not called, the required gauge is the same as the sheet gauge.

(k) Annealed corrosion resistant steel sheet is assumed to be of MIL-S-5059 specification, Comp. D.

(m) M rivets are AN435M Monel rivets.

(n) B rivets are AN470B 56S aluminum alloy rivets.

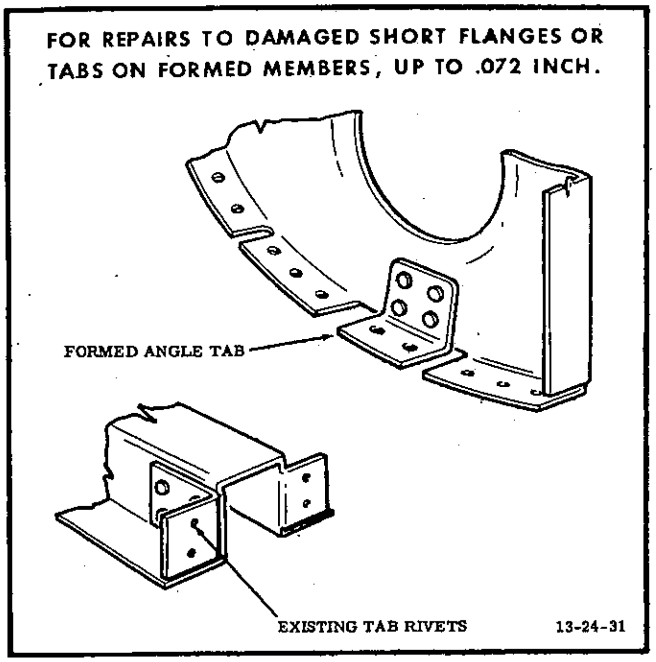


Figure 24-27 Flange Repair with Tab

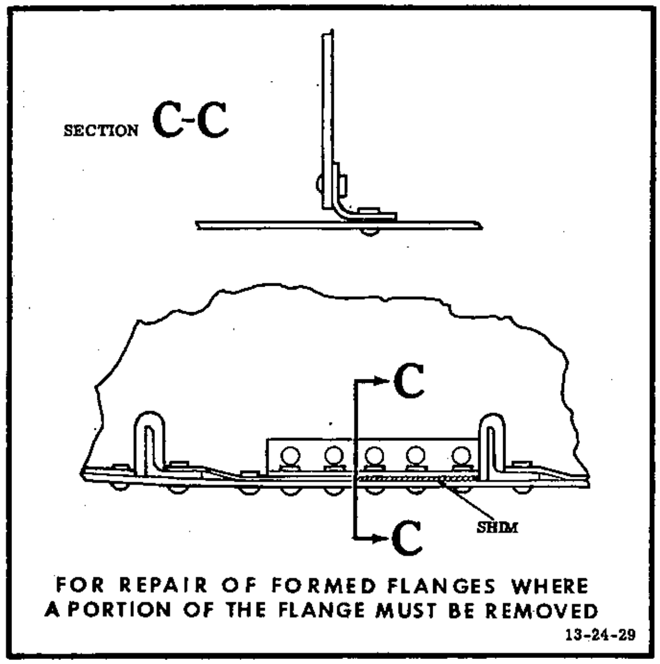


Figure 24-29 Formed Flange Repair

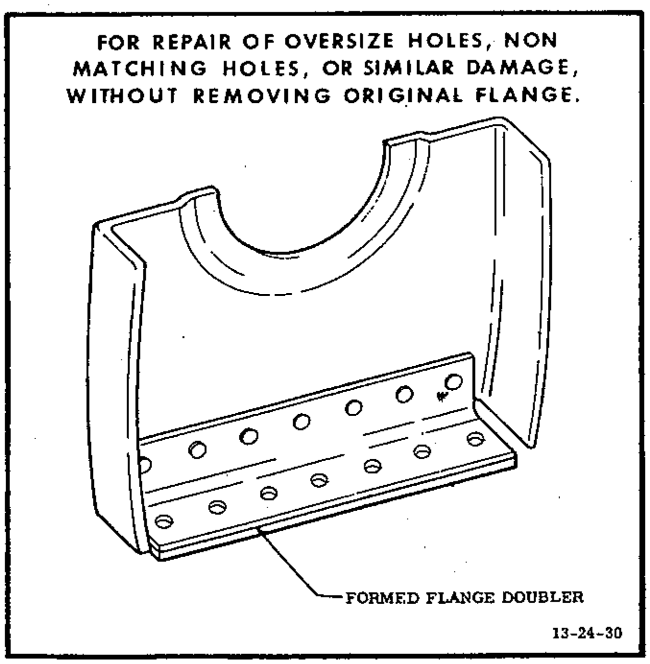


Figure 24-28 Flange Repair with Doubler

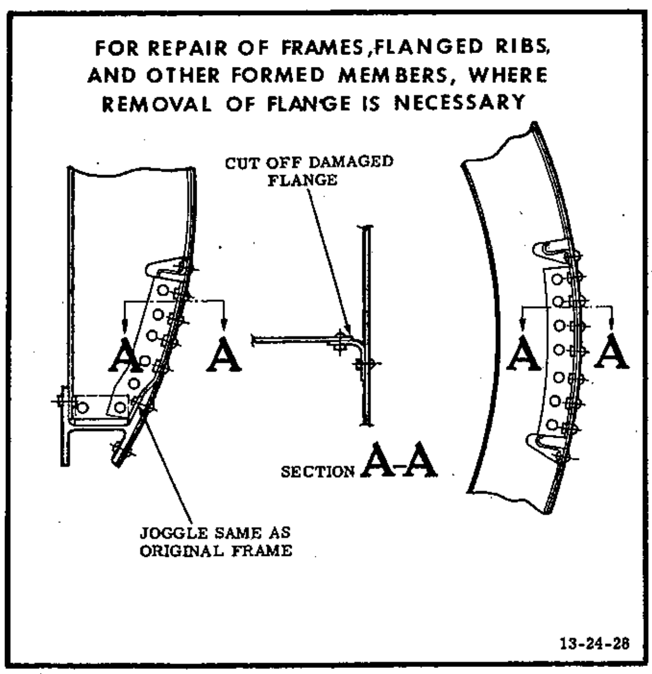
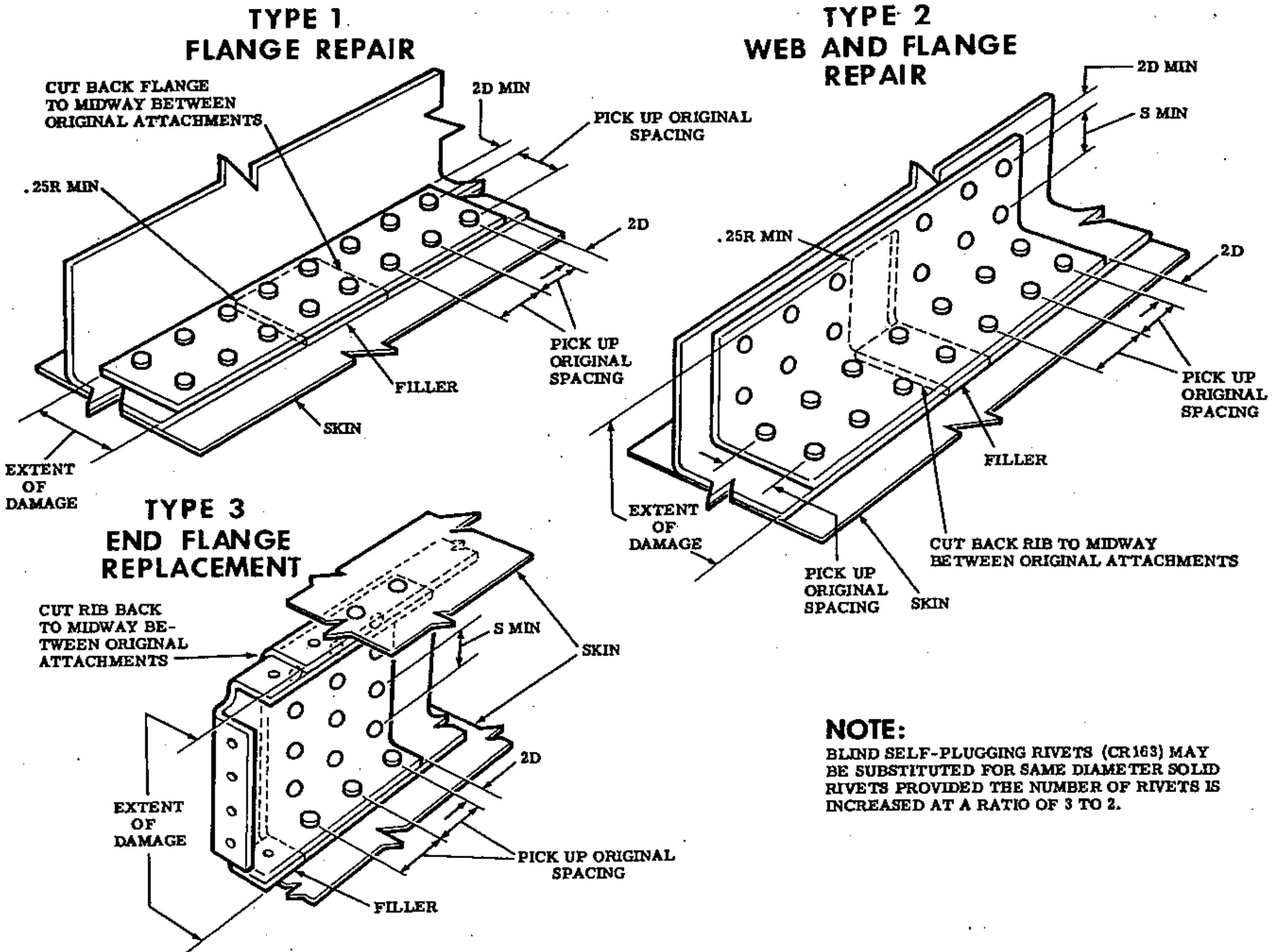


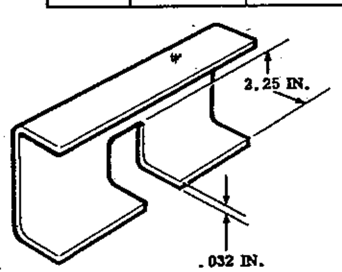
Figure 24-30 Joggled Flange Repair



NOTE:
BLIND SELF-PLUGGING RIVETS (CR163) MAY BE SUBSTITUTED FOR SAME DIAMETER SOLID RIVETS PROVIDED THE NUMBER OF RIVETS IS INCREASED AT A RATIO OF 3 TO 2.

RIVET REQUIREMENTS
NUMBER RIVETS REQUIRED ON EACH SIDE OF DAMAGED AREA INTERPOLATE FOR INTERMEDIATE VALUES

RIB GAUGE	TYPE OF RIVETS REQUIRED	MINIMUM TRANSVERSE SPACING (S)	MINIMUM EDGE DISTANCE (2D)	NUMBER OF RIVETS REQUIRED WHEN EXTENT OF DAMAGE ACROSS RIB IS									
				.50 IN.	1 IN.	1.50 IN.	2 IN.	2.50 IN.	3 IN.	4 IN.	5 IN.	6 IN.	7 IN.
.025	AN470AD4	.55	.25	3	5	7	9	12	14	18	22	27	31
.032	AN470AD4	.55	.25	3	6	8	11	14	16	22	27	32	38
.040	AN470AD5	.67	.31	3	5	7	9	11	13	18	22	26	30
.051	AN470AD5	.67	.31	3	6	8	11	14	16	22	27	32	37
.064	AN470AD5 AN470DD6	.67 .81	.31 .38	4 2	7 4	10 5	14 7	17 9	20 11	27 14	34 17	40 21	47 24
.072	AN470AD5 AN470DD6	.67 .81	.31 .38	4 2	8 4	12 6	15 8	19 10	23 12	30 15	38 19	45 23	53 27



EXAMPLE

ASSUME A DAMAGE WHEN CLEANED UP EXTENDS 2.25 INCHES ACROSS A .032 RIB. APPLY TYPE 2. REPAIR. DETERMINE THE NUMBER OF AN470AD4 RIVETS REQUIRED BY INTERPOLATING BETWEEN .032-2 INCHES AND .032-2.50 INCHES WHICH GIVES 12-1/2 RIVETS REQUIRED ON EACH SIDE OF DAMAGE. USE 13 RIVETS. ALWAYS INTERPOLATE TO HIGHEST VALUE. NUMBER OF CR163-4 BLIND RIVETS IS 3/2 x 13=20 RIVETS REQUIRED ON EACH SIDE OF DAMAGE.

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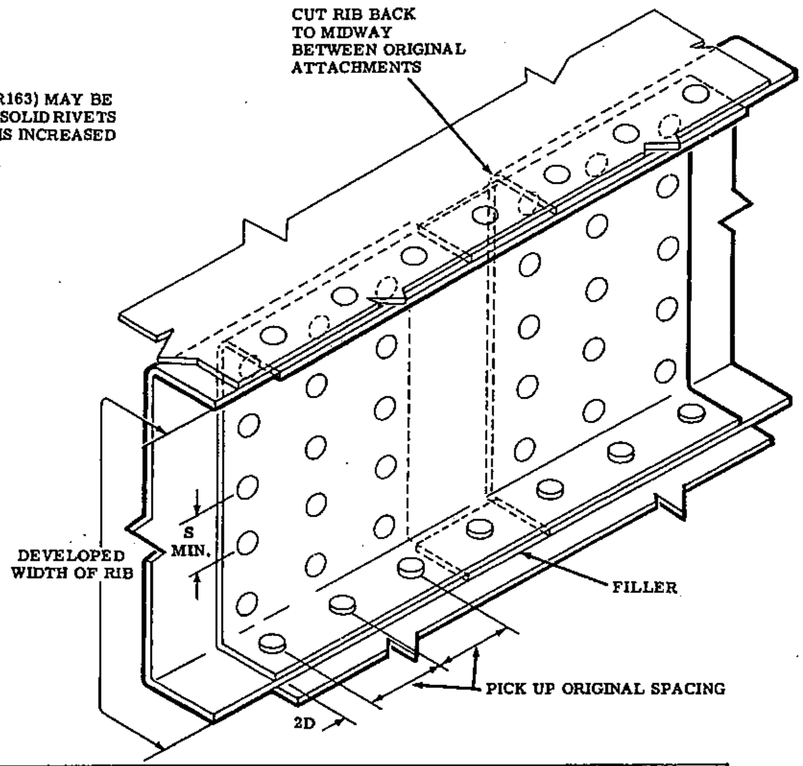
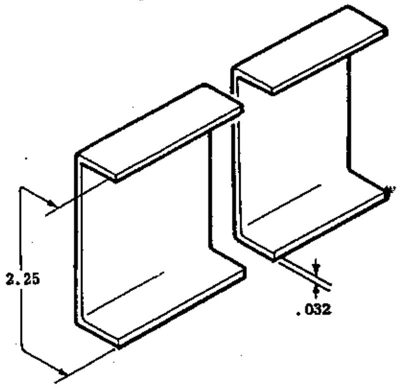
Figure 24-31 Rib Repairs at Side and End Flanges

NOTE:
BLIND SELF-PLUGGING RIVETS (CR163) MAY BE SUBSTITUTED FOR SAME DIAMETER SOLID RIVETS PROVIDED THE NUMBER OF RIVETS IS INCREASED AT A RATIO OF 3 TO 2.



RIVET REQUIREMENTS NUMBER OF RIVETS REQUIRED ON EACH SIDE OF DAMAGED AREA INTERPOLATE FOR INTERMEDIATE VALUES													
RIB GAUGE	TYPE OF RIVET REQUIRED	MINIMUM TRANSVERSE SPACING (S)	MINIMUM EDGE DISTANCE (2D)	NUMBER OF RIVETS REQUIRED WHEN DEVELOPED WIDTH OF RIB IS									
				.50 IN	1 IN.	1.50IN	2 IN.	2.50IN	3 IN.	4 IN.	5 IN.	6 IN.	7 IN.
.025	AN470AD4	.55	.25	3	5	7	9	12	14	18	22	27	31
.032	AN470AD4	.55	.25	3	6	8	11	14	16	22	27	32	38
.040	AN470AD5	.67	.31	3	5	7	9	11	13	18	22	26	30
.051	AN470AD5	.67	.31	3	6	8	11	14	16	22	27	32	37
.064	AN470AD5	.67	.31	4	7	10	14	17	20	27	34	40	47
.06	AN470DD6	.81	.38	2	4	5	7	9	11	14	17	21	24
.072	AN470AD5	.67	.31	4	8	12	15	19	23	30	38	45	53
	AN470DD6	.81	.38	2	4	6	8	10	12	15	19	23	27



EXAMPLE

ASSUME THE DEVELOPED WIDTH OF A .032 RIB IS 2.25 INCHES. DETERMINE THE NUMBER OF AN470AD4 RIVETS BY INTERPOLATING BETWEEN .032-2 INCHES AND .032-2.50 INCHES, WHICH GIVES 12-1/2 RIVETS REQUIRED ON EACH SIDE OF DAMAGE. USE 13 RIVETS. ALWAYS INTERPOLATE TO HIGHEST VALUE. NUMBER OF CR163-4 BLIND RIVETS IS 3/2 x 13=20 RIVETS REQUIRED ON EACH SIDE OF DAMAGE.

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Figure 24-32 Rib Splice

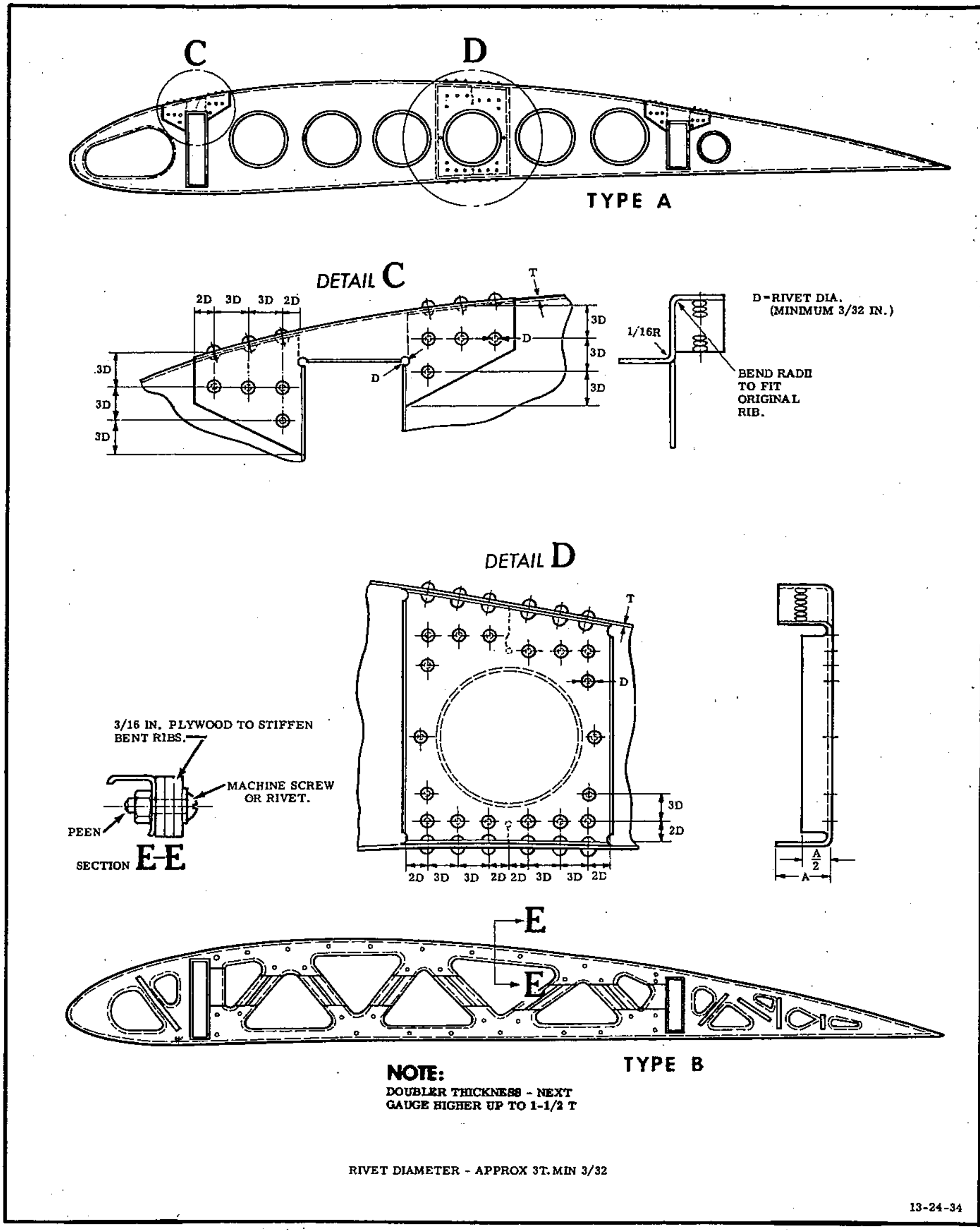


Figure 24-33 Metal Rib Repairs (Small Aircraft)

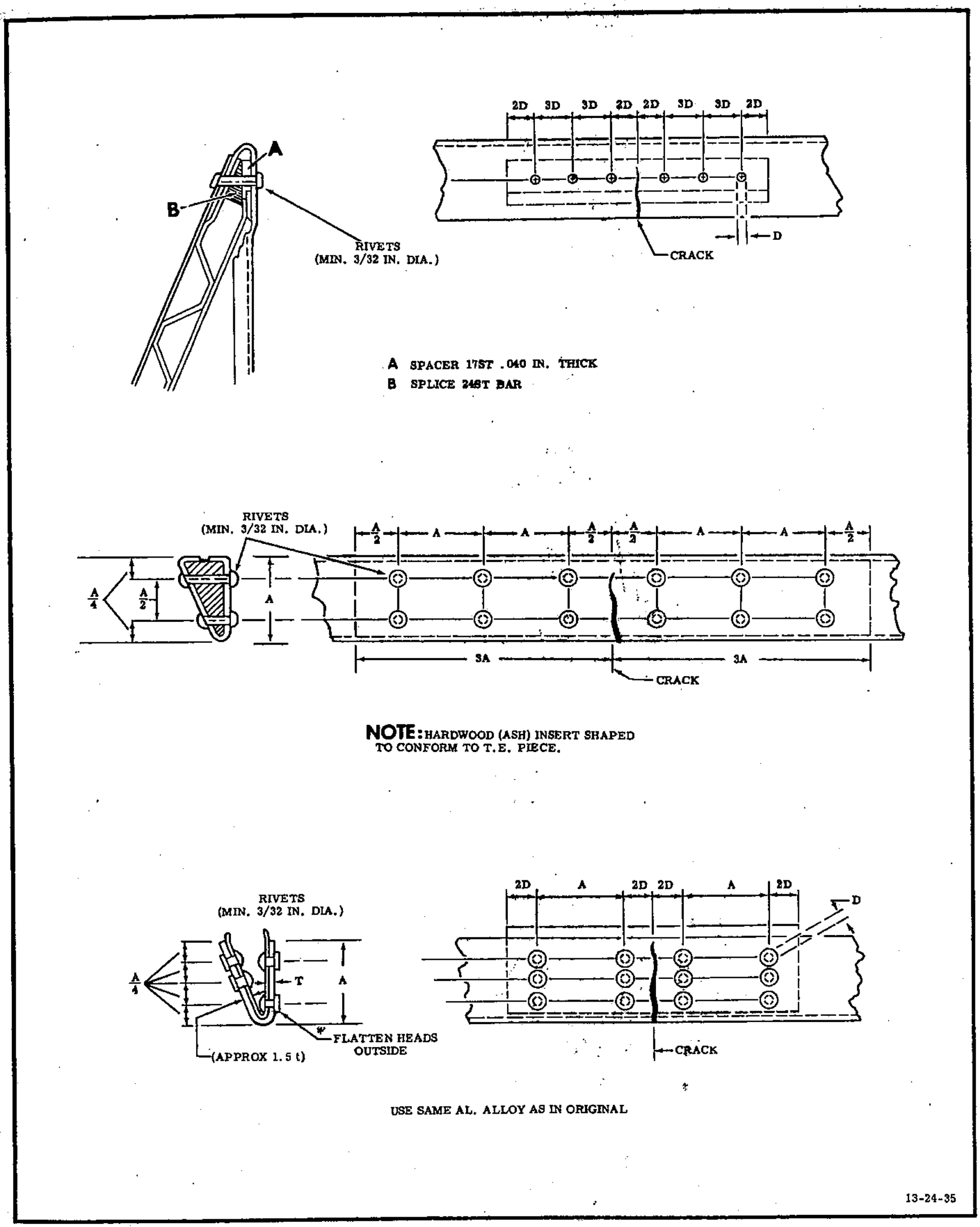
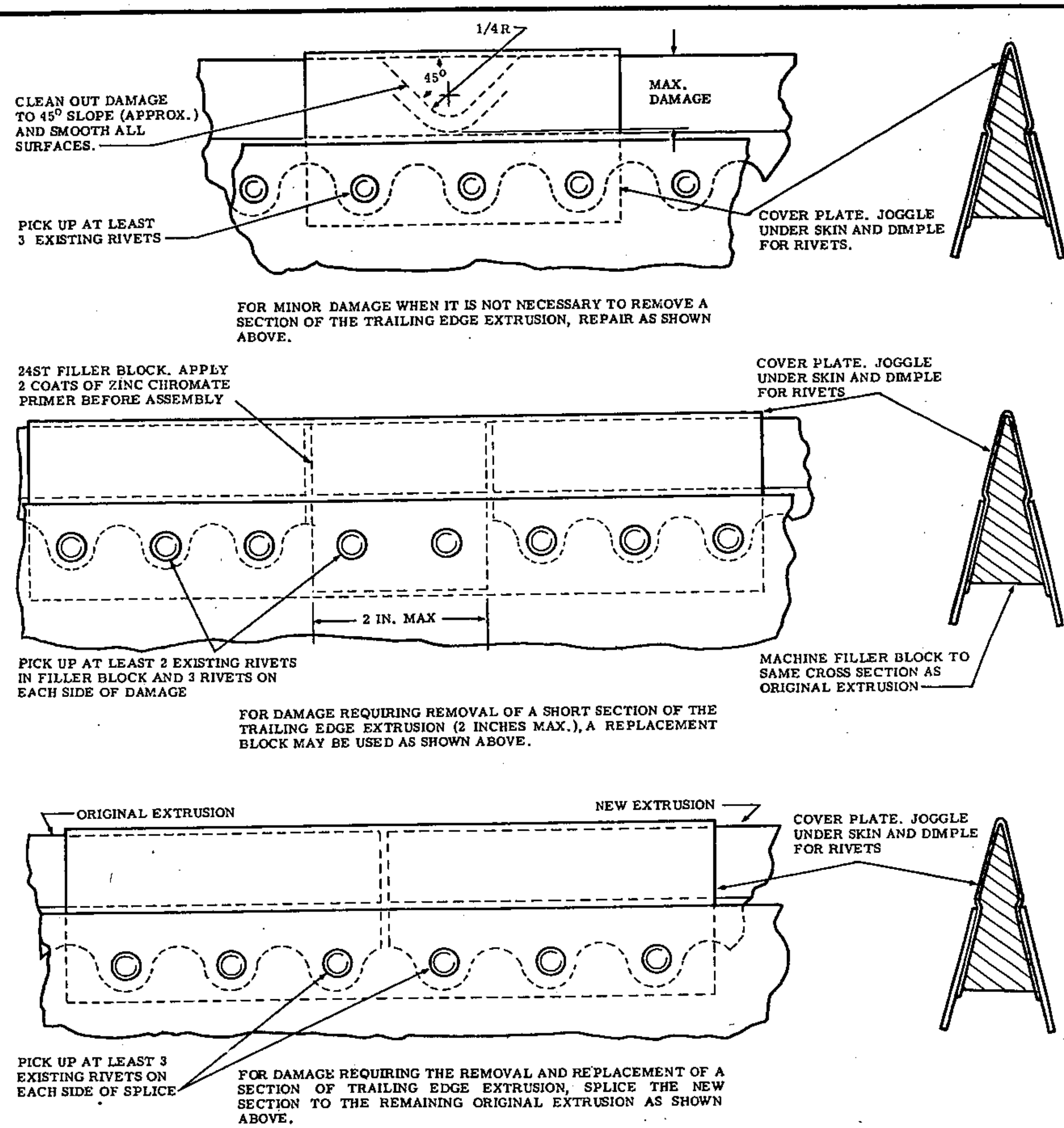


Figure 24-34 Trailing Edge Repairs (Small Aircraft)

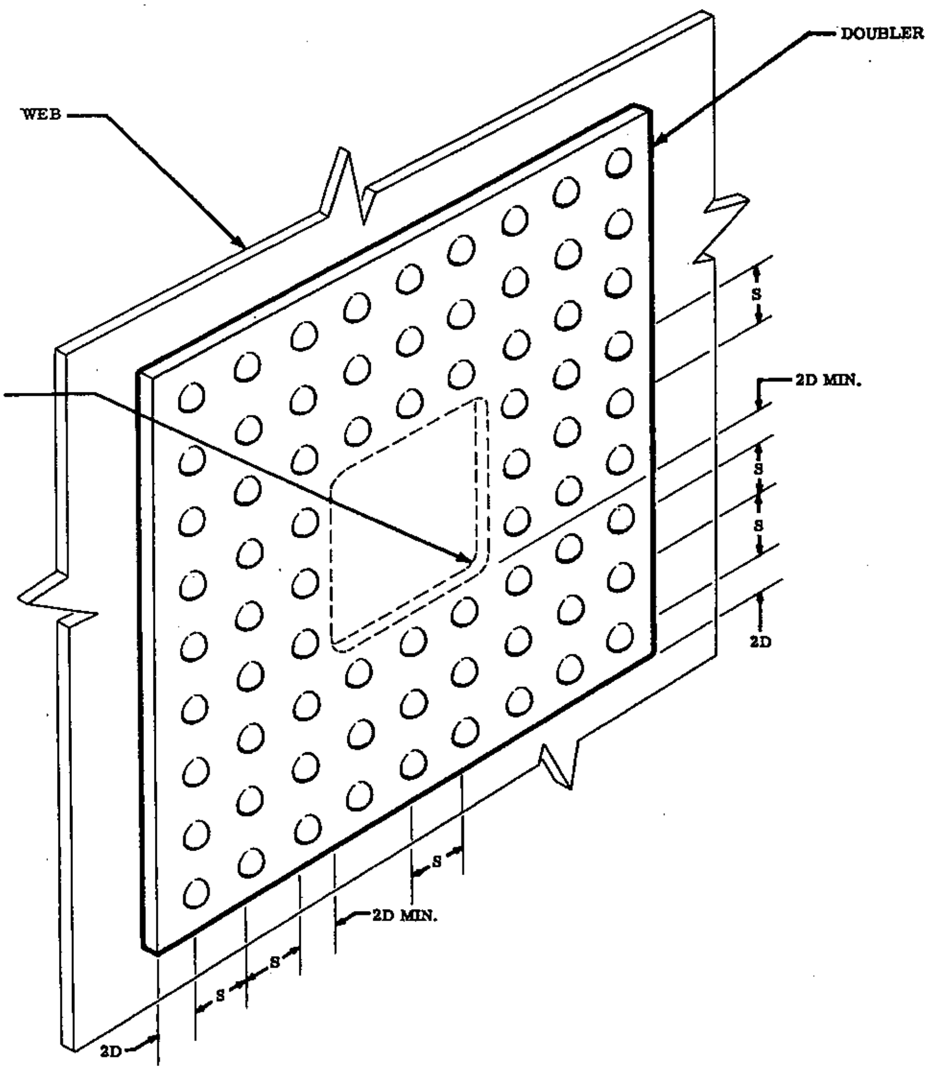


NOTES: THE FOLLOWING NOTES ARE APPLICABLE TO ALL THREE TYPES OF TRAILING EDGE REPAIR SHOWN.

1. THESE REPAIRS ARE APPLICABLE PRINCIPALLY TO THE SIMPLE ARROWHEAD TYPE TRAILING EDGE EXTRUSION. REPAIRS NO. 1 AND 2 MAY ALSO BE USED WHERE PRACTICAL FOR THE COMPOSITE-TYPE EXTRUSION COMPRISING TRAILING EDGE, TRAILING EDGE RIBS, AND REAR SPAR IN ONE PIECE.
2. NO MORE THAN TWO REPAIRS MAY BE USED PER CONTROL SURFACE AND THEY MUST BE AT LEAST 16 INCHES APART.
3. ELEVATORS, RUDDERS, AND AILERONS MUST BE CHECKED FOR STATIC BALANCE AFTER REPAIRING AND REBALANCED IF NECESSARY.
4. COVER PLATES SHOWN IN ILLUSTRATIONS ARE TO BE MADE FROM .020 24ST ALCLAD SHEET.
5. WHEN TRAILING EDGE EXTRUSION IS MAGNESIUM ALLOY:
   - A CHROME PICKLE ALL FRESHLY EXPOSED MAGNESIUM SURFACES.
   - B APPLY THREE COATS OF ZINC CHROMATE PRIMER TO MAGNESIUM SURFACES TO BE COVERED BY ALUMINUM COVER PLATES.
   - C APPLY TWO COATS OF ZINC CHROMATE PRIMER TO INSIDE OF COVER PLATES.
   - D USE ONLY 56S ALUMINUM ALLOY RIVETS (B RIVETS) FOR ASSEMBLY.

13-24-36

Figure 24-35 Trailing Edge Repair - Arrowhead Type



GAUGE	RIVET REQUIREMENTS											
	NO. OF ROWS REQ			RIVET SIZE REQ			SPACING (S)			EDGE DISTANCE (2D)		
	AD	DD	BLIND	AD	DD	BLIND	AD	DD	BLIND	AD	DD	BLIND
.025	3		4	3		4	.41		.57	.19		.25
.032	3		4	4		4	.55		.55	.25		.25
.040	3		4	5		5	.68		.72	.31		.31
.051	4		4	5		5	.71		.68	.31		.31
.064	4	3	4	6	6	6	.85	.86	.82	.38	.38	.38
.072	4	3	4	6	6	6	.81	.82	.82	.38	.38	.38
.081	5	4	5	6	6	6	.86	.90	.89	.38	.38	.38
.091	5	4	5	6	6	6	.82	.86	.85	.38	.38	.38

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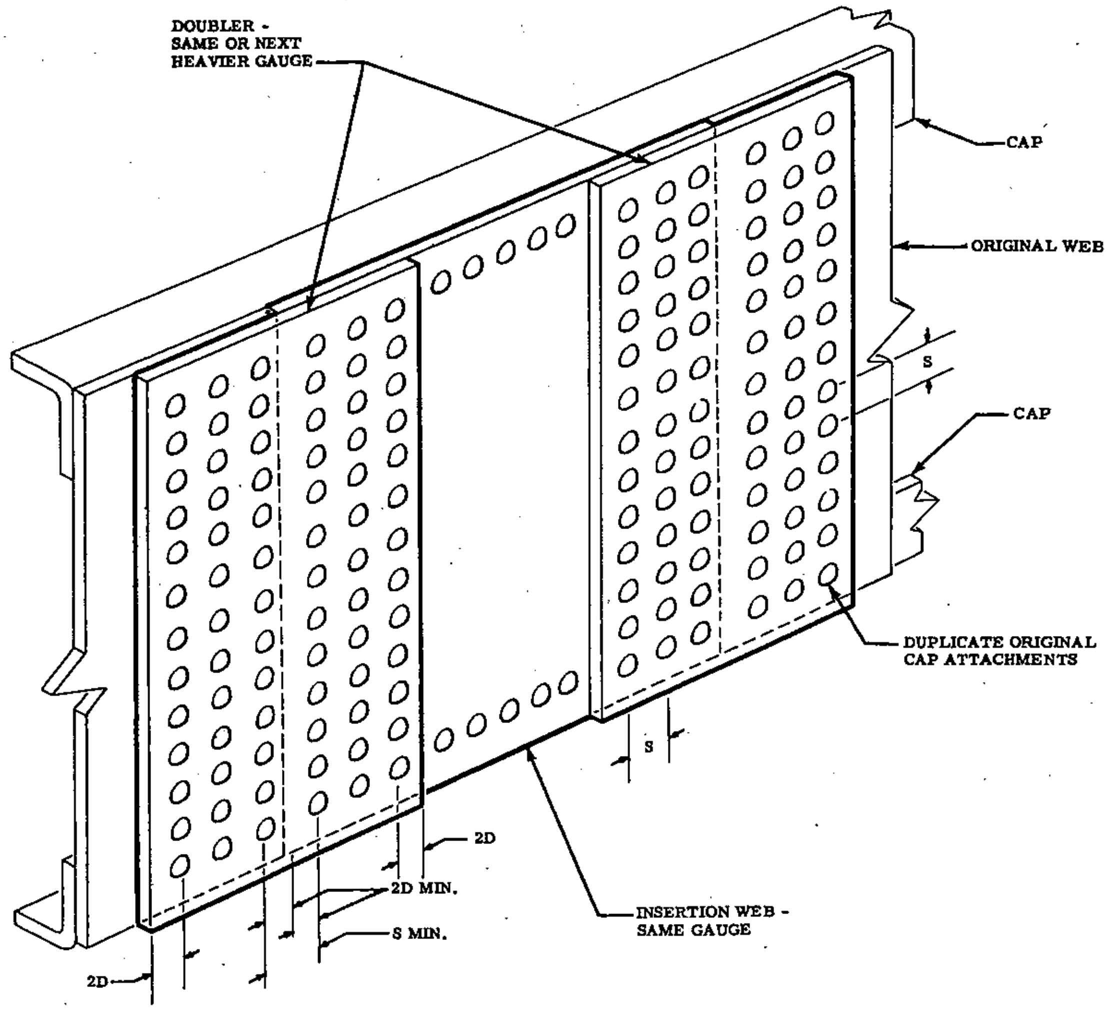
Figure 24-36 Web Repairs - Solid Areas



GAUGE	RIVET REQUIREMENTS											
	NO. OF ROWS REQ			RIVET SIZE REQ			SPACING (S)			EDGE DISTANCE (2D)		
	AD	DD	BLIND	AD	DD	BLIND	AD	DD	BLIND	AD	DD	BLIND
.025	3		4	3		4	.41		.57	.19		.25
.032	3		4	4		4	.55		.55	.25		.25
.040	3		4	5		5	.68		.72	.31		.31
.051	4		4	5		5	.71		.68	.31		.31
.064	4	3	4	6	6	6	.85	.86	.82	.38	.38	.38
.072	4	3	4	6	6	6	.81	.82	.82	.38	.38	.38
.081	5	4	5	6	6	6	.86	.90	.89	.38	.38	.38
.091	5	4	5	6	6	6	.82	.86	.85	.38	.38	.88

13-24-38

Figure 24-37 Web Repairs - Insertion of New Section

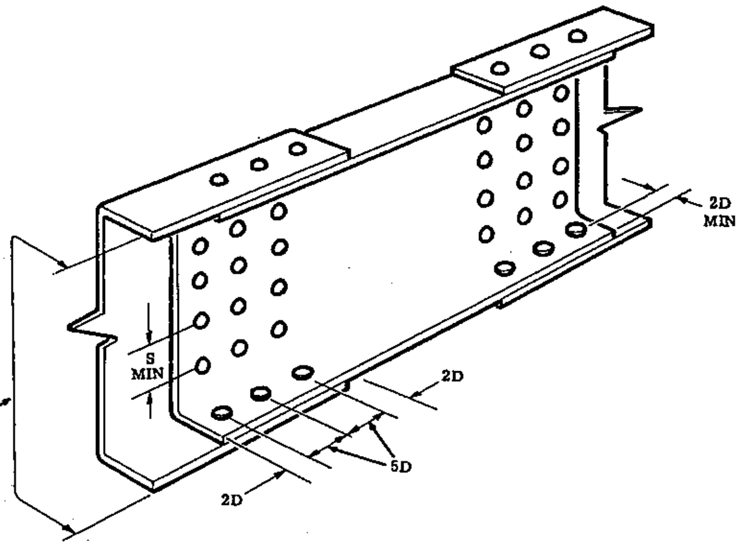
NOTES:

1 USE SAME GAUGE AS ORIGINAL IF REPAIR IS APPLIED TO OUTSIDE OF CHANNEL, REPAIR MEMBER TO BE NEXT HEAVIER GAUGE IF APPLIED TO INSIDE OF CHANNEL AS SHOWN.

2 USE EXISTING ATTACHMENT SPACING WHERE MEMBER WAS ORIGINALLY ATTACHED, OTHERWISE USE INDICATED SPACING.

3 BLIND SELF-PLUGGING RIVETS MAY BE SUBSTITUTED FOR SAME DIAMETER SOLID RIVETS PROVIDED THE NUMBER OF RIVETS IS INCREASED AT A RATIO OF 3 TO 2.

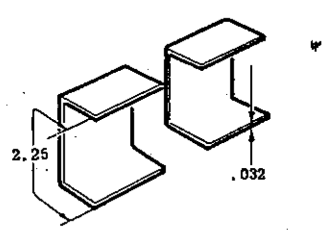
4 FOR SKIN ATTACHMENT USE FLUSH HEAD (AN426) OR BLIND FLUSH HEAD RIVETS.



RIVET REQUIREMENTS

NUMBER OF RIVETS REQUIRED ON EACH SIDE OF DAMAGED AREA. INTERPOLATE FOR INTERMEDIATE VALUES

CHANNEL GAUGE	TYPE OF RIVETS REQUIRED	LONGDITUDINAL SPACING (5D)	MINIMUM TRANSVERSE SPACING (S)	MINIMUM EDGE DISTANCE (2D)	NUMBER OF RIVETS REQUIRED WHEN DEVELOPED WIDTH OF CHANNEL IS									
					.50"	1"	1.50"	2"	2.50"	3"	4"	5"	6"	7"
.025	AN470AD4	.63	.55	.25	3	5	7	9	12	14	18	22	27	31
.032	AN470AD4	.63	.55	.25	3	6	8	11	14	16	22	27	32	38
.040	AN470AD5	.78	.67	.31	3	5	7	9	11	13	18	22	26	30
.051	AN470AD5	.78	.67	.31	3	6	8	11	14	16	22	27	32	37
.064	AN470AD5	.78	.67	.31	4	7	10	14	17	20	27	34	40	47
	AN470DD6	.94	.81	.38	2	4	5	7	9	11	14	17	21	24
.072	AN470AD5	.78	.67	.31	4	8	12	15	19	23	30	38	45	53
	AN470DD6	.94	.81	.38	2	4	6	8	10	12	15	19	23	27
.081	AN470AD6	.94	.81	.38	3	6	9	12	15	18	23	29	35	41
	AN470DD6	.94	.81	.38	3	5	7	9	11	13	17	22	26	30
.091	AN470AD6	.94	.81	.38	4	7	10	13	17	20	27	33	40	46
	AN470DD6	.94	.81	.38	3	5	8	10	12	15	19	24	29	34
.102	AN470AD8	1.25	1.07	.50	2	4	7	9	11	13	17	21	25	29
	AN470DD8	1.25	1.07	.50	2	3	5	6	8	9	12	15	18	21
.125	AN470AD8	1.25	1.07	.50	3	5	8	10	13	15	20	25	30	35
	AN470DD8	1.25	1.07	.50	2	4	6	8	10	11	15	19	22	26
.156	AN470AD8	1.25	1.07	.50	4	7	10	13	16	19	25	32	38	44
	AN470DD8	1.25	1.07	.50	3	5	7	10	12	14	19	24	28	33
.188	AN470AD8	1.25	1.07	.50	4	8	12	15	19	23	30	38	45	53
	AN470DD8	1.25	1.07	.50	3	6	9	11	14	17	22	28	33	39



EXAMPLE

ASSUME THE DEVELOPED WIDTH OF A .032 CHANNEL IS 2.25 INCHES. DETERMINE THE NUMBER OF AN470AD4 RIVETS REQUIRED BY INTERPOLATING BETWEEN .032-2 INCHES AND .032-2.50 INCHES, WHICH GIVES 12-1/2 RIVETS REQUIRED ON EACH SIDE OF DAMAGE. USE 13 RIVETS. ALWAYS INTERPOLATE TO HIGHEST VALUE. NUMBER OF CR163-4 BLIND RIVETS IS 3/2 x 13 = 20 RIVETS REQUIRED ON EACH SIDE OF DAMAGE.

13-24-39

Figure 24-38 Formed Channel Splice

24S-T3 Clad and 24S-T4 Clad Aluminum Sheet (Non-Flush)					
Sheet Gauge	Type Rivet	Spacing	Edge Distance	Number of Rows	Distance between Rows
.020	AD3	7/16	7/32	3	7/16
.025	AD4	9/16	9/32	3	9/16
.032	AD5	3/4	3/8	3	3/4
.040	DD6	7/8	7/16	3	7/8
.051	DD6	7/8	7/16	3	7/8
.064	NAS178-6	7/8	7/16	3	7/8
.072	NAS178-6	7/8	7/16	3	7/8
.081	NAS178-6	7/8	7/16	3	7/8
.091	NAS178-8	1-1/8	9/16	3	1-1/8
.102	NAS178-8	1-1/8	9/16	3	1-1/8
.125	NAS178-8	1-1/8	9/16	3	1-1/8
.156	NAS178-10	1-7/16	3/4	3	1-7/16
.188	NAS178-12	1-11/16	7/8	3	1-11/16

Figure 24-39 (Sheet 1 of 10) Sheet Splices

24S-T3 Clad and 24S-T4 Clad Aluminum Sheet (Flush)							
Sheet Gauge	Type Rivet	Flush Rivet Install.	Spacing	Edge Distance	Number of Rows	Distance between Rows	Min. Splice Plate Gauge
.020	AD4	D2	9/16	9/32	3	9/16	
.025	AD5	D2	3/4	3/8	3	3/4	
.032	AD5	D2	3/4	3/8	3	3/4	
.040	AD5	D2	3/4	3/8	3	3/4	
.051	DD6	D2	7/8	7/16	3	7/8	
.064	DD6	D2	7/8	7/16	3	7/8	
.072	NAS177-8	DC	1-1/8	9/16	3	1-1/8	.081
.081	NAS177-8	DC	1-1/8	9/16	3	1-1/8	.091
.091	NAS177-8	DC	1-1/8	9/16	3	1-1/8	.102
.102	NAS177-8	C	1-1/8	9/16	4	1-1/8	
.125	NAS177-10	C	1-7/16	3/4	4	1-7/16	

Figure 24-39 (Sheet 2 of 10) Sheet Splices

75S-T6 Clad Aluminum Sheet (Non-flush)					
Sheet Gauge	Type Rivet	Spacing	Edge Distance	Number of Rows	Distance between Rows
.020	AD3	7/16	7/32	4	7/16
.025	AD4	9/16	9/32	3	9/16
.032	AD5	3/4	3/8	4	3/4
.040	DD6	7/8	7/16	3	7/8
.051	DD6	7/8	7/16	3	7/8
.064	NAS178-6	7/8	7/16	3	7/8
.072	NAS178-6	7/8	7/16	3	7/8
.081	NAS178-8	1-1/8	9/16	3	1-1/8
.091	NAS178-8	1-1/8	9/16	3	1-1/8
.102	NAS178-8	1-1/8	9/16	3	1-1/8
.125	NAS178-10	1-7/16	3/4	3	1-7/16
.156	NAS178-12	1-11/16	7/8	3	1-11/16
.188	NAS178-12	1-11/16	7/8	3	1-11/16

Figure 24-39 (Sheet 3 of 10) Sheet Splices

75S-T6 Bare Aluminum Sheet (Non-flush)					
Sheet Gauge	Type Rivet	Spacing	Edge Distance	Number of Rows	Distance between Rows
.020	AD3	7/16	7/32	4	7/16
.025	AD4	9/16	9/32	4	9/16
.032	AD5	3/4	3/8	4	3/4
.040	DD6	7/8	7/16	3	7/8
.051	DD6	7/8	7/16	4	7/8
.064	NAS178-6	7/8	7/16	3	7/8
.072	NAS178-6	7/8	7/16	3	7/8
.081	NAS178-8	1-1/8	9/16	3	1-1/8
.091	NAS178-8	1-1/8	9/16	3	1-1/8
.102	NAS178-10	1-7/16	3/4	3	1-7/16
.125	NAS178-12	1-11/16	7/8	3	1-11/16
.156	NAS178-12	1-11/16	7/8	3	1-11/16
.188	AN7 Bolt	2	1	3	2

Figure 24-39 (Sheet 4 of 10) Sheet Splices

75S-T6 Clad Aluminum Sheet (Flush)							
Sheet Gauge	Type Rivet	Flush Rivet Install.	Spacing	Edge Distance	Number of Rows	Distance between Rows	Minimum Splice Plate Gauge
.020	AD4	D2	9/16	9/32	3	9/16	
.025	AD4	D2	9/16	9/32	3	9/16	
.032	DD6	D2	7/8	7/16	3	7/8	
.040	DD6	D2	7/8	7/16	3	7/8	
.051	DD6	D2	7/8	7/16	3	7/8	
.064	NAS177-8	DC	1-1/8	9/16	3	1-1/8	.072
.072	NAS177-8	DC	1-1/8	9/16	3	1-1/8	.081
.081	NAS177-8	DC	1-1/8	9/16	3	1-1/8	.091
.091	NAS177-8	C	1-1/8	9/16	4	1-1/8	
.102	NAS177-8	C	1-1/8	9/16	4	1-1/8	
.125	NAS177-10	C	1-7/16	3/4	4	1-7/16	

Figure 24-39 (Sheet 5 of 10) Sheet Splices

1/2 Hard Corrosion Resistant Steel Sheet (Non-Flush)					
Sheet Gauge	Type Rivet	Spacing	Edge Distance	Number of Rows	Distance between Rows
.020	M3	7/16	7/32	4	7/16
.025	M4	9/16	9/32	4	9/16
.032	M5	3/4	3/8	4	3/4
.036	M6	7/8	7/16	4	7/8
.040	M6	7/8	7/16	4	7/8
.045	NAS178-6	7/8	7/16	4	7/8
.050	NAS178-6	7/8	7/16	4	7/8
.063	NAS178-8	1-1/8	9/16	4	1-1/8
.080	NAS178-8	1-1/8	9/16	4	1-1/8
.090	NAS178-10	1-7/16	3/4	4	1-7/16
.112	NAS178-12	1-11/16	7/8	4	1-11/16
.125	NAS178-12	1-11/16	7/8	4	1-11/16

Figure 24-39 (Sheet 6 of 10) Sheet Splices

Annealed Corrosion Resistant Steel Sheet (Non-flush)					
Sheet Gauge	Type Rivet	Spacing	Edge Distance	Number of Rows	Distance between Rows
.020	M3	7/16	7/32	3	7/16
.025	M4	9/16	9/32	3	9/16
.032	M4	9/16	9/32	3	9/16
.036	M5	3/4	3/8	3	3/4
.040	M5	3/4	3/8	3	3/4
.045	M6	7/8	7/16	3	7/8
.050	M6	7/8	7/16	3	7/8
.063	M6	7/8	7/16	3	7/8
.080	NAS178-8	1-1/8	9/16	3	1-1/8
.090	NAS178-8	1-1/8	9/16	3	1-1/8
.112	NAS178-8	1-1/8	9/16	3	1-1/8
.125	NAS178-8	1-1/8	9/16	3	1-1/8

Figure 24-39 (Sheet 7 of 10) Sheet Splices

Annealed Corrosion Resistant Steel Sheet (Flush)						
Sheet Gauge	Type Rivet	Flush Rivet Install.	Spacing	Edge Distance	Number of Rows	Distance between Rows
.020	M4	D2	9/16	9/32	2	9/16
.025	M4	D2	9/16	9/32	2	9/16
.032	M5	D2	3/4	3/8	2	3/4
.036	M5	D2	3/4	3/8	2	3/4
.040	M6	D2	7/8	7/16	2	7/8
.045	M6	D2	7/8	7/16	2	7/8
.050	M6	D2	7/8	7/16	2	7/8
.063	M6	D2	7/8	7/16	2	7/8

Figure 24-39 (Sheet 8 of 10) Sheet Splices

FS-1H Magnesium Sheet (Non-flush)					
Sheet Gauge	Type Rivet	Spacing	Edge Distance	Number of Rows	Distance between Rows
.020	B3	7/16	7/32	3	7/16
.025	B4	9/16	9/32	3	9/16
.032	B5	3/4	3/8	3	3/4
.040	B6	7/8	7/16	3	7/8
.051	B6	7/8	7/16	3	7/8
.064	NAS178-6	7/8	7/16	3	7/8
.081	NAS178-6	7/8	7/16	3	7/8
.102	NAS178-6	7/8	7/16	3	7/8
.125	NAS178-6	7/8	7/16	3	7/8
.188	NAS178-8	1-1/8	9/16	3	1-1/8

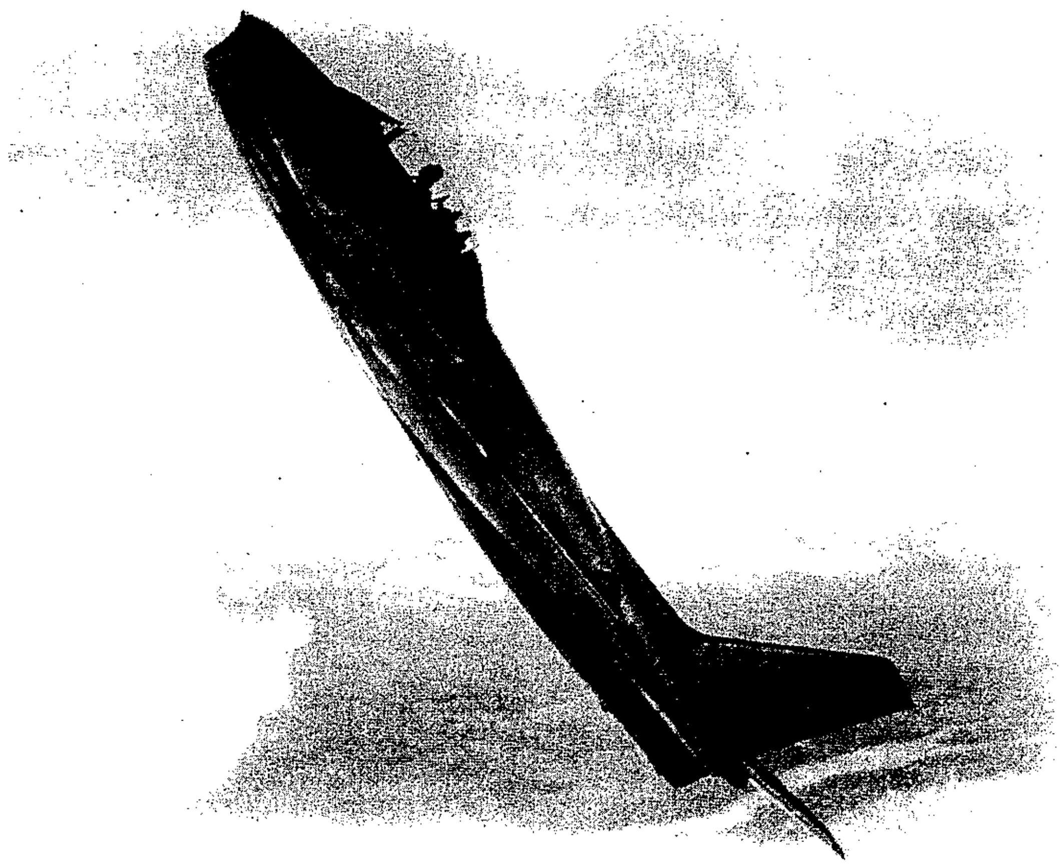
Figure 24-39 (Sheet 9 of 10) Sheet Splices

FS-1H Magnesium Sheet (Flush)						
Sheet Gauge	Type Rivet	Flush Rivet Install.	Spacing	Edge Distance	Number of Rows	Distance between Rows
.032	B3	C	7/16	7/32	4	7/16
.040	B4	C	9/16	9/32	4	9/16
.051	B5	C	3/4	3/8	4	3/4
.064	B6	C	7/8	7/16	4	7/8
.081	B6	C	7/8	7/16	4	7/8
.102	B8	C	1-1/8	9/16	4	1-1/8
.125	B8	C	1-1/8	9/16	4	1-1/8

Figure 24-39 (Sheet 10 of 10) Sheet Splices

PART 25

TABLES AND FORMULAE



PART 25

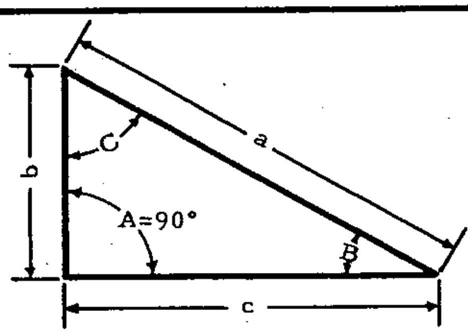
TABLES AND FORMULAE

LIST OF ILLUSTRATIONS

(Continued)

PART 25

TABLES AND FORMULAE



As shown in the illustration, the sides of the right-angled triangle are designated a, b, and c. The angles opposite each of these sides are designated A, B and C, respectively.

Angle A, opposite the hypotenuse a is the right angle, and is therefore always one of the known quantities.

Sides and Angles Known	Formulae for Sides and Angles to be Found		
Sides a and b	$c=\sqrt{a^2-b^2}$	$\sin B=\frac{b}{a}$	$C=90^o-B$
Sides a and c	$b=\sqrt{a^2-c^2}$	$\sin C=\frac{c}{a}$	$B=90^o-C$
Sides b and c	$a=\sqrt{b^2+c^2}$	$\tan B=\frac{b}{c}$	$C=90^o-B$
Side a; angle B	b=a x sin B	c=a x cos B	$C=90^o-B$
Side a; angle C	b=a x cos C	c=a x sin C	$B=90^o-C$
Side b; angle B	$a=\frac{b}{\sin B}$	c=b x cot B	$C=90^o-B$
Side b; angle C	$a=\frac{b}{\cos C}$	c=b x tan C	$B=90^o-C$
Side c; angle B	$a=\frac{c}{\cos B}$	b=c x tan B	$C=90^o-B$
Side c; angle C	$a=\frac{c}{\sin C}$	b=c x cot C	$B=90^o-C$

Figure 25-1 Solution of Right-angled Triangles

To Convert	Multiply By
Atmospheres to pounds per square inch	14.696
British Thermal Units to Centigrade Heat Units	0.5556
British Thermal Units to foot-pounds	778.4
British Thermal Units per minute to horsepower	0.023572
British Thermal Units per second to horsepower	1.41503
Centigrade Heat Units to British Thermal Units	1.8
Centigrade to Fahrenheit	$(^{o}C \times 9/5) + 32$
Centimetres to feet	0.0328
Cheval vapeur to kilowatts	0.7355
Cubic inches to Imperial gallons	0.003604
Cubic inches to litres	0.01639
Cubic inches to United States gallons	0.004329
Cubic metres to cubic yards	1.30795
Cubic yards to cubic metres	0.76455
Dynes to poundals	0.00007233
Fahrenheit to Centigrade	$(^{o}F - 32) \times 5/9$
Feet to centimetres	30.48
Feet per minute to miles per hour	0.0114
Feet per second to metres per minute	18.288
Foot-pounds to British Thermal Units	0.001285
Foot-pounds to Centigrade Heat Units	0.0007138
Foot-pounds per second to horsepower	0.0018
Imperial gallons to cubic inches	227.42
United States gallons to litres	3.785332
Grammes per litre to ounces per gallon	0.160354
Horsepower to British Thermal units per minute	42.42
Horsepower to British Thermal Units per second	0.707
Horsepower to kilogrammetres per second	76.04025
Inches of mercury to pounds per square inch	0.49117
Kilogrammes to pounds	2.205
Kilogrammes to tons	0.00098421

Figure 25-2 (Sheet 1 of 2) Table of Conversion Factors

To Convert	Multiply By
Kilogrammetres per second to cheval vapeur	0.0133
Kilogrammetres per second to horsepower	0.013151
Kilogrammes per square centimetre to millimetres of mercury	735.54
Kilometres (1000 metres) to feet	3280.8
Kilometres per litre to miles per United States gallon	2.3521
Kilowatts to cheval vapeur	1.35962
Litres to cubic inches	61.024
Litres to United States gallons	0.26417
Litres per kilometre to United States gallons per mile	0.4252
Metres per minute to feet per second	0.054664
Metres per second to miles per hour	2.23694
Miles per hour to feet per minute	88.0
Miles per hour to metres per second	0.44704
Millimetres of mercury (gauge) to kilogrammes per square centimetre	0.0013596
Ounces per gallon to grammes per litre	28.349527
Piezes to atmospheres	0.0098692
Pounds per square inch to atmospheres	0.0680
Pounds per square inch to inches of mercury	2.03596
Poundals to pounds weight	32.19
Poundals to dynes	13825.5
Poundals to Newtons	0.13825497
Square metres to square yards	1.19599
Square yards to square metres	0.83613
Ton miles to tonne kilometres	1.583
Tonne kilometres to ton miles	0.631
Tonne kilometres per litre to ton miles per gallon	2.868
Ton miles per gallon to tonne kilometres per litre	0.348
United States gallons to cubic inches	231.0
United States gallons to litres	3.785411
United States tons to tonnes (1000 kilogrammes)	0.907185
Long tons (2240 pounds) to tons	1.12

Figure 25-2 (Sheet 2 of 2) Table of Conversion Factors

Size	Decimal Equiv.	Size	Decimal Equiv.	Size	Decimal Equiv.	Size	Decimal Equiv.
1/2	.5000	17/64	.2656	22	.1570	50	.0700
31/64	.4844	G	.2610	5/32	.1562	51	.0670
15/32	.4687	F	.2570	23	.1540	52	.0635
29/64	.4531	1/4	.2500	24	.1520	1/16	.0625
7/16	.4375	D	.2460	25	.1495	53	.0595
29/64	.4219	C	.2420	26	.1470	54	.0550
Z	.4130	B	.2380	27	.1440	55	.0520
13/32	.4062	15/64	.2344	9/64	.1406	3/64	.0469
Y	.4040	A	.2340	28	.1405	56	.0465
X	.3970	1	.2280	29	.1360	57	.0430
25/64	.3906	2	.2210	30	.1285	58	.0420
W	.3860	7/32	.2187	1/8	.1250	59	.0410
V	.3770	3	.2130	31	.1200	60	.0400
3/8	.3750	4	.2090	32	.1160	61	.0390
U	.3680	5	.2055	33	.1130	62	.0380
23/64	.3594	6	.2040	34	.1110	63	.0370
T	.3580	13/64	.2031	35	.1100	64	.0360
S	.3480	7	.2010	7/64	.1094	65	.0350
11/32	.3437	8	.1990	36	.1065	66	.0330
R	.3390	9	.1960	37	.1040	67	.0320
Q	.3320	10	.1935	38	.1015	1/32	.0313
21/64	.3281	11	.1910	39	.0995	68	.0310
P	.3230	12	.1890	40	.0980	69	.0292
O	.3160	3/16	.1875	41	.0960	70	.0280
5/16	.3125	13	.1850	3/32	.0937	71	.0260
N	.3020	14	.1820	42	.0935	72	.0250
19/64	.2969	15	.1800	43	.0890	73	.0240
M	.2950	16	.1770	44	.0860	74	.0225
L	.2900	17	.1730	45	.0820	75	.0210
9/32	.2812	11/64	.1719	46	.0810	76	.0200
K	.2810	18	.1695	47	.0785	77	.0180
J	.2770	19	.1660	5/64	.0781	78	.0160
I	.2720	20	.1610	48	.0760	1/64	.0156
H	.2660	21	.1590	49	.0730	79	.0145
Fractional sizes are available in 1/64 increasing up to 1-3/4 dia.						80	.0135

Figure 25-3 Table of Twist Drill Sizes for Decimal Equivalents

Inch Fraction	Decimal Equiv.	Area Sq.In.	mm Equiv.	Inch Fraction	Decimal Equiv.	Area Sq.In.	mm Equiv.
1/64	.0156	.0002	.397	17/32	.5312	.2217	13.494
1/32	.0312	.0008	.794	35/64	.5469	.2349	13.891
3/64	.0469	.0017	1.191	9/16	.5625	.2485	14.288
1/16	.0625	.0031	1.587	37/64	.5781	.2625	14.684
5/64	.0781	.0048	1.984	19/32	.5937	.2769	15.081
3/32	.0937	.0069	2.381	39/64	.6094	.2916	15.478
7/64	.1049	.0094	2.778	5/8	.6250	.3068	15.875
1/8	.1250	.0123	3.175	41/64	.6406	.3223	16.272
9/64	.1406	.0154	3.572	21/32	.6562	.3382	16.669
5/32	.1562	.0192	3.969	43/64	.6719	.3545	17.065
11/64	.1719	.0232	4.366	11/16	.6875	.3712	17.462
3/16	.1875	.0276	4.762	45/64	.7031	.3883	17.859
13/64	.2031	.0324	5.159	23/32	.7187	.4057	18.256
7/32	.2187	.0376	5.556	47/64	.7344	.4235	18.653
15/64	.2344	.0431	5.953	3/4	.7500	.4418	19.050
1/4	.2500	.0491	6.350	49/64	.7656	.4604	19.447
17/64	.2656	.0553	6.747	25/32	.7812	.4794	19.844
9/32	.2812	.0621	7.144	51/64	.7969	.4987	20.241
19/64	.2969	.0692	7.540	13/16	.8125	.5185	20.637
5/16	.3125	.0767	7.937	53/64	.8281	.5386	21.034
21/64	.3281	.0845	8.334	27/32	.8437	.5591	21.431
11/32	.3437	.0928	8.731	55/64	.8594	.5800	21.828
23/64	.3594	.1014	9.128	7/8	.8750	.6013	22.225
3/8	.3750	.1105	9.525	57/64	.8906	.6229	22.622
25/64	.3906	.1198	9.922	29/32	.9062	.6450	23.019
13/32	.4062	.1296	10.319	59/64	.9219	.6675	23.416
27/64	.4219	.1398	10.716	15/16	.9375	.6903	23.812
7/16	.4375	.1503	11.112	61/64	.9531	.7134	24.209
29/64	.4531	.1612	11.509	31/32	.9687	.7371	24.606
15/32	.4687	.1726	11.906	63/64	.9844	.7610	25.003
31/64	.4844	.1842	12.303	1	1.0000	.7854	25.400
1/2	.5000	.1964	12.700	1-1/8	1.1250	.9940	
33/64	.5156	.2088	13.097		1.1300	1.0030	

Figure 25-4 Table of Decimal Equivalents and Areas

Screw Thread		Commercial Tap Drills*		Screw Thread		Commercial Tap Drills*	
Outside Diam. Pitch	Root Diam.	Size or Number	Equiv. Decimal	Outside Diam. Pitch	Root Diam.	Size or Number	Equiv. Decimal
1/16-64	0.0422	3/64	0.0469	20	0.3100	21/64	0.3281
72	0.0445	3/64	0.0469	24	0.3209	Q	0.3320
5/64-60	0.0563	1/16	0.0625	27	0.3269	R	0.3390
72	0.0601	52	0.0635	7/16-14	0.3447	U	0.3680
3/32-48	0.0667	49	0.0730	20	0.3726	25/64	0.3906
50	0.0678	49	0.0730	24	0.3834	X	0.3970
7/64-48	0.0823	43	0.0890	27	0.3894	Y	0.4040
1/8-32	0.0844	3/32	0.0937	1/2-12	0.3918	27/64	0.4219
-40	0.0925	38	0.1015	13	0.4001	27/64	0.4219
9/64-40	0.1081	32	0.1160	20	0.4351	29/64	0.4531
5/32-32	0.1157	1/8	0.1250	24	0.4459	29/64	0.4531
36	0.1202	30	0.1285	27	0.4519	15/32	0.4687
11/64-32	0.1313	9/64	0.1406	9/16-12	0.4542	31/64	0.4844
3/16-24	0.1334	26	0.1470	18	0.4903	33/64	0.5156
32	0.1469	22	0.1570	27	0.5144	17/32	0.5312
13/64-24	0.1490	20	0.1610	5/8-11	0.5069	17/32	0.5312
7/32-24	0.1646	16	0.1770	12	0.5168	35/64	0.5469
32	0.1782	12	0.1890	18	0.5528	37/64	0.5781
15/64-24	0.1806	10	0.1935	27	0.5769	19/32	0.5937
1/4-20	0.1850	7	0.2010	11/16-11	0.5694	19/32	0.5937
24	0.1959	4	0.2090	16	0.6063	5/8	0.6250
27	0.2019	3	0.2130	3/4-10	0.6201	21/32	0.6562
28	0.2036	3	0.2130	12	0.6418	43/64	0.6719
32	0.2094	7/32	0.2187	16	0.6688	11/16	0.6875
5/16-18	0.2403	F	0.2570	27	0.7019	23/32	0.7187
20	0.2476	17/64	0.2656	13/16-10	0.6826	23/32	0.7187
24	0.2584	I	0.2720	7/8-9	0.7307	49/64	0.7656
27	0.2644	J	0.2770	12	0.7668	51/64	0.7969
32	0.2719	9/32	0.2812	14	0.7822	13/16	0.8125
3/8-16	0.2938	5/16	0.3125	18	0.8028	53/64	0.8281

*These tap drill diameters allow approximately 75 percent of a full thread.

Figure 25-5 (Sheet 1 of 2) Table of Tap Drill Sizes for Unified and American Threads

Screw Thread		Commercial Tap Drills*		Screw Thread		Commercial Tap Drills*	
Outside Diam. Pitch	Root Diam.	Size or Number	Equiv. Decimal	Outside Diam. Pitch	Root Diam.	Size or Number	Equiv. Decimal
27	0.8269	27/32	0.8437	12	1.2668	1-19/64	1.2969
15/16- 9	0.7932	53/64	0.8281	1-1/2 - 6	1.2835	1-11/32	1.3437
1 - 8	0.8376	7/8	0.8750	12	1.3918	1-27/64	1.4219
12	0.8918	59/64	0.9219	1-5/8 - 5-1/2	1.3888	1-29/64	1.4531
14	0.9072	15/16	0.9375	1-3/4 - 5	1.4902	1-9/16	1.5625
27	0.9519	31/32	0.9687	1-7/8 - 5	1.6152	1-11/16	1.6875
1-1/8- 7	0.9394	63/64	0.9844	2 -4-1/2	1.7113	1-25/32	1.7812
12	1.0168	1-3/64	1.0469	2-1/8 - 4-1/2	1.8363	1-29/32	1.9062
1-1/4- 7	1.0644	1-7/64	1.1094	2-1/4 - 4-1/2	1.9613	2-1/32	2.0312
12	1.1418	1-11/64	1.1719	2-3/8 - 4	2.0502	2-1/8	2.1250
1-3/8- 6	1.1585	1-7/32	1.2187	2-1/2 - 4	2.1752	2-1/4	2.2500

*These tap drill diameters allow approximately 75 percent of a full thread.

Figure 25-5 (Sheet 2 of 2) Table of Tap Drill Sizes for Unified and American Threads

Screw Size	Basic Major Diameter	No. of Threads		Tap Drill Size			
				Coarse		Fine	
		Coarse	Fine	No. or size	Dec.Equiv.	No. or size	Dec.Equiv.
0	0.0600		80			3/64	.047
1	0.0730	64	72	53	.060	53	.060
2	0.0860	56	64	50	.070	50	.070
3	0.0990	48	56	47	.079	45	.082
4	0.1120	40	48	43	.089	42	.094
5	0.1250	40	44	38	.102	37	.104
6	0.1380	32	40	36	.107	33	.113
8	0.1640	32	36	29	.136	29	.136
10	0.1900	24	32	25	.150	21	.159
12	0.2160	24	28	16	.177	14	.182

To find No. or size of screw, measure the diameter and divide by 12. The remainder is the screw number, e.g., 0.164 diameter screw. Divide by 12. Result 13 and 8 remainder. This is a No. 8 screw. Reason: This is an arithmetical progression with base at .060 inch diameter for a number 0 screw. Other numbers increase by .013.

Figure 25-6 Table of Tap Drill Sizes for Machine Screws

Designation			External Thread Limits of Size							
				Major Diameter			Pitch Diameter[1]			
				Limits			Limits			
Size	Thds Per In.	Thread Symbol	Allow-ance	Max	Min	Toler-ance	Max	Min	Toler-ance	Minor Dia-meter Max[2]
1(.073)	64	NC-2A	0.0006	0.0724	0.0686	0.0038	0.0623	0.0603	0.0020	0.0532
2(.086)	56	NC-2A	0.0006	0.0854	0.0813	0.0041	0.0738	0.0717	0.0021	0.0635
3(.099)	48	NC-2A	0.0007	0.0983	0.0938	0.0045	0.0848	0.0825	0.0023	0.0727
4(.112)	40	NC-2A	0.0008	0.1112	0.1061	0.0051	0.0950	0.0925	0.0025	0.0805
5(.125)	40	NC-2A	0.0008	0.1242	0.1191	0.0051	0.1080	0.1054	0.0026	0.0935
6(.138)	32	NC-2A	0.0008	0.1372	0.1312	0.0060	0.1169	0.1141	0.0028	0.0989
8(.164)	32	NC-2A	0.0009	0.1631	0.1571	0.0060	0.1428	0.1399	0.0029	0.1248
10(.190)	24	NC-2A	0.0010	0.1890	0.1818	0.0072	0.1619	0.1586	0.0033	0.1379
1/4	20	UNC-2A	0.0011	0.2489	0.2408	0.0081	0.2164	0.2127	0.0037	0.1876
5/16	18	UNC-2A	0.0012	0.3113	0.3026	0.0087	0.2752	0.2712	0.0040	0.2431
3/8	16	UNC-2A	0.0013	0.3737	0.3643	0.0094	0.3331	0.3287	0.0044	0.2970
7/16	14	UNC-2A	0.0014	0.4361	0.4258	0.0103	0.3897	0.3850	0.0047	0.3485
1/2	13	UNC-2A	0.0015	0.4985	0.4876	0.0109	0.4485	0.4435	0.0050	0.4041
9/16	12	UNC-2A	0.0016	0.5609	0.5495	0.0114	0.5068	0.5016	0.0052	0.4587
5/8	11	UNC-2A	0.0016	0.6234	0.6113	0.0121	0.5644	0.5589	0.0055	0.5119
3/4	10	UNC-2A	0.0018	0.7482	0.7353	0.0129	0.6832	0.6773	0.0059	0.6255
7/8	9	UNC-2A	0.0019	0.8731	0.8592	0.0139	0.8009	0.7946	0.0063	0.7368
1	8	UNC-2A	0.0020	0.9980	0.9830	0.0150	0.9168	0.9100	0.0068	0.8446

[1] British: Effective Diameter.

[2] The minimum minor diameter may be determined by subtracting 0.6495p (=3/4H) from the minimum pitch diameter of the external thread.

Figure 25-7
Table of Threads - Class 2A, Coarse Thread Series, External Threads, Symbols UNC-2A and NC-2A

Designation			Internal Thread Limits of Size						
			Minor Diameter			Pitch Diameter[1]			Major Diameter Min[2]
			Limits		Tolerance	Limits		Tolerance	
Size	Thds Per In.	Thread Symbol	Min	Max		Min	Max		
1(.073)	64	NC-2B	0.0561	0.0623	0.0062	0.0629	0.0655	0.0026	0.0730
2(.086)	56	NC-2B	0.0667	0.0737	0.0070	0.0744	0.0772	0.0028	0.0860
3(.099)	48	NC-2B	0.0764	0.0845	0.0081	0.0855	0.0885	0.0030	0.0990
4(.112)	40	NC-2B	0.0849	0.0939	0.0090	0.0958	0.0991	0.0033	0.1120
5(.125)	40	NC-2B	0.0979	0.1062	0.0083	0.1088	0.1121	0.0033	0.1250
6(.138)	32	NC-2B	0.1042	0.1140	0.0098	0.1177	0.1214	0.0037	0.1380
8(.164)	32	NC-2B	0.1302	0.1389	0.0087	0.1437	0.1475	0.0038	0.1640
10(.190)	24	NC-2B	0.1449	0.1555	0.0106	0.1629	0.1672	0.0043	0.1900
1/4	20	UNC-2B	0.1959	0.2067	0.0108	0.2175	0.2223	0.0048	0.2500
5/16	18	UNC-2B	0.2524	0.2630	0.0106	0.2764	0.2817	0.0053	0.3125
3/8	16	UNC-2B	0.3073	0.3182	0.0109	0.3344	0.3401	0.0057	0.3750
7/16	14	UNC-2B	0.3602	0.3717	0.0115	0.3911	0.3972	0.0061	0.4375
1/2	13	UNC-2B	0.4167	0.4284	0.0117	0.4500	0.4565	0.0065	0.5000
9/16	12	UNC-2B	0.4723	0.4843	0.0120	0.5084	0.5152	0.0068	0.5625
5/8	11	UNC-2B	0.5266	0.5391	0.0125	0.5660	0.5732	0.0072	0.6250
3/4	10	UNC-2B	0.6417	0.6545	0.0128	0.6850	0.6927	0.0077	0.7500
7/8	9	UNC-2B	0.7547	0.7681	0.0134	0.8028	0.8110	0.0082	0.8750
1	8	UNC-2B	0.8647	0.8797	0.0150	0.9188	0.9276	0.0088	1.0000

[1]British: Effective Diameter.

[2]The maximum major diameter of the internal thread may be determined by adding 0.7039p (=11/12 H) to the maximum pitch diameter of the internal thread.

Figure 25-8
Table of Threads - Class 2B, Coarse Thread Series, Internal Threads, Symbols UNC-2B and NC-2B

Designation			External Thread Limits of Size						
			Major Diameter			Pitch Diameter[1]			Minor Diameter Max[2]
			Limits		Tolerance	Limits		Tolerance	
Size	Thds Per Inch	Thread Symbol	Max	Min		Max	Min		
1(.073)	64	NC-3A	0.0730	0.0692	0.0038	0.0629	0.0614	0.0015	0.0538
2(.086)	56	NC-3A	0.0860	0.0819	0.0041	0.0744	0.0728	0.0016	0.0641
3(.099)	48	NC-3A	0.0990	0.0945	0.0045	0.0855	0.0838	0.0017	0.0734
4(.112)	40	NC-3A	0.1120	0.1069	0.0051	0.0958	0.0939	0.0019	0.0813
5(.125)	40	NC-3A	0.1250	0.1199	0.0051	0.1088	0.1068	0.0019	0.0943
6(.138)	32	NC-3A	0.1380	0.1320	0.0060	0.1177	0.1156	0.0021	0.0997
8(.164)	32	NC-3A	0.1640	0.1580	0.0060	0.1437	0.1415	0.0022	0.1257
10(.190)	24	NC-3A	0.1900	0.1828	0.0072	0.1629	0.1604	0.0025	0.1389
1/4	20	UNC-3A	0.2500	0.2419	0.0081	0.2175	0.2147	0.0028	0.1887
5/16	18	UNC-3A	0.3125	0.3038	0.0087	0.2764	0.2734	0.0030	0.2443
3/8	16	UNC-3A	0.3750	0.3656	0.0094	0.3344	0.3311	0.0033	0.2983
7/16	14	UNC-3A	0.4375	0.4272	0.0103	0.3911	0.3876	0.0035	0.3499
1/2	13	UNC-3A	0.5000	0.4891	0.0109	0.4500	0.4463	0.0037	0.4056
9/16	12	UNC-3A	0.5625	0.5511	0.0114	0.5084	0.5045	0.0039	0.4603
5/8	11	UNC-3A	0.6250	0.6129	0.0121	0.5660	0.5619	0.0041	0.5135
3/4	10	UNC-3A	0.7500	0.7371	0.0129	0.6850	0.6806	0.0044	0.6273
7/8	9	UNC-3A	0.8750	0.8611	0.0139	0.8028	0.7981	0.0047	0.7387
1	8	UNC-3A	1.0000	0.9850	0.0150	0.9188	0.9137	0.0051	0.8466

[1] British: Effective Diameter.

[2] The minimum minor diameter may be determined by subtracting 0.6495p (=3/4H) from the minimum pitch diameter of the external thread.

Figure 25-9
Table of Threads - Class 3A, Coarse Thread Series, External Threads, Symbols UNC-3A and NC-3A

Designation			Internal Thread Limits of Size						
			Minor Diameter			Pitch Diameter[1]			
			Limits			Limits			
Size	Thds. Per Inch	Thread Symbol	Min	Max	Toler-ance	Min	Max	Toler-ance	Major Dia-meter Min[2]
1(.013)	64	NC-3B	0.0561	0.0623	0.0062	0.0629	0.0648	0.0019	0.0730
2(.086)	56	NC-3B	0.0667	0.0737	0.0070	0.0744	0.0765	0.0021	0.0860
3(.099)	48	NC-3B	0.0764	0.0845	0.0081	0.0855	0.0877	0.0022	0.0990
4(.112)	40	NC-3B	0.0849	0.0939	0.0890	0.0958	0.0982	0.0024	0.1120
5(.125)	40	NC-3B	0.0979	0.1062	0.0083	0.1088	0.1113	0.0025	0.1250
6(.138)	32	NC-3B	0.1042	0.1140	0.0098	0.1177	0.1204	0.0027	0.1380
8(.164)	32	NC-3B	0.1302	0.1389	0.0087	0.1437	0.1465	0.0028	0.1640
10(.190)	24	NC-3B	0.1449	0.1555	0.0106	0.1629	0.1661	0.0032	0.1900
1/4	20	UNC-38	0.1959	0.2067	0.0108	0.2175	0.2211	0.0036	0.2500
5/16	18	UNC-3B	0.2524	0.2630	0.0106	0.2764	0.2803	0.0039	0.3125
3/8	16	UNC-3B	0.3073	0.3182	0.0109	0.3344	0.3387	0.0043	0.3750
7/16	14	UNC-3B	0.3602	0.3717	0.0115	0.3911	0.3957	0.0046	0.4375
1/2	13	UNC-3B	0.4167	0.4284	0.0117	0.4500	0.4548	0.0048	0.5000
9/16	12	UNC-3B	0.4723	0.4846	0.0120	0.5084	0.5135	0.0051	0.5625
5/8	11	UNC-3B	0.5266	0.5391	0.0125	0.5660	0.5714	0.0054	0.6250
3/4	10	UNC-3B	0.6417	0.6545	0.0128	0.6850	0.6907	0.0057	0.7500
7/8	9	UNC-3B	0.7547	0.7681	0.0134	0.8028	0.8089	0.0061	0.8750
1	8	UNC-3B	0.8647	0.8797	0.0150	0.9188	0.9254	0.0066	1.0000

[1] British: Effective Diameter.

[2] The maximum major diameter of the internal thread may be determined by adding 0.7930p (=11/12 H) to the maximum pitch diameter of the internal thread.

Figure 25-10
Table of Threads - Class 3B, Coarse Thread Series, Internal Threads, Symbols UNC-3B and NC-3B

Designation			External Thread Limits of Size							
				Major Diameter			Pitch Diameter[1]			
				Limits			Limits			
Size	Thds Per Inch	Thread Symbol	Allowance	Max	Min	Tolerance	Max	Min	Tolerance	Minor Diameter Max[2]
0 (.060)	80	NF-2A	0.0005	0.0595	0.0563	0.0032	0.0514	0.0496	0.0018	0.0442
1 (.073)	72	NF-2A	0.0006	0.0724	0.0689	0.0035	0.0634	0.0615	0.0019	0.0554
2 (.086)	64	NF-2A	0.0006	0.0854	0.0816	0.0038	0.0753	0.0733	0.0020	0.0662
3 (.099)	56	NF-2A	0.0007	0.0983	0.0942	0.0041	0.0867	0.0845	0.0022	0.0764
4 (.112)	48	NF-2A	0.0007	0.1113	0.1068	0.0045	0.0978	0.0954	0.0024	0.0857
5 (.125)	44	NF-2A	0.0007	0.1243	0.1195	0.0048	0.1095	0.1070	0.0025	0.0964
6 (.138)	40	NF-2A	0.0008	0.1372	0.1321	0.0051	0.1210	0.1184	0.0026	0.1065
8 (.164)	36	NF-2A	0.0008	0.1632	0.1577	0.0055	0.1452	0.1424	0.0028	0.1291
10 (.190)	32	NF-2A	0.0009	0.1891	0.1831	0.0060	0.1688	0.1658	0.0030	0.1508
1/4	28	UNF-2A	0.0010	0.2490	0.2425	0.0065	0.2258	0.2225	0.0033	0.2052
5/16	24	UNF-2A	0.0011	0.3114	0.3042	0.0072	0.2843	0.2806	0.0037	0.2603
3/8	24	UNF-2A	0.0011	0.3739	0.3667	0.0072	0.3468	0.3430	0.0038	0.3228
7/16	20	UNF-2A	0.0013	0.4362	0.4281	0.0081	0.4037	0.3995	0.0042	0.3749
1/2	20	UNF-2A	0.0013	0.4987	0.4906	0.0081	0.4662	0.4619	0.0043	0.4374
9/16	18	UNF-2A	0.0014	0.5611	0.5524	0.0087	0.5250	0.5205	0.0045	0.4929
5/8	18	UNF-2A	0.0014	0.6236	0.6149	0.0087	0.5875	0.5828	0.0047	0.5554
3/4	16	UNF-2A	0.0015	0.7485	0.7391	0.0094	0.7079	0.7029	0.0050	0.6718
7/8	14	UNF-2A	0.0016	0.8734	0.8631	0.0103	0.8270	0.8216	0.0054	0.7858
1	14	NF-2A	0.0017	0.9983	0.9880	0.0103	0.9519	0.9463	0.0056	0.9107
1	12	UNF-2A	0.0018	0.9982	0.9868	0.0114	0.9441	0.9382	0.0059	0.8960
1-1/8	12	UNF-2A	0.0018	1.1232	1.1118	0.0114	1.0691	1.0631	0.0060	1.0210
1-1/4	12	UNF-2A	0.0018	1.2482	1.2368	0.0114	1.1941	1.1879	0.0062	1.1460
1-3/8	12	UNF-2A	0.0019	1.3731	1.3617	0.0114	1.3190	1.3127	0.0063	1.2709
1-1/2	12	UNF-2A	0.0019	1.4981	1.4867	0.0114	1.4440	1.4376	0.0064	1.3959

[1] British: Effective Diameter.

[2] The minimum minor diameter may be determined by subtracting 0.6495p (=3/4 H) from the minimum pitch diameter of the external thread.

Figure 25-11
Table of Threads - Class 2A, Fine Thread Series, External Threads, Symbols UNF-2A and NF-2A

Designation			Internal Thread Limits of Size						
			Minor Diameter			Pitch Diameter[1]			
			Limits			Limits			
Size	Thds Per Inch	Thread Symbol	Min	Max	Toler-ance	Min	Max	Toler-ance	Major Dia-meter Min[2]
0 (.060)	80	NF-2B	0.0465	0.0514	0.0049	0.0519	0.0542	0.0023	0.0600
1 (.073)	72	NF-2B	0.0580	0.0635	0.0055	0.0640	0.0665	0.0025	0.0730
2 (.086)	64	NF-2B	0.0691	0.0753	0.0062	0.0759	0.0786	0.0027	0.0860
3 (.099)	56	NF-2B	0.0797	0.0865	0.0068	0.0874	0.0902	0.0028	0.0990
4 (.112)	48	NF-2B	0.0894	0.0968	0.0074	0.0985	0.1016	0.0031	0.1120
5 (.125)	44	NF-2B	0.1004	0.1079	0.0075	0.1102	0.1134	0.0032	0.1250
6 (.138)	40	NF-2B	0.1109	0.1186	0.0077	0.1218	0.1252	0.0034	0.1380
8 (.164)	36	NF-2B	0.1339	0.1416	0.0077	0.1460	0.1496	0.0036	0.1640
10 (.190)	32	NF-2B	0.1562	0.1641	0.0079	0.1697	0.1736	0.0039	0.1900
1/4	28	UNF-2B	0.2113	0.2190	0.0077	0.2268	0.2311	0.0043	0.2500
5/16	24	UNF-2B	0.2674	0.2754	0.0080	0.2854	0.2902	0.0048	0.3125
3/8	24	UNF-2B	0.3299	0.3372	0.0073	0.3479	0.3528	0.0049	0.3750
7/16	20	UNF-2B	0.3834	0.3916	0.0082	0.4050	0.4104	0.0054	0.4375
1/2	20	UNF-2B	0.4459	0.4537	0.0078	0.4675	0.4731	0.0056	0.5000
9/16	18	UNF-2B	0.5024	0.5106	0.0082	0.5264	0.5323	0.0059	0.5625
5/8	18	UNF-2B	0.5649	0.5730	0.0081	0.5889	0.5949	0.0060	0.6250
3/4	16	UNF-2B	0.6823	0.6908	0.0085	0.7094	0.7159	0.0065	0.7500
7/8	14	UNF-2B	0.7977	0.8068	0.0091	0.8286	0.8356	0.0070	0.8750
1	14	NF-2B	0.9227	0.9313	0.0088	0.9536	0.9609	0.0073	1.0000
1	12	UNF-2B	0.9098	0.9198	0.0100	0.9459	0.9535	0.0076	1.0000
1-1/8	12	UNF-2B	1.0348	1.0448	0.0100	1.0709	1.0787	0.0078	1.1250
1-1/4	12	UNF-2B	1.1598	1.1698	0.0100	1.1959	1.2039	0.0080	1.2500
1-3/8	12	UNF-2B	1.2848	1.2948	0.0100	1.3209	1.3291	0.0082	1.3750
1-1/2	12	UNF-2B	1.4098	1.4198	0.0100	1.4459	1.4542	0.0083	1.5000

[1] British: Effective Diameter.

[2] The maximum major diameter of the internal thread may be determined by adding 0.7939p (=11/12 H) to the maximum pitch diameter of the internal thread.

Figure 25-12
Table of Threads - Class 2B, Fine Thread Series, Internal Threads, Symbols UNF-2B and NF-2B

Designation			External Thread Limits of Size						
			Major Diameter			Pitch Diameter[1]			Minor Diameter Max[2]
			Limits		Tolerance	Limits		Tolerance	
Size	Thds Per Inch	Thread Symbol	Max	Min		Max	Min		
0 (.060)	80	NF-3A	0.0600	0.0568	0.0032	0.0519	0.0506	0.0013	0.0447
1 (.073)	72	NF-3A	0.0730	0.0695	0.0035	0.0640	0.0626	0.0014	0.0560
2 (.086)	64	NF-3A	0.0860	0.0822	0.0038	0.0759	0.0744	0.0015	.0668
3 (.099)	56	NF-3A	0.0990	0.0949	0.0041	0.0874	0.0858	0.0016	0.0771
4 (.112)	48	NF-3A	0.1120	0.1075	0.0045	0.0985	0.0967	0.0018	0.0864
5 (.125)	44	NF-3A	0.1250	0.1202	0.0048	0.1102	0.1083	0.0019	0.0971
6 (.138)	40	NF-3A	0.1380	0.1329	0.0051	0.1218	0.1198	0.0020	0.1073
8 (.164)	36	NF-3A	0.1640	0.1585	0.0055	0.1460	0.1439	0.0021	0.1299
10 (.190)	32	NF-3A	0.1900	0.1840	0.0060	0.1697	0.1674	0.0023	0.1517
1/4	28	UNF-3A	0.2500	0.2435	0.0065	0.2268	0.2243	0.0025	0.2062
5/16	24	UNF-3A	0.3125	0.3053	0.0072	0.2854	0.2827	0.0027	0.2614
3/8	24	UNF-3A	0.3750	0.3678	0.0072	0.3479	0.3450	0.0029	0.3239
7/16	20	UNF-3A	0.4375	0.4294	0.0081	0.4050	0.4019	0.0031	0.3762
1/2	20	UNF-3A	0.5000	0.4919	0.0081	0.4675	0.4643	0.0032	0.4387
9/16	18	UNF-3A	0.5625	0.5538	0.0087	0.5264	0.5230	0.0034	0.4943
5/8	18	UNF-3A	0.6250	0.6163	0.0087	0.5889	0.5854	0.0035	0.5568
3/4	16	UNF-3A	0.7500	0.7406	0.0094	0.7094	0.7056	0.0038	0.6733
7/8	14	UNF-3A	0.8750	0.8647	0.0103	0.8286	0.8245	0.0041	0.7874
1	14	NF-3A	1.0000	0.9897	0.0103	0.9536	0.9494	0.0042	0.9124
1	12	UNF-3A	1.0000	0.9886	0.0114	0.9459	0.9415	0.0044	0.8978
1-1/8	12	UNF-3A	1.1250	1.1136	0.0114	1.0709	1.0664	0.0045	1.0228
1-1/4	12	UNF-3A	1.2500	1.2386	0.0114	1.1959	1.1913	0.0046	1.1478
1-3/8	12	UNF-3A	1.3750	1.3636	0.0114	1.3209	1.3162	0.0047	1.2728
1-1/2	12	UNF-3A	1.5000	1.4886	0.0114	1.4459	1.4411	0.0048	1.3978

[1]British: Effective Diameter.

[2]The minimum minor diameter may be obtained by subtracting 0.6495p (=3/4 H) from the minimum pitch diameter of the external thread.

Figure 25-13
Table of Threads - Class 3A, Fine Thread Series, External Threads, Symbols UNF-3A and NF-3A

Designation			Internal Thread Limits of Size						
			Minor Diameter			Pitch Diameter[1]			Major Diameter Min[2]
			Limits		Tolerance	Limits		Tolerance	
Size	Thds Per Inch	Thread Symbol	Min	Max		Min	Max		
0 (.060)	80	NF-3B	0.0465	0.0514	0.0049	0.0519	0.0536	0.0017	0.0600
1 (.073)	72	NF-3B	0.0580	0.0635	0.0055	0.0640	0.0659	0.0019	0.0730
2 (.086)	64	NF-3B	0.0691	0.0753	0.0062	0.0759	0.0779	0.0020	0.0860
3 (.099)	56	NF-3B	0.0797	0.0865	0.0068	0.0874	0.0895	0.0021	0.0990
4 (.112)	48	NF-3B	0.0894	0.0968	0.0074	0.0985	0.1008	0.0023	0.1120
5 (.125)	44	NF-3B	0.1004	0.1079	0.0075	0.1102	0.1126	0.0024	0.1250
6 (.138)	40	NF-3B	0.1109	0.1186	0.0077	0.1218	0.1243	0.0025	0.1380
8 (.164)	36	NF-3B	0.1339	0.1416	0.0077	0.1460	0.1487	0.0027	0.1640
10 (.190)	32	NF-3B	0.1562	0.1641	0.0079	0.1697	0.1726	0.0029	0.1900
1/4	28	UNF-3B	0.2113	0.2190	0.0077	0.2268	0.2300	0.0032	0.2500
5/16	24	UNF-3B	0.2674	0.2754	0.0080	0.2854	0.2890	0.0036	0.3125
3/8	24	UNF-3B	0.3299	0.3372	0.0073	0.3479	0.3516	0.0037	0.3750
7/16	20	UNF-3B	0.3834	0.3916	0.0082	0.4050	0.4091	0.0041	0.4375
1/2	20	UNF-3B	0.4459	0.4537	0.0078	0.4675	0.4717	0.0042	0.5000
9/16	18	UNF-3B	0.5024	0.5106	0.0082	0.5264	0.5308	0.0044	0.5625
5/8	18	UNF-3B	0.5649	0.5730	0.0081	0.5889	0.5934	0.0045	0.6250
3/4	16	UNF-3B	0.6823	0.6908	0.0085	0.7094	0.7143	0.0049	0.7500
7/8	14	UNF-3B	0.7977	0.8068	0.0091	0.8286	0.8339	0.0053	0.8750
1	14	NF-3B	0.9227	0.9315	0.0088	0.9536	0.9590	0.0054	1.0000
1	12	UNF-3B	0.9098	0.9198	0.0100	0.9459	0.9516	0.0057	1.0000
1-1/8	12	UNF-3B	1.0348	1.0448	1.0100	1.0709	1.0768	0.0059	1.1250
1-1/4	12	UNF-3B	1.1598	1.1698	0.0100	1.1959	1.2019	0.0060	1.2500
1-3/8	12	UNF-3B	1.2848	1.2948	0.0100	1.3209	1.3270	0.0061	1.3750
1-1/2	12	UNF-3B	1.4098	1.4198	0.0100	1.4459	1.4522	0.0063	1.5000

[1] British: Effective Diameter.

[2] The maximum major diameter of the internal thread may be determined by adding 0.7939p (=11/12 H) to the maximum pitch diameter of the internal thread.

Figure 25-14
Table of Threads - Class 3B, Fine Thread Series, Internal Threads, Symbols UNF-3B and NF-3B

Gauge Number	B.& S.G.	B.W.G.	U.S.S.G.	N.W.G.	M.W.G.	S.W.G.
	Brown and Sharpe Gauge	Birmingham Wire & Stubs Iron Wire Gauge	United States Standard Gauge	National Wire Gauge	Music Wire Gauge	British Imperial Standard Wire Gauge
	Material Applied To					
	Sheets: Aluminum Brass Copper Wire: Brass Copper	Tubing: Aluminum Steel Brass Copper Sheet: Spring Steel	Sheets: Steel Terneplate	Wire: Steel Spring Steel	Wire: Piano Wire	Sheets: Aluminum Wire: All Wire (in England)
000000	.5800		.4688	.4615	.004	.464
00000	.5165	.500(1/2)	.4375	.4305	.005	.432
0000	.4600	.454	.4063	.3938	.006	.400
000	.4096	.425	.3750	.3625	.007	.372
00	.3648	.380	.3438	.3310	.008	.348
0	.3249	.340	.3125	.3065	.009	.324
1	.2893	.300	.2813	.2830	.010	.300
2	.2576	.284	.2656	.2625	.011	.276
3	.2294	.259	.2500	.2437	.012	.252
4	.2043	.238	.2344	.2253	.013	.232
5	.1819	.220	.2188	.2070	.014	.212
6	.1620	.203	.2031	.1920	.016	.192
7	.1443	.180	.1875	.1770	.018	.176
8	.1285	.165	.1719	.1620	.020	.160
9	.1144	.148	.1563	.1483	.022	.144
10	.1019	.134	.1406	.1330	.024	.128
11	.0907	.120	.1250	.1205	.026	.116
12	.0808	.109	.1094	.1055	.029	.104
13	.0720	.095	.0938	.0915	.031	.092
14	.0641	.083	.0781	.0800	.033	.080
15	.0571	.072	.0703	.0720	.035	.072
16	.0508	.065	.0625	.0625	.037	.064
17	.0453	.058	.0563	.0540	.039	.056

Figure 25-15 (Sheet 1 of 2) Table of Wire and Sheet Metal Gauges

Gauge Number	B.& S.G. Brown and Sharpe Gauge	B.W.G. Birmingham Wire & Stubs Iron Wire Gauge	U.S.S.G. United States Standard Gauge	N.W.G. National Wire Gauge	M.W.G. Music Wire Gauge	S.W.G. British Imperial Standard Wire Gauge
	Material Applied To					
	Sheets: Aluminum Brass Copper Wire: Brass Copper	Tubing: Aluminum Steel Brass Copper Sheet: Spring Steel	Sheets: Steel Terneplate	Wire: Steel Spring Steel	Wire: Piano Wire	Sheets: Aluminum Wire: All Wire (in England)
18	.0403	.049	.0500	.0475	.041	.048
19	.0359	.042	.0438	.0410	.043	.040
20	.0320	.035	.0375	.0348	.045	.036
21	.0285	.032	.0344	.0317	.047	.032
22	.0253	.028	.0313	.0286	.049	.028
23	.0226	.025	.0281	.0258	.051	.024
24	.0201	.022	.0250	.0230	.055	.022
25	.0179	.020	.0219	.0204	.059	.020
26	.0159	.018	.0188	.0181	.063	.018
27	.0142	.016	.0172	.0173	.067	.0164
28	.0126	.014	.0156	.0162	.071	.0148
29	.0113	.013	.0141	.0150	.075	.0136
30	.0100	.012	.0125	.0140	.080	.0124
31	.0089	.010	.0109	.0132	.085	.0116
32	.0080	.009	.0102	.0128	.090	.0108
33	.0071	.008	.0094	.0118	.095	.0100
34	.0063	.007	.0086	.0104	.100	.0092
35	.0056	.005	.0078	.0095	.106	.0084
36	.0050	.004	.0070	.0090	.112	.0076
37	.0045		.0066	.0085	.118	.0068
38	.0040		.0063	.0080	.124	.0060
39	.0035			.0075	.130	.0052
40	.0031			.0070	.138	.0048

Figure 25-15 (Sheet 2 of 2) Table of Wire and Sheet Metal Gauges

Diam., Inches	Threads per Inch	Pitch, Inch	Depth of Thread, Inch	Full or Major Diam., Max.	Effective Diam., Max.	Minor Diam.	Tap Drill Diam., Inch
1/8	40	0.02500	0.01600	0.1250	0.1090	0.0930	0.0980
3/16	24	0.04167	0.02670	0.1875	0.1608	0.1341	0.1405
1/4	20	0.05000	0.03200	0.2500	0.2180	0.1860	0.1960
5/16	18	0.05556	0.03555	0.3125	0.2769	0.2414	1/4
3/8	16	0.06250	0.04000	0.3750	0.3350	0.2950	5/16
7/16	14	0.07143	0.04575	0.4375	0.3918	0.3460	23/64
1/2	12	0.08333	0.05335	0.5000	0.4466	0.3933	13/32
9/16	12	0.08333	0.05335	0.5625	0.5091	0.4558	15/32
5/8	11	0.09091	0.05820	0.6250	0.5668	0.5086	17/32
11/16*	11	0.09091	0.05820	0.6875	0.6293	0.5711	37/64
3/4	10	0.10000	0.06405	0.7500	0.6860	0.6219	41/64
13/16*	10	0.10000	0.06405	0.8125	0.7485	0.6844	45/64
7/8	9	0.11111	0.07115	0.8750	0.8039	0.7327	3/4
15/6*	9	0.11111	0.07115	0.9375	0.8664	0.7952	13/16
1	8	0.12500	0.08005	1.0000	0.9200	0.8399	55/64
1-1/8	7	0.14286	0.09150	1.1250	1.0335	0.9420	31/32
1-1/4	7	0.14286	0.09150	1.2500	1.1585	1.0670	1-3/32
1-3/8*	6	0.16667	0.10670	1.3750	1.2683	1.1616	1-3/16
1-1/2	6	0.16667	0.10670	1.5000	1.3933	1.2866	1-5/16
1-5/8*	5	0.20000	0.12806	1.6250	1.4969	1.3689	1-13/32
1-3/4	5	0.20000	0.12806	1.7500	1.6219	1.4939	1-33/64

*Sizes marked (*) not recommended for general use by British Standards Institution.

Tap drill diam. = major diam. - 1.1328 X pitch (to yield about 88% full thread form).

Figure 25-16 (Sheet 1 of 3) Table of British Standard Whitworth Threads

Diam., Inches	Threads per Inch	Pitch, Inch	Depth of Thread, Inch	Full or Major Diam., Max.	Effective Diam., Max.	Minor Diam.	Tap Drill Diam., Inch
1-7/8*	4-1/2	0.22222	0.14228	1.8750	1.7327	1.5904	1-5/8
2	4-1/2	0.22222	0.14228	2.0000	1.8577	1.7154	1-3/4
2-1/8*	4-1/2	0.22222	0.14228	2.1250	1.9827	1.8404	1-7/8
2-1/4	4	0.25000	0.16008	2.2500	2.0899	1.9298	1-31/32
2-3/8*	4	0.25000	0.16008	2.3750	2.2149	2.0548	2-3/32
2-1/2	4	0.25000	0.16008	2.5000	2.3399	2.1798	2-7/32
2-5/8*	4	0.25000	0.16008	2.6250	2.4649	2.3048	2-23/64
2-3/4	3-1/2	0.28571	0.18295	2.7500	2.5670	2.3841	2-7/16
2-7/8*	3-1/2	0.28571	0.18295	2.8750	2.6920	2.5091	2-9/16
3	3-1/2	0.28571	0.18295	3.0000	2.8170	2.6341	2-11/16
3-1/8*	3-1/2	0.28571	0.18295	3.1250	2.9420	2.7591	2-13/16
3-1/4	3-1/4	0.30769	0.19700	3.2500	3.0530	2.8560	
3-3/8*	3-1/4	0.30769	0.19700	3.3750	3.1780	2.9810	
3-1/2	3-1/4	0.30769	0.19700	3.5000	3.3030	3.1060	
3-5/8*	3-1/4	0.30769	0.19700	3.6250	3.4280	3.2310	
3-3/4	3	0.33333	0.21345	3.7500	3.5366	3.3231	
3-7/8*	3	0.33333	0.21345	3.8750	3.6616	3.4481	
4	3	0.33333	0.21345	4.0000	3.7866	3.5731	
4-1/8*	3	0.33333	0.21345	4.1250	3.9116	3.6981	
4-1/4*	2-7/8	0.34783	0.22270	4.2500	4.0273	3.8046	
4-3/8*	2-7/8	0.34783	0.22270	4.3750	4.1523	3.9296	

*Sizes marked (*) not recommended for general use by British Standards Institution.

Tap drill diam. = major diam. - 1.1328 X pitch (to yield about 88% full thread form).

Figure 25-16 (Sheet 2 of 3) Table of British Standard Whitworth Threads

Diameter, Inch	Threads per Inch	Pitch, Inch	Depth of Thread, Inch	Full or Major Diam., Max.	Effective Diam., Max.	Minor Diam.
4-1/2	2-7/8	0.34783	0.22270	4.5000	4.2773	4.0546
4-5/8*	2-7/8	0.34783	0.22270	4.6250	4.4023	4.1796
4-3/4*	2-3/4	0.36364	0.23285	4.7500	4.5172	4.2843
4-7/8*	2-3/4	0.36364	0.23285	4.8750	4.6422	4.4093
5	2-3/4	0.36364	0.23285	5.0000	4.7672	4.5343
5-1/4*	2-5/8	0.38095	0.24395	5.2500	5.0061	4.7621
5-1/2	2-5/8	0.38095	0.24395	5.5000	5.2561	5.0121
6	2-1/2	0.40000	0.25615	6.0000	5.7439	5.4877

*Sizes marked (*) not recommended for general use by British Standards Institution.

Tap drill diam. = major diam. - 1.1328 X pitch (to yield about 88% full thread form).

Figure 25-16 (Sheet 3 of 3) Table of British Standard Whitworth Threads

British Association Number	Diameter		Pitch		Depth of Thread	Radius	Threads per Inch Approx.
	Millimetres	Inches	Millimetres	Inches	Inches	Inches	
0	6.0	0.2362	1.00	0.0394	0.0236	0.0072	25.4
1	5.3	0.2087	0.90	0.0354	0.0212	0.0064	28.2
2	4.7	0.1850	0.81	0.0319	0.0191	0.0058	31.4
3	4.1	0.1614	0.73	0.0287	0.0172	0.0052	34.8
4	3.6	0.1417	0.66	0.0260	0.0156	0.0047	38.5
5	3.2	0.1260	0.59	0.0232	0.0139	0.0042	43.0
6	2.8	0.1102	0.53	0.0209	0.0125	0.0038	47.9
7	2.5	0.0984	0.48	0.0189	0.0113	0.0034	52.9
8	2.2	0.0866	0.43	0.0169	0.0101	0.0031	59.1
9	1.9	0.0748	0.39	0.0154	0.0092	0.0028	65.1
10	1.7	0.0669	0.35	0.0138	0.0083	0.0025	72.6

Figure 25-17 Table of British Association Standard Threads

Diam., Inches	Threads per Inch	Pitch Inch	Depth of Thread, Inch	Major Diam.	Effective or Pitch Diam.	Minor Diam.	Tap Drill Size, Inch
3/16	32	0.03125	0.0200	0.1875	0.1675	0.1475	No.25
7/32	28	0.03571	0.0229	0.2188	0.1959	0.1730	No.16
1/4	26	0.03846	0.0246	0.2500	0.2254	0.2008	No.5
9/32	26	0.03846	0.0246	0.2812	0.2566	0.2320	B
5/16	22	0.04545	0.0291	0.3125	0.2834	0.2543	G
3/8	20	0.05000	0.0320	0.3750	0.3430	0.3110	O
7/16	18	0.05556	0.0356	0.4375	0.4019	0.3663	3/8
1/2	16	0.06250	0.0400	0.5000	0.4600	0.4200	27/64
9/16	16	0.06250	0.0400	0.5625	0.5225	0.4825	1/2
5/8	14	0.07143	0.0457	0.6250	0.5793	0.5336	35/64
11/16	14	0.07143	0.0457	0.6875	0.6418	0.5961	39/64
3/4	12	0.08333	0.0534	0.7500	0.6966	0.6432	21/32
13/16	12	0.08333	0.0534	0.8125	0.7591	0.7057	23/32
7/8	11	0.09091	0.0582	0.8750	0.8168	0.7586	25/32
1	10	0.10000	0.0640	1.0000	0.9360	0.8720	57/64
1-1/8	9	0.11111	0.0711	1.1250	1.0539	0.9828	1
1-1/4	9	0.11111	0.0711	1.2500	1.1789	1.1078	1-1/8
1-3/8	8	0.12500	0.0800	1.3750	1.2950	1.2150	1-15/16
1-1/2	8	0.12500	0.0800	1.5000	1.4200	1.3400	1-23/64
1-5/8	8	0.12500	0.0800	1.6250	1.5450	1.4650	1-31/64
1-3/4	7	0.14286	0.0915	1.7500	1.6585	1.5670	1-19/32
2	7	0.14286	0.0915	2.0000	1.9085	1.8170	1-27/32
2-1/4	6	0.16667	0.1067	2.2500	2.1433	2.0366	2-1/16
2-1/2	6	0.16667	0.1067	2.5000	2.3933	2.2866	2-5/16
2-3/4	6	0.16667	0.1067	2.7500	2.6433	2.5366	2-9/16
3	5	0.20000	0.1281	3.0000	2.8719	2.7438	2-3/4
3-1/4	5	0.20000	0.1281	3.2500	3.1219	2.9938	
3-1/2	4-1/2	0.22222	0.1423	3.5000	3.3577	3.2154	
3-3/4	4-1/2	0.22222	0.1423	3.7500	3.6077	3.4654	
4	4-1/2	0.22222	0.1423	4.0000	3.8577	3.7154	
4-1/4	4	0.25000	0.1601	4.2500	4.0899	3.9298	

Figure 25-18 Table of British Standard Fine Threads

Shore Scleroscope	Rockwell(1) C 150 Kg Load	Rockwell(1) B 100 Kg Load 1/16 Ball	Vickers Diamond Pyramid 50 Kg Load (2)	Brinell (3) 3000 Kg Load - 10 mm Ball Tungsten Carbide Ball	Brinell (3) 3000 Kg Load - 10 mm Ball Steel Ball	Tensile Strength 1000 lb.per sq.in.	Shore Scleroscope	Rockwell(1) C 150 Kg Load	Rockwell(1) B 100 Kg Load 1/16 Ball	Vickers Diamond Pyramid 50 Kg Load (2)	Brinell (3) 3000 Kg Load - 10 mm Ball Tungsten Carbide Ball	Brinell (3) 3000 Kg Load - 10 mm Ball Steel Ball	Tensile Strength 1000 lb.per sq.in.
	67		918	820	717		56	42	113.3	417	405	398	194
	66		884	796	701		54	41	112.7	406	394	387	188
	65		852	774	686		53	40	112.1	396	385	377	181
	64		822	753	671		52	39	111.5	386	375	367	176
84	63		793	732	656		51	38	110.9	376	365	357	170
82	62		765	711	642		50	37	110.4	367	356	347	165
81	61		740	693	628		48	36	109.7	357	346	337	160
80	60		717	675	613		47	35	109.1	348	337	327	155
78	59		694	657	600		46	34	108.5	339	329	318	150
77	58		672	639	584		45	33	107.8	330	319	309	147
76	57		650	621	574		44	32	107.1	321	310	301	142
74	56	121.3	630	604	561		43	31	106.4	312	302	294	139
73	55	120.8	611	588	548		42	30	105.7	304	293	286	136
71	54	120.2	592	571	536		41	29	105.0	296	286	279	132
70	53	119.6	573	554	524	283	40	28	104.3	288	278	272	129
69	52	119.1	556	538	512	273	39	27	103.7	281	271	265	126
67	51	118.5	539	523	500	264	38	26	102.9	274	264	259	123
66	50	117.9	523	508	488	256	37	25	102.2	267	258	253	120
65	49	117.4	508	494	476	246	36	24	101.5	261	252	247	118
63	48	116.8	493	479	464	237	36	23	100.8	255	246	241	115
62	47	116.2	479	465	453	231	35	22	100.2	250	241	235	112
61	46	115.6	465	452	442	221	34	21	99.5	245	236	230	110
59	45	115.0	452	440	430	215	33	20	98.9	240	231	225	107
58	44	114.4	440	427	419	208	32	19	98.1	235	226	220	104
57	43	113.8	428	415	408	201	32	18	97.5	231	222	215	103

Figure 25-19 (Sheet 1 of 2) Table of Hardness and Tensile Strength Co-ordination

Shore Scleroscope	Rockwell(1) C 150 Kg Load	Rockwell(1) B 100 Kg Load 1/16 Ball	Vickers Diamond Pyramid 50 Kg Load (2)	Brinell (3) 3000 Kg Load - 10 mm Ball Tungsten Carbide Ball	Brinell (3) 3000 Kg Load - 10 mm Ball Steel Ball	Tensile Strength 1000 lb. per sq. in.
32	17	96.9	227	218	210	102
31	16	96.2	223	214	206	100
30	15	95.5	219	210	201	99
30	14	94.9	215	206	197	97
30	13	94.1	211	202	193	95
29	12	93.4	207	199	190	93
29	11	92.6	203	195	186	91
29	10	91.8	199	191	183	90
29	9	91.2	196	187	180	89
28	8	90.3	192	184	177	88
27	7	89.7	189	180	174	87
26	6	89	186	177	171	85
26	5	88.3	183	174	168	84
26	4	87.5	179	171	165	83
26	3	87	177	169	162	82
25	2	86	173	165	160	81
25	1	85.5	171	163	158	80
	0	84.5	167	159	154	78
		83.2	162	153	150	76
		82	157	148	145	74
		80.5	153	144	140	72
		79	149	140	136	70
		77.5	143	134	131	68
		76	139	130	127	66
		74	135	126	122	64
		72	129	120	117	62
		70	125	116	113	60
		68	120	111	108	58
		66	116	107	104	56
		64	112	104	100	54
		61	108	100	96	52
		58	104	95	92	50
		55	99	91	87	48
		51	95	86	83	46
		47	91	83	79	44
		44	88	80	76	42
		39	84	76	72	40
		35	80	72	68	38
		30	76	67	64	36
		24	72	64	60	34
		20	69	61	57	32
		11	65	57	53	30
		0	62	54	50	28

(1) Rockwell C values below 20 and B values above 100 are not recommended for correlation; however, these values are sufficiently accurate to indicate the trend of relationship.

(2) Vickers values of 167 to 95 inclusive with 30 kg load; 91 to 62 inclusive with 10 kg load.

(3) Brinell tungsten carbide ball values 159 to 86 inclusive obtained with 1500 kg load; 83 to 54 inclusive with 500 kg load.

Figure 25-19 (Sheet 2 of 2) Table of Hardness and Tensile Strength Co-ordination

Bolt Size	Hole Sizes For all components of the assembly, arranged from left to right in order of decreasing preference.					Spotface Sizes	
	Drilled			Reamed			
	Oversize	Clearance	Close	Standard Tolerance	Close Tolerance	Dia.	Fillet Radius
#2		#43 (.089)					
#4		#31 (.120)				3/8	
#6	#1 (.228)	#27 (.144)				7/16	.031
#8	#1 (.228)	#18 (.169)	#19 (.166)				
*3/16		#11 (.191)	3/16	.1875 $^{+.0005}_{-.0010}$		9/16	
#10	F (.257)	#10 (.193)	#12 (.189)	.1900 $^{+.0005}_{-.0010}$	.1900(±.0005)		
1/4	5/16	F (.257)	1/4	.2500 $^{+.0005}_{-.0010}$	.2500(±.0005)	5/8	
3/16	3/8	O (.316)	5/16	.3125 $^{+.0005}_{-.0010}$	.3125(±.0005)	11/16	.062
3/8	7/16	V (.377)	3/8	.3750 $^{+.0005}_{-.0010}$	.3750(±.0005)	13/16	
7/16		29/64	7/16	.4375 $^{+.0005}_{-.0010}$	.4375(±.0005)	7/8	
1/2		33/64	1/2	.5000 $^{+.0005}_{-.0010}$	.5000(±.0005)	1	

*AN23 is the only standard fastener of 3/16 size. Nearest standard size is #10.

Figure 25-20 Table of Standard Bolt Hole Sizes

Material Commercial Designation	Hardness Temper	Brinell Hardness Number	Material Commercial Designation	Hardness Temper	Brinell Hardness Number
2S(pure aluminum)	O	23	24S	RT	116
	H	44	25S forging	O	80
3S	O	28		W	100
	H	55		T	90
14S forging	T	125	A51S forging	T	90
17S	O	45	57S	O	45
	T	100		H	85
	RT	110	65S	O	30
24S	O	42		T	95
	T	105	75S	T	168

Temper Code	
O	Annealed condition
H	Maximum commercial degree of work hardening
T	Fully heat-treated
RT	Heat-treated and cold worked
W	Quenched but not completely aged. W temper applies only to alloys requiring artificial aging to attain T condition

Figure 25-21 Table of Hardness Values for Aluminum Alloys

Values shown in Figure 25-22 (Sheet 2 of 2) are for dry (lubricant free) cadmium plated steel bolts and nuts. Stainless Steel bolts and nuts must be used with anti-seize compound. Use column 3. Where torquing must be done through bolt head, use high value in tables. Where shear nuts are used, use column 3 regardless of bolt type. Where adapter is used on torque wrench, adapter must be at right angles to wrench. If adapter lengthens arm, recalculate values. For joints sealed with synthetic rubber sheet or gasket material, use the following table:-

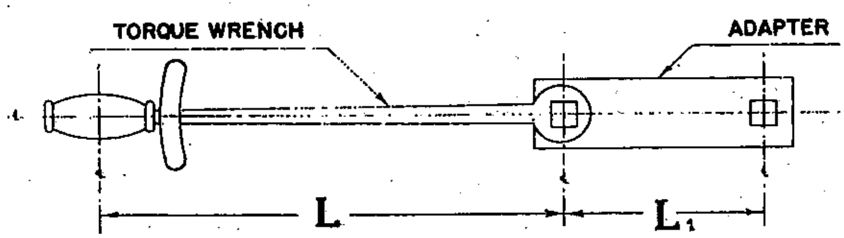
Bolt size	Torque (Inch-pounds)
No. 10	20-25
1/4	25-60
5/16	35-60

NOTE

A Torque wrench should never be used to loosen or back off a nut

NOTE

Many special aircraft tools are torque wrench adapters designed to be used with any of a number of standard torque wrenches. The mechanical value of these adapters must be considered in arriving at the correct dial reading to give the specified torque at the nut or bolt being tightened. To determine what torque wrench dial reading should be to indicate a specified torque value, the following equation is used.



$$\frac{\text{ACTUAL OR SPECIFIED TORQUE} \times L}{L + L_1} = \text{DIAL READING}$$

WHEN SUBSTITUTING VALUES IN FORMULA,
USE INCH UNITS THROUGHOUT TO OBTAIN ANSWER IN INCH POUNDS.
USE FOOT UNITS THROUGHOUT TO GET ANSWER IN FOOT POUNDS.
WRENCH AND ADAPTER CENTERLINES MUST ALIGN.

TORQUE READING CORRECTION FORMULA

Note TORQUE WRENCH MUST BE ATTACHED IN A STRAIGHT LINE WITH ADAPTER (AS SHOWN)

Figure 25-22 (Sheet 1 of 2)
Table of Torque Values - Steel Nuts and Bolts - NF and NC Threads

Bolts Stud or Screw Size	Standard Nuts, Bolts and Screws AN3-20 And AN173-186 Series Bolts		High-Strength Nuts, Bolts And Screws NAS 333-340 NAS 144-158 MS 20004-20024 Series Bolts	Maximum Allowable Tightening Torque	
	Tension Nuts AN310 and AN365 (40,000 psi in bolt)	Shear Nuts AN320 and AN364 (60% of column 2)	Any Nut Except Shear Type	Tension Nuts AN310 and AN365 (90,000 psi in bolt)	Shear Nuts AN320 and AN364 (60% of column 5)
1	2	3	4	5	6
8-36	12 - 15	7 - 9	15 - 18	20	12
10-32	20 - 25	12 - 15	25 - 35	40	25
1/4-28	50 - 70	30 - 40	70 - 90	100	60
5/16-24	100 - 140	60 - 85	140 - 203	225	140
3/8-24	160 - 190	95 - 110	190 - 351	390	240
7/16-20	450 - 500	270 - 300	500 - 756	840	500
1/2-20	480 - 690	290 - 410	690 - 990	1,100	660
9/16-18	800 - 1,000	480 - 600	1,000 - 1,440	1,600	960
5/8-18	1,000 - 1,300	660 - 780	1,300 - 2,160	2,400	1,400
3/4-16	2,300 - 2,500	1,300 - 1,500	2,500 - 4,500	5,000	3,000
7/8-14	2,500 - 3,000	1,500 - 1,800	3,000 - 6,300	7,000	4,200
1-14	3,700 - 5,500	2,200 - 3,300	5,500 - 9,000	10,000	6,000
1-1/8-12	5,000 - 7,000	3,000 - 4,200	7,000 - 13,500	15,000	9,000
1-1/4-12	9,000 - 11,000	5,400 - 6,600	11,000 - 22,500	25,000	15,000
8-32	12 - 15	7 - 9	15 - 18	20	12
10-24	20 - 25	12 - 15	25 - 35	35	21
1/4-20	40 - 50	25 - 30	50 - 68	75	45
5/16-18	80 - 90	48 - 55	90 - 144	160	100
3/8-16	160 - 185	95 - 110	185 - 248	275	170
7/16-14	235 - 255	140 - 155	255 - 428	475	280
1/2-13	400 - 480	240 - 290	480 - 792	880	520
9/16-12	500 - 700	300 - 420	700 - 990	1,100	650
5/8-11	700 - 900	420 - 540	900 - 1,350	1,500	900
3/4-10	1,150 - 1,600	700 - 950	1,600 - 2,250	2,500	1,500
7/8-9	2,200 - 3,000	1,300 - 1,800	3,000 - 4,140	4,600	2,700
1-8	3,700 - 5,000	2,200 - 3,000	5,000 - 6,840	7,600	4,500
1-1/8-8	5,500 - 6,500	3,300 - 4,000	6,500 - 10,800	12,000	7,200
1-1/4-8	6,500 - 8,000	4,000 - 5,000	8,000 - 14,000	16,000	10,000

Figure 25-22 (Sheet 2 of 2) Table of Torque Values - Steel Nuts and Bolts - NF and NC Threads

The coefficients for bend allowance are computed from the bend allowance empirical formula. This formula, as the name implies, was developed by experimentation. The neutral axis was found to lie slightly inside the 1/2T, therefore, the formula (.01743R + .0078T) gives the bend allowance for 1° bend. The table gives the 1° bend allowances for certain given radii and thicknesses. These are multiplied by the bend angle (in degrees) to arrive at the total bend allowance.

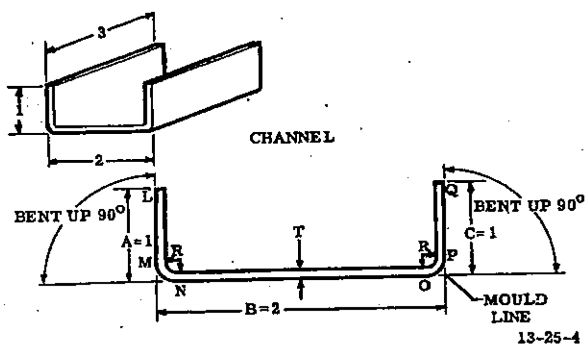
Values are for 1° bend. Values derived from formula:

$$B.A. = (.0078T + .01743R)N$$

N = No. of degrees
T = Metal thickness
R = Radius of bend

Example: T = .032, R = 1/8, angle = 90°

$$B.A. = .00243 \times 90 = .2187$$

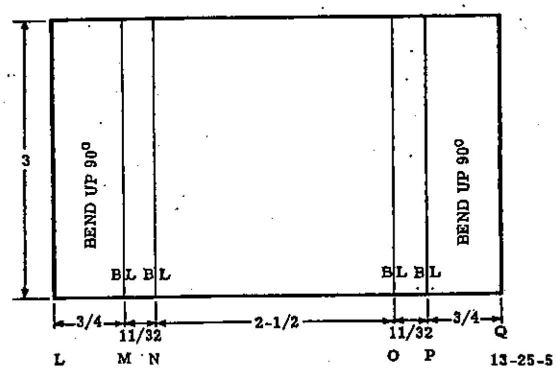


The mould lines (ML) indicate the point to which the dimension is given. The length of the channel will remain unchanged from flat pattern to finished part. On the other hand, the material necessary to make the channel web and the two flanges will not be the sum of their dimensions in the finished part, as it might at first seem, but rather, this developed length will be less than that sum, owing to the short cuts taken around the curved corners. The procedure for use of the formula is as follows:

1. Imagine that the length around the cross section of the channel is divided into sections according to the letters L, M, N, O, P, and Q. Length LM = 1 in, - R (radius of bend) - T (thickness of metal). If R = 3/16 and T = 1/16 (.064), then

LM = 1 in. - (3/16 in. + 1/16 in.) = 3/4 in.

Lay this length out along the metal as shown and draw the bend line (BL).



2. Next, for the length MN, called the bend allowance, refer to the bend allowance chart for 1° bend allowance and multiply it by the number of degrees of bend (90°). The chart gives .00377 for 3/16R and .064T; when multiplied by 90, we get .3393 or 11/32 (closest fraction) to the next bend line.

3. The web of the channel has two bends to be subtracted. Therefore it is 2 in. - 2 (T + R) or 2 in. - 1/2 in. = 1-1/2 in. from N to O. Repeat the first two operations in reverse order to complete the pattern.

Therefore, the developed length (sum LM + MN + NO + OP + PQ) equals 3.6726. Referring back, this is less than the sum of the dimensioned sides in Figure 6B.

Formed angles of open or closed bevels may be developed in the same manner except that the distance from the corner mould line to the bend line is found by the formula:

(T + R) x (the tangent of half the bent-up angle)

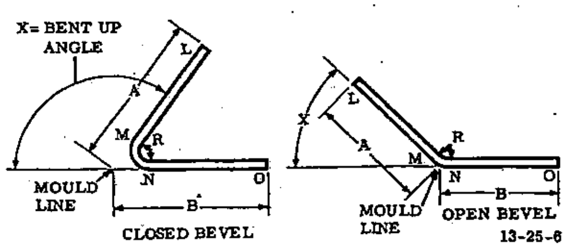


Figure 25-23 (Sheet 1 of 2) Bend Allowance Derivation - Bend Allowance Chart for 1° Angle

Radius of Bend	Metal Thickness									
	.020 .022	.023 .025	.028 .029	.031 .032	.038 .040	.050 .051	.063 .064	.081	.091 .094	.125 .129
1/32	00072	00073	00076	00079	00086	00094	00104	00117	00125	00154
1/16	00126	00128	00131	00135	00140	00149	00159	00172	00188	00209
3/32	00180	00183	00185	00188	00195	00203	00213	00226	00234	00263
1/8	00235	00237	00240	00243	00249	00258	00268	00281	00289	00317
5/32	00290	00292	00294	00297	00304	00312	00322	00335	00343	00372
3/16	00344	00346	00349	00352	00358	00367	00377	00390	00398	00426
7/32	00398	00401	00403	00406	00412	00421	00431	00444	00452	00481
1/4	00454	00455	00458	00461	00467	00476	00486	00500	00507	00535
9/32	00507	00510	00512	00515	00521	00530	00540	00553	00561	00590
5/16	00562	00564	00567	00570	00576	00584	00595	00608	00616	00644
11/32	00616	00619	00620	00624	00630	00639	00649	00662	00670	00699
3/8	00671	00673	00675	00679	00685	00693	00704	00717	00725	00753
13/32	00725	00728	00730	00733	00739	00748	00758	00771	00779	00808
7/16	00780	00782	00784	00767	00794	00802	00812	00826	00834	00862
15/32	00834	00836	00839	00842	00848	00857	00867	00853	00888	00917
1/2	00889	00891	00893	00896	00903	00911	00921	00935	00943	00971
17/32	00943	00945	00948	00951	00957	00966	00976	00989	00997	01025
9/16	00998	01000	01002	01005	01012	01020	01030	01044	01051	01080
19/32	01051	01054	01055	01058	01065	01073	01083	01098	01105	01133
5/8	01107	01109	01111	01114	01121	01129	01139	01152	01160	01189
21/32	01161	01163	01166	01170	01175	01183	01193	01207	01214	01245
11/16	01216	01218	01220	01223	01230	01238	01248	01261	01269	01298
23/32	01269	01272	01273	01276	01283	01291	01301	01316	01322	01351
3/4	01324	01327	01329	01332	01338	01347	01357	01370	01378	01407
25/32	01378	01381	01383	01386	01392	01401	01411	01425	01432	01461
13/16	01433	01436	01438	01441	01447	01456	01466	01479	01487	01516
27/32	01487	01490	01491	01494	01501	01509	01519	01534	01540	01569
7/8	01542	01545	01548	01550	01556	01565	01575	01588	01596	01625
29/32	01596	01600	01601	01604	01610	01619	01629	01643	01650	01679
15/16	01651	01654	01655	01657	01665	01674	01684	01697	01705	01734
31/32	01705	01708	01709	01712	01718	01727	01737	01752	01758	01787
1	01760	01763	01765	01768	01774	01783	01793	01806	01814	01834

Figure 25-23 (Sheet 2 of 2) Bend Allowance Derivation - Bend Allowance Chart for 1° Angle

Gauge	3S			24S		57S		65S			75S			14S		
	-0 Bent Cold	-H12 Bent Cold	-H16 Bent Cold	Bare And Clad -0 Bent Cold	Bare And Clad -T3 Bent Cold (inc. -T4)	-0 Bent Cold	-H34 Bent Cold	-0 Bent Cold	-T4 Bent Cold	-T6 Bent Cold	Bare And Clad -0 Bent Cold	Bare And Clad -W Bent Cold & -T6 Bent Hot	Clad Only -T6 Bent Cold	Bare And Clad -0 Bent Cold	Bare And Clad -T4 Bent Cold & -T6 Bent Hot	Clad Only -T6 Bent Cold
*.012	.03	.03	.03	.03	.06	.03	.03				.06	.09	.12	.06	.06	.06
.014	.03	.03	.03	.03	.06	.03	.03				.06	.09	.12	.06	.06	.06
*.016	.03	.03	.03	.03	.06	.03	.03				.06	.09	.12	.06	.06	.06
.018	.03	.03	.03	.03	.06	.03	.03				.06	.09	.12	.06	.06	.06
*.020	.03	.03	.03	.03	.06	.03	.03				.06	.09	.12	.06	.06	.06
.022	.03	.03	.03	.03	.06	.03	.06				.06	.09	.12	.06	.06	.06
.024	.03	.06	.06	.06	.06	.03	.06				.06	.09	.12	.06	.06	.09
*.025	.03	.06	.06	.06	.06	.03	.06	.03	.03	.06	.06	.09	.12	.06	.06	.09
.028	.06	.06	.06	.06	.06	.06	.06				.06	.12	.12	.06	.06	.09
*.032	.06	.06	.06	.06	.09	.06	.06	.03	.03	.06	.06	.12	.12	.06	.06	.12
.036	.06	.06	.06	.06	.09	.06	.06				.06	.16	.16	.06	.09	.12
*.040	.06	.06	.06	.06	.09	.06	.06	.06	.06	.09	.06	.16	.19	.06	.09	.16
.048	.06	.06	.06	.06	.12	.06	.09				.09	.19	.25	.09	.09	.19
*.051	.06	.06	.06	.06	.12	.06	.09	.06	.06	.09	.09	.19	.25	.09	.09	.19
.056	.06	.09	.09	.06	.16	.06	.09				.09	.22	.28	.09	.12	.28
.063	.06	.09	.09	.09	.16	.06	.09				.09	.25	.31	.12	.12	.31
*.064	.06	.09	.09	.09	.16	.06	.09	.06	.09	.12	.09	.25	.31	.12	.12	.31
.071	.09	.12	.12	.12	.22	.09	.12				.16	.28	.38	.12	.16	.38
*.072	.09	.12	.12	.12	.22	.09	.12				.16	.28	.38	.12	.16	.38
.080	.12	.12	.16	.12	.25	.12	.12				.19	.31	.44	.16	.16	.41

* = standard gauges.

T = thickness (gauge) of material.

Figure 25-24 (Sheet 1 of 2)
Table of Minimum Bend Radii for Simple Bends in Aluminum Alloy Sheet and Plate

Gauge	3S			24S		57S		65S			75S			14S		
	-0 Bent Cold	-H12 Bent Cold	-H16 Bent Cold	Bare And Clad -0 Bent Cold	Bare And Clad -T3 Bent Cold (inc. -T4)	-0 Bent Cold	-H34 Bent Cold	-0 Bent Cold	-T4 Bent Cold	-T6 Bent Cold	Bare And Clad -0 Bent Cold	Bare And Clad -W Bent Cold & -T6 Bent Hot	Clad Only -T6 Bent Cold	Bare And Clad -0 Bent Cold	Bare And Clad -T4 Bent Cold & -T6 Bent Hot	Clad Only -T6 Bent Cold
*.081	.12	.12	.16	.12	.25	.12	.12	.09	.16	.19	.19	.31	.44	.16	.16	.41
.090	.12	.12	.19	.12	.28	.12	.19				.25	.38	.50	.16	.19	.47
*.091	.12	.12	.19	.12	.28	.12	.19	.09	.19	.22	.25	.38	.50	.16	.19	.47
.095	.12	.16	.25	.16	.31	.12	.19				.28	.41	.50	.19	.19	.47
.100	.14	.16	.25	.16	.34	.12	.19				.31	.41	.56	.19	.19	.50
*.102	.14	.16	.25	.16	.34	.12	.19	.16	.25	.28	.31	.41	.56	.19	.19	.50
.112	.16	.19	.25	.19	.41	.16	.19				.34	.44	.69	.19	.22	.56
*.125	.16	.19	.25	.19	.44	.16	.22	.16	.25	.28	.34	.50	.75	.25	.25	.63
.132				.22	.47	.16	.22				.41	.50	.81	.25	.34	.81
.140				.25	.50	.16	.22				.41	.56	.84	.25	.38	.84
*.156				.25	.56	.16	.22	.22	.38	.47	.47	.63	.94	.31	.41	.94
.160				.25	.56	.16	.22				.47	.69	.94	.31	.41	.94
.170				.31	.75	.16	.25				.50	.69	1.03	.31	.41	1.03
*.188				.34	.84	.16	.25	.22	.38	.47	.56	.75	1.12	.34	.47	1.16
.190				.34	.84	.16	.25				.56	.75	1.12	.34	.47	1.16
.212				.38	1.06						.63	.84	1.25	.38	.56	1.28
.224				.41	1.12						.69	.94	1.34	.41	.56	1.34
*.250				.47	1.25			.31	.50	.63	.75	1.00	1.50			
Over .250				2T	5T			1-1/2 T	2T	2-1/2 T	3T	4T	6T			

* = standard gauges.

T = thickness (gauge) of material.

Figure 25-24 (Sheet 2 of 2)
Table of Minimum Bend Radii for Simple Bends in Aluminum Alloy Sheet and Plate

Gauge	SAE 1010 Annealed Bent Cold		SAE 1020 SAE 1025 SAE 1095 Annealed Bent Cold		SAE 4130 and NE 8630 (1)				Corrosion Resistant Steel			
					Normalized Bent Cold		Annealed Bent Cold		Annealed Bent Cold		1/2 Hard Bent Cold	
	90°	180°	90°	180°	90°	180°	90°	180°	90°	180°	90°	180°
.010											.03	.06
.012			.03		.06				.03	.03	.03	.06
.014			.03		.06				.03		.03	
.016			.03	.06	.06				.03	.03	.03	.06
.018	.03	.06	.03		.06				.03		.03	
.020			.03	.06	.06	.09			.03	.06	.06	.09
.022			.06		.06				.03		.06	
.024	.03	.06	.06		.06	.09			.03		.06	
.025			.06	.09	.06	.09			.03	.06	.06	.09
.028			.06		.06				.03		.06	
.030	.03	.06			.06	.09						
.032			.06	.09	.12				.03		.06	
.035	.06	.12	.06	.12	.12	.19						
.036	.06	.12	.06		.12				.06	.12	.12	.19
.040			.06		.12				.06	.12	.12	.19
.042			.06	.12	.12	.19						
.045									.06	.12	.12	.19
.048	.06	.12	.09		.12				.06		.12	
.049			.09	.12								
.050					.12	.19			.06	.12	.12	.19
.056					.12				.06		.12	
.060	.06	.12										
.063			.09		.12	.19			.06	.12	.12	.19
.065			.09	.12								
.071			.12		.16				.06		.16	
.072			.12	.19								
.075	.09	.19										
.078					.16	.25						

Figure 25-25 (Sheet 1 of 2)
Table of Minimum Bend Radii for Simple Bends in Steel Sheet and Plate

Gauge	SAE 1010 Annealed, Bent Cold		SAE 1020 SAE 1025 SAE 1095 Annealed Bent Cold		SAE 4130 and NE 8630 (1) Normalized Bent Cold		SAE 4130 and NE 8630 (1) Annealed Bent Cold		Corrosion Resistant Steel Annealed Bent Cold		Corrosion Resistant Steel 1/2 Hard Bent Cold	
	90°	180°	90°	180°	90°	180°	90°	180°	90°	180°	90°	180°
.080			.12		.16				.09	.19	.19	.31
.083			.12	.19	.16	.25						
.090			.19		.19				.09	.19	.19	.31
.093					.19	.38	.09	.16				
.095			.19	.25	.19				.12		.22	
.100					.22				.12		.22	
.104	.12	.25										
.109			.19	.25	.22	.44	.12	.19				
.112			.19		.22				.12	.25	.25	.38
.119	.12	.25	.19	.25								
.120												
.125			.25		.25	.50	.12	.19	.12	.25	.25	.38
.132			.25						.19			
.134	.19	.38	.25	.38								
.140			.25						.19			
.156			.25	.38	.31	.63	.16	.25				
.160			.28		.31				.19			
.170			.31		.34				.19			
.188			.31	.38	.38	.75	.19	.28	.19	.38		
.190			.31		.38				.19			
.212			.38		.44				.22			
.224			.38		.47				.22			
.250			.38	.50	.50	1.00	.25	.38	.25	.50		
Over (2) .250			1-1/2T	2T	2-1/2T	1-1/2T	2T	1T	2T			

Notes: 1. The minimum bend radii for SAE.4130 are applicable to the following steels:-
- a. Normalized values shown in the Table - SAE.4135, SAE.4137, NE.8735 and NE.8740 all in the normalized and tempered condition.
- b. Annealed values shown in the Table - SAE.4135, SAE.4137, NE.8735 and NE.8740 all in the annealed condition.

2. T = material thickness.

Figure 25-25 (Sheet 2 of 2)
Table of Minimum Bend Radii for Simple Bends in Steel Sheet and Plate

Gauge	AMS 4900 90°	AMS 4908 AMS 4901 90°	Gauge	AMS 4900 90°	AMS 4908 AMS 4901 90°
.016	.06	.06	.063	.16	.19
.018	.06	.06	.071	.16	.22
.020	.06	.06	.080	.22	.28
.025	.06	.09	.090	.25	.34
.028	.06	.09	.100	.25	.38
.032	.09	.12	.112	.28	.41
.036	.09	.12	.125	.34	.44
.040	.09	.12	.140	.38	.50
.045	.09	.16	.160	.41	.56
.050	.12	.16	.180	.47	.63
.056	.12	.19			

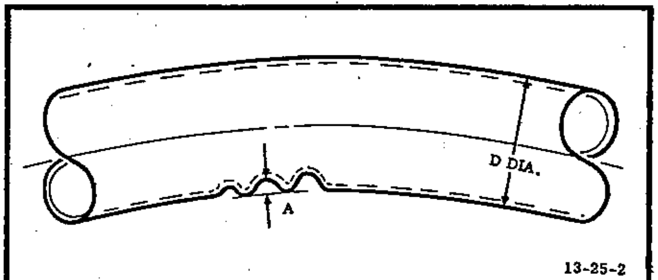
Figure 25-26 Table of Minimum Bend Radii for Simple Bends in Titanium Alloy Sheet

Gauge	QQ-M-44 Condition A Bent Cold	QQ-M-44 Condition H Bent Cold	QQ-M-44 Condition A Bent Cold	Gauge	QQ-M-54 Condition A Bent Cold	QQ-M-54 Condition H Bent Cold	QQ-M-54 Condition A Bent Cold
.012	.06	.12	.06	.071	.28	.75	.34
.014	.06	.16	.06	.080	.31	.81	.41
.016	.06	.16	.09	.090	.38	.94	.45
.018	.06	.19	.09	.095	.38	1.00	.47
.020	.09	.19	.12	.100	.41	1.00	.50
.022	.09	.22	.12	.112	.44	1.12	.56
.024	.09	.25	.12	.125	.50	1.25	.63
.028	.12	.28	.16	.132	.50	1.31	.69
.032	.12	.31	.16	.140	.56	1.41	.69
.036	.16	.38	.19	.160	.63	1.63	.81
.040	.16	.41	.22	.170	.69	1.75	.88
.048	.19	.47	.25	.190	.75	1.94	.94
.056	.22	.56	.28	.212	.88	2.12	1.06
.063	.25	.63	.31	.224	.88	2.25	1.12

Figure 25-27 Table of Minimum Bend Radii for Simple Bends in Magnesium Alloy Sheet

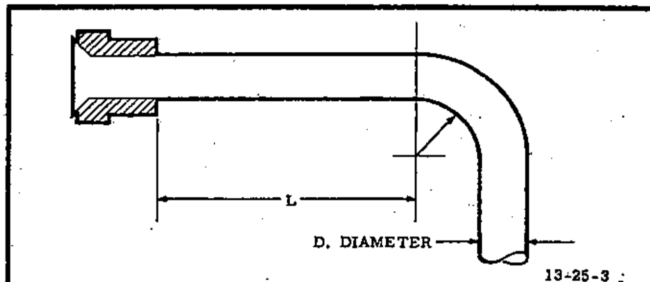
Outside Diameter of Tube inches	Minimum Bend Radii (Measure at Inside of Bend) - Inches							
	Annealed Aluminum Alloy		Heat Treated Aluminum Alloy		MIL-T-6845 Corr. Resistant Steel (1/6 Hard)		MIL-T-8504 Corr. Resistant Steel (Annealed)	
	Minimum Wall	Minimum Bend	Minimum Wall	Minimum Bend	Minimum Wall	Minimum Bend	Minimum Wall	Minimum Bend
3/16					0.020	5/8	0.020	5/8
1/4	0.035	5/8	0.035	5/8	0.020	5/8	0.020	3/4
5/16	0.035	5/8	0.035	5/8	0.020	5/8	0.020	3/4
3/8	0.049	3/4	0.049	3/4	0.028	3/4	0.028	1
1/2	0.049	1	0.065	1	0.035	1	0.035	1-1/4
5/8	0.049	1	0.065	1	0.049	1	0.035	1-1/2
3/4	0.049	1	0.083	1	0.049	1	0.028	1
1	0.049	1	0.083	2	0.065	2	0.028	1
1-1/4	0.049	1-1/4	0.083	3	0.065	3	0.028	1-1/4
1-1/2	0.049	1-1/2					0.028	1-1/2
1-3/4	0.049	1-3/4					0.028	1-3/4
2	0.049	2					0.028	2
2-1/2	0.049	2-1/2					0.035	2-1/2
3	0.049	3					0.035	3
3-1/2	0.049	3-1/2					0.035	3-1/2
4	0.064	4					0.035	4

Figure 25-28 Table of Minimum Bend Radii for Rigid Fluid Tubing



D Outside Diameter of Tube inches	A Depth Maximum inches
Up to 3/4	.005
1 to 1-3/4	.020
2 to 2-3/4	.030
3 to 3-3/4	.040
4 and over	.060

Figure 25-29 Table of Allowable Wrinkles in Rigid Fluid Tube Bends



Clearance for Single Flares	
D Outside Diameter of Tube inches	L Minimum inches
1/8 to 5/8	1
3/4 to 1	7/8
1-1/4 to 1-1/2	1
1-3/4 to 2	1-1/4

Figure 25-30 Table of Minimum Sleeve-to-start-of-bend Clearances on Rigid Fluid Tubing

Outside Diameter of Tube inches	Hose Assy. Size Dash No.	Thread Size of Fittings inches	57S-O Aluminum Alloy Tubing		MIL-T-6845 and AMS-5566 Stainless Steel Tubing		Flexible Hose Assemblies and 65S-T6 Aluminum Alloy Tubing	
			Minimum Torque in./lb.	Maximum Torque in./lb.	Minimum Torque in./lb.	Maximum Torque in./lb.	Minimum Torque in./lb.	Maximum Torque in./lb.
1/8	-2	5/16-24	20	25				
3/16	-3	3/8-24	25	35	90	140	30	70
1/4	-4	7/16-20	40	65	135	185	70	120
5/16	-5	1/2-20	60	80	180	230	70	120
3/8	-6	9/16-18	75	125	270	345	130	180
1/2	-8	3/4-16	150	250	450	525	300	400
5/8	-10	7/8-14	200	350	650	750	430	550
3/4	-12	1-1/16-12	300	500	900	1100	650	800
1	-16	1-5/16-12	500	700	1200	1400	900	1100
1-1/4	-20	1-5/8-12	600	900	1500	1800	1200	1450
1-1/2	-24	1-7/8-12	600	900	2000	2300	1550	1850
1-3/4	-28	2-1/4-12	700	1000	2600	2900	2000	2350
2	-32	2-1/2-12	800	1100	3200	3600	2500	2900
NOTE: These values apply regardless of fitting or nut material.								

Figure 25-31 Table of Torque Values for Fittings with Straight Threads in Other than Oxygen Systems

Nominal Pipe Size inches	Minimum Torque Value in./lb.	Maximum Torque Value in./lb.
1/8	40	300
1/4	60	600
3/8	75	700
1/2	100	900
3/4	300	1600
1-	400	2200
1-1/4	500	2500
Note: These values apply regardless of fitting or nut material.		

All fittings with tapered (pipe) threads shall be torqued as follows:

a. Torque to the minimum value specified, then continue to tighten until the fitting is correctly positioned, but do not exceed the maximum torque value specified.

b. If leakage develops, tighten one full turn further, but do not exceed the maximum torque value specified.

c. If leakage persists, reject the parts.

Figure 25-32 Table of Torque Values for Fittings with Tapered (Pipe) Threads in Other than Oxygen Systems

Tubing Size-inches	Torque Value-in./lb.
5/16	100 - 125
3/8	125 - 150
1/2	125 - 150

If a torque wrench cannot be used, the coupling nut may be tightened 1/2 turn beyond the point of hand tightness for new lines or 1/3 turn beyond the point of hand tightness for used lines.

Figure 25-33 Table of Torque Values for Flared Tube Fittings in Oxygen Systems

Nominal Pipe Size Inches	Torque Value in./lb.
1/8	*50 - 100
1/4	100 - 200

* The 1/8 inch tapered thread boss in the Type A-12 oxygen regulator (for connections to A-3 indicator) are not to be torqued above 50 inch-pounds.

Figure 25-34 Table of Torque Values for Aluminum and Bronze Fittings with Tapered (Pipe) Threads in Oxygen Systems

Sheet thickness	Diameter of Rivet							
	1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8
0.014	44							
0.016	107							
0.018	121	173						
0.020	134	192						
0.025	168	240	321					
0.032	214	307	411	509				
0.036	241	346	463	572	688			
0.040	268	384	514	636	764			
0.045	302	432	578	716	860			
0.051	342	490	655	811	974	1,310		
0.064	429	614	822	1,020	1,220	1,640	2,070	
0.072	482	691	925	1,140	1,370	1,850	2,330	2,780
0.081	543	778	1,040	1,290	1,550	2,080	2,620	3,130
0.091	610	874	1,170	1,450	1,740	2,340	2,940	3,510
0.102	683	979	1,310	1,620	1,910	2,620	3,290	3,940
0.128	858	1,230	1,640	2,030	2,410	3,290	4,130	4,940
0.156	1,050	1,500	2,010	2,480	2,980	4,010	5,040	6,030
0.188	1,250	1,800	2,410	2,980	3,580	4,820	6,060	7,240
0.250	1,670	2,400	3,210	3,970	4,770	6,420	8,070	

Note: This table is based on a stress of 100,000 psi. For ratios of actual bearing strength to 100,000 psi for various aluminum alloy sheets, see Figure 24-27.

Figure 25-35 Table of Unit Bearing Strength of Sheets on Rivets

Plate Sizes	Size of Pins or Bolts												
	1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1
	Bearing strength of plate												
0.028	175	263	350										
0.035	219	328	438	547	656								
0.049	306	459	612	766	919	1,225							
0.058	362	544	725	906	1,087	1,450	1,812						
0.065	406	609	812	1,016	1,219	1,625	2,031						
0.072	450	675	900	1,125	1,350	1,800	2,250	2,700					
0.083	519	778	1,038	1,297	1,556	2,075	2,594	3,112					
0.095	594	891	1,188	1,484	1,781	2,375	2,969	3,563	4,750				
0.120	750	1,125	1,500	1,875	2,250	3,000	3,750	4,500	6,000	7,500			
3/16	1,172	1,758	2,344	2,930	3,516	4,688	5,859	7,031	9,375	11,719	14,063	16,406	18,750
1/4	1,563	2,344	3,125	3,906	4,688	6,250	7,813	9,375	12,500	15,625	18,750	21,875	25,000

Note: This table is based on a stress of 100,000 psi. For ratios of actual bearing strength to 100,000 psi for various aluminum alloy sheets, see Figure 25-37.

Figure 25-36 Table of Unit Bearing Strength of Sheets on Bolts and Pins

Material	Thickness	(Minimum guaranteed properties) K ultimate e/D=2.0	K ultimate e/D=1.5	K yield e/D=2.0	K yield e/D=1.5	Ultimate Tensile Strength psi.
24S-T4 (heat-treated by user)	<0.250	1.18	0.93	0.64	0.56	62000
24S-T42 (heat-treated by user)	0.250-0.500	1.22	0.96	0.61	0.53	64000
	.501-1.000	1.18	0.93	0.61	0.53	62000
	1.001-2.000	1.14	0.90	0.61	0.53	60000
	2.001-3.000	1.06	0.84	0.61	0.53	56000
24S-T3	<0.250	1.24	0.98	0.79	0.69	65000
24S-T4	.250-0.500	1.24	0.98	0.74	0.64	65000
	.501-1.000	1.20	0.95	0.70	0.62	63000
	1.001-2.000	1.16	0.92	0.68	0.60	61000
24S-T36	≷0.500	1.33	1.05	0.96	0.84	70000
24S-T4 (coiled)	<0.250	1.18	0.93	0.64	0.56	62000
Clad 24S-T4(heat-treated by user)	<0.064	1.10	0.87	0.59	0.52	56000
	.064-0.249	1.16	0.92	0.61	0.53	59000
Clad 24S-T4(heat-treated by user)	.250-0.499	1.18	0.93	0.61	0.53	62000
	.500-1.000	1.14	0.90	0.58	0.50	60000
	1.001-2.000	1.10	0.87	0.58	0.50	58000
	2.001-3.000	1.03	0.81	0.58	0.50	54000
Clad 24S-T3	.010-0.063	1.14	0.90	0.73	0.64	60000
	.064-0.249	1.20	0.95	0.74	0.64	63000
Clad 24S-T4	.250-0.499	1.20	0.95	0.74	0.64	63000
	.500-1.000	1.16	0.92	0.67	0.59	61000
	1.001-2.000	1.12	0.89	0.64	0.56	59000
Clad 24S-T36	.019-0.063	1.20	0.95	0.88	0.77	63000
	.064-0.500	1.27	1.01	0.93	0.81	67000
Clad 24S-T4 (coiled)	.012-0.063	1.10	0.87	0.59	0.52	58000
	0.064	1.16	0.92	0.61	0.53	61000
Clad 24S-T6	<0.064	1.14	0.90	0.75	0.66	60000
	≥0.064	1.18	0.93	0.78	0.69	62000
Clad 24S-T81	<0.064	1.22	0.96	0.90	0.78	64000
	≥0.064	1.27	1.00	0.94	0.83	67000

For e/D values between 1.5 and 2.0 bearing factors may be obtained by linear interpolation (e=edge distance, D=hole diameter).

Figure 25-37 (Sheet 1 of 2) Table of Bearing Factors - Aluminum Alloy Sheet and Plate

Material	Thickness	(Minimum guaranteed properties)				Ultimate Tensile Strength psi.
		K ultimate		K yield		
		e/D-2.0	e/D=1.5	e/D=2.0	e/D=1.5	
Clad 24S-T84	<0.064	1.27	1.00	1.01	0.88	67000
	≯0.064	1.33	1.05	1.06	0.92	70000
Clad 24S-T86	<0.064	1.33	1.05	1.04	0.91	70000
	≯0.064	1.35	1.06	1.09	0.95	72000
75S-T6 (aged)	.016-0.039	1.44	1.14	1.06	0.92	76000
	.040-0.249	1.46	1.16	1.07	0.94	77000
	.250-0.500	1.46	1.16	1.07	0.94	77000
	.501-1.000	1.50	1.19	1.10	0.97	79000
	1.001-2.000	1.50	1.19	1.10	0.97	78000
Clad 75S-T6 (aged)	.016-0.039	1.33	1.05	0.98	0.85	70000
	.040-0.249	1.37	1.08	1.01	0.88	72000
	.250-0.499	1.37	1.08	1.01	0.88	72000
	.500-1.000	1.41	1.11	1.02	0.90	74000
	1.001-2.000	1.41	1.11	1.02	0.90	73000
Hardclad R301-T3 and Alclad 14S-T3	.020-0.039	1.06	0.84	0.64	0.56	
	.040-0.250	1.08	0.85	0.69	0.60	
Hardclad R301-T6 and Alclad 14S-T6	.020-0.039	1.20	0.94	0.90	0.78	64000
	.040-0.250	1.22	0.96	0.91	0.80	65000
52S-H32 (1/4H)		0.65	0.50	0.34	0.29	31000
52S-H34 (1/2H)		0.71	0.54	0.38	0.34	34000
52S-H36 (3/4H)		0.78	0.59	0.46	0.41	37000
52S-H38(H)		0.82	0.62	0.53	0.46	39000
61S-T4		0.63	0.48	0.26	0.22	30000
61S-T6		0.88	0.67	0.56	0.49	42000

For e/D values between 1.5 and 2.0 bearing factors may be obtained by linear interpolation (e=edge distance, D=hole diameter).

1. K = Ratio of actual bearing stress to 100,000 psi.

2. The tables of e/D=1.5 are given here for interest only. Edge distance should never be less than 2D. Use this table in conjunction with the Table of Unit Bearing Strength of Sheets on Rivets, and the Table of Unit Bearing Strengths of Sheets on Bolts and Pins.

3. < = Less than. ≮ = Not less than. ≯ = Not greater than.

Figure 25-37 (Sheet 2 of 2) Table of Bearing Factors - Aluminum Alloy Sheet and Plate

Species (common and botanical names) **Hardwoods (broad-leaved species) *Softwoods (conifers)	S.G. based on weight and volume when oven-dry	Weight at 12% moisture content	Shrinkage from green to oven-dry conditions based on dimensions when green		Static bending				Compression parallel to grain		Compression normal to grain stress at proportional limit	Side hardness load required to embed a 0.444 in. ball to 1/2 its diam.	Shear parallel to grain; maximum shearing stress	Tension normal to grain max. tensile strength
			Radial	Tangential	Stress at proportional limit	Modulus of rupture	Modulus of elasticity	Work to maximum load	Stress at proportional limit	Maximum crushing strength				
		lbs. per cu. ft.	Per-cent	Per-cent	psi	psi	1,000 psi	In-lb per cu in	psi	psi	psi	lbs.	psi	psi
**Ash, black (Fraxinus nigra)	.53	34	5.0	6.8	7,200	12,600	1,600	14.9	4,520	5,970	940	850	1,570	700
Ash, commercial (Fraxinus spp.)	.62	41	4.3	5.9	8,800	14,800	1,690	16.1	5,570	7,270	1,510	1,280	1,950	870
Basswood, American (Tilia glabra)	.40	26	6.6	9.3	5,900	8,700	1,460	7.2	3,800	4,730	450	410	990	350
Birch Alaska (Betula neoalaskana)	.59	38	6.5	9.9	7,700	13,600	1,900	13.9	5,290	7,450	820	830	1,400	660
Birch, paper (Betula papyrifera)	.60	38	6.3	8.6	6,900	12,300	1,590	16.0	3,610	5,690	740	910	1,210	
Birch (Betula spp.)	.68	44	7.0	8.5	10,100	16,700	2,070	19.8	6,200	8,310	1,250	1,340	2,010	930
Magnolia, southern (Magnolia grandiflora)	.53	35	5.4	6.6	6,800	11,200	1,400	12.8	3,420	5,460	1,060	1,020	1,530	740
Mahogany (Swietenia spp.)	.51		3.4	4.7	8,600	11,000	1,410	6.7		6,410	1,270	820	1,090	
Maple, soft	.51	37	3.7	7.9	8,000	12,200	1,510	11.4	4,570	6,190	1,150	880	1,750	500
Maple, hard	.67	44	4.8	9.4	9,400	15,700	1,820	16.3	5,350	7,770	1,780	1,440	2,300	670
Oak, commercial white and red (Quercus spp.)	.69	45	4.6	9.0	8,100	14,100	1,730	14.2	4,440	6,900	1,330	1,300	1,850	780
Walnut, black (Juglans nigra)	.56	38	5.2	7.1	10,500	14,600	1,680	10.7	5,780	7,580	1,250	1,010	1,370	690
Yellow poplar (Liriodendron tulipifera)	.43	28	4.0	7.1	6,100	9,200	1,500	6.8	3,550	5,290	580	450	1,100	520
*Cedar, Alaska (Chamaecyparis noothatensis)	.46	31	2.8	6.0	7,100	11,100	1,420	10.4	5,210	6,310	770	580	1,130	360
Douglas fir (Pseudotsuga taxifolia)	.51	34	5.0	7.8	8,100	11,700	1,920	8.6	6,450	7,420	910	670	1,140	300

Figure 25-38 (Sheet 1 of 2)
Table of Strength and Related Properties of Aircraft Woods at 12 Percent Moisture Content

Species (common and botanical names)	S.G. based on weight and volume when oven-dry		Shrinkage from green to oven-dry conditions based on dimensions when green: Radial	Shrinkage: Tangential	Static bending: Stress at proportional limit	Static bending: Modulus of rupture	Static bending: Modulus of elasticity	Static bending: Work to maximum load	Compression parallel to grain: Stress at proportional limit	Compression parallel to grain: Maximum crushing strength	Compression normal to grain stress at proportional limit	Side hardness load required to embed a 0.444 in. ball to 1/2 its diam.	Shear parallel to grain; maximum shearing stress	Tension normal to grain max. tensile strength
		lbs. per cu. ft.	Per-cent	Per-cent	psi	psi	1,000 psi	In-lb per cu in	psi	psi	psi	lbs.	psi	psi
Fir, California red (Abies magnifica)	.42	27	3.8	6.9	7,200	11,200	1,590	9.5		5,290	850	530	1,050	350
Fir, noble (Abies nobilis)	.40	26	4.5	8.3	6,600	10,100	1,580	8.8	4,960	5,550	640	410	980	220
Fir, Pacific silver (Abies amabilis)	.42	27	4.5	10.0	6,200	9,400	1,530	9.3	4,660	5,550	490	430	1,050	
Fir, white (Abies concolor)	.40	26	3.2	7.0	6,500	9,300	1,380	6.7	3,590	5,350	600	440	930	260
Hemlock, western (Tsuga heterophylla)	.44	29	4.3	7.9	6,800	10,100	1,490	7.5	5,340	6,210	680	580	1,170	310
Pine, eastern white (Pinus strobus)	.38	25	2.2	6.0	6,000	8,800	1,280	6.7	3,680	4,840	550	400	860	300
Pine, ponderosa (Pinus ponderosa)	.42	28	3.9	6.3	6,300	9,200	1,260	6.6	4,060	5,270	740	450	1,160	400
Pine, red (Pinus resinosa)	.51	34	4.6	7.2	9,400	12,500	1,800	10.0	5,330	7,340	830	580	1,230	490
Pine, sugar (Pinus lambertiana)	.38	25	2.9	5.6	5,700	8,000	1,200	5.5	4,140	4,770	590	380	1,050	350
Pine, western white (Pinus monticola)	.42	27	4.1	7.4	6,200	9,500	1,510	8.8	4,480	5,620	540	370	850	
Red cedar, western (Thuja plicata)	.34	23	2.5	5.1	5,300	7,700	1,120	5.8	4,360	5,020	610	350	860	220
Spruce (Picea spp.)	.40	28	4.1	7.4	6,700	10,100	1,510	8.8	4,500	5,650	650	500	1,120	360
White cedar, northern (Thuja occidentalis)	.32	22	2.1	4.9	4,900	6,500	800	4.8	2,630	3,960	380	320	850	240
White cedar, Port Orford (Chamaecyparis lawsoniana)	.44	29	4.6	6.9	7,700	11,300	1,730	9.1	5,890	6,470	760	560	1,080	400

(These are the average values of the properties based on extensive tests made at the U.S. Forest Products Laboratory and are not to be confused with the design values)

Figure 25-38 (Sheet 2 of 2)
Table of Strength and Related Properties of Aircraft Woods at 12 Percent Moisture Content