ROYAL CANADIAN AIR FORCE

TYPICAL METAL REPAIRS

REVISION
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TYPICAL METAL REPAIRS

GENERAL

TYPICAL REPAIRS

1 Typical repairs in this Engineering Order are based on ultimate strength of materials. They may be used singly or in combination for a wide variety of damage on all aircraft within the following general limits, and within specific limits to each damage given in the repair figure.

LIMITATION OF TYPICAL REPAIRS

2 The following general limits apply to typical repairs:

(a) Typical repairs must not be used to repair damage for which a specific repair has been issued. (Refer to applicable aircraft -3 EO.)

(b) Do not use typical repairs in restricted areas, as defined in Paragraph 3, following.

(c) Do not use typical repairs for highly loaded members in primary structure e.g., main spars, longerons, frames in fuselage openings, heavy extruded stringers, structural members supporting fittings and hinges, etc. Damage to these components in excess of negligible limits will require specific repairs. Refer to Paragraph 4, following, for classification of structure.

(d) If damage occurs at two places one close to another, the Chief Technical Services Officer (CTSO) or his delegated representative will be required to approve the method of repair.

DEFINITION OF RESTRICTED AREAS

3 The areas in the vicinity of hinge fittings and their attachments, major component attachments and reinforced cut-outs, e.g., entrance doors, cargo doors, inspection or service doors, access apertures, etc., are classified as restricted areas. The stress or/and alignment tolerances preclude the use of typical repairs. Specific repair schemes will be required for any damage, except negligible damage, occurring in these areas.

CLASSIFICATION OF STRUCTURE

4 The aircraft structure has been divided into three classes to indicate its relative importance. The classification into which the damaged structure falls will determine the urgency and character of the repair, and will indicate to the technician whether the aircraft will need immediate attention or, alternatively, remain in operation until repair is convenient. The illustrations of such classification are usually included in applicable aircraft -3 EO. The classification of fittings and attachments may be taken to be the same as that of the adjacent structure. The definitions of the structure classification are as follows:

(a) Primary Structure - Primary structure is defined as a structural assembly which is essential for carrying loads imposed by all flight manoeuvres, take-offs or landings within the design limitations of the aircraft. The primary structure assembly may contain auxiliary members which are classified as secondary structure. Any failure in the primary structure may directly cause structural collapse, loss of control or motive power.

(b) Secondary Structure - Secondary structure is defined as any structural member or assembly designed to assist the primary structure, maintain aerodynamic configuration and support items of equipment. Loads carried by the secondary structure are transmitted to the primary structure. Damage to the secondary structure will not directly impair the safety of the aircraft.

(c) Tertiary Structure - Tertiary structure is defined as a structural member or assembly carrying low stresses, such as fillets, fairings, access doors, etc., which, when damaged, will not impair the safety of the aircraft.

INVESTIGATION OF DAMAGE

GENERAL

5 Investigation of damage is a very important function in maintaining the aircraft in a structurally sound condition. A thorough under-

standing of causes of damage and where to inspect will greatly help to detect the damage before it spreads, to establish its extent and to determine the methods of repair or necessity for replacement.

WHEN TO INSPECT

6 An aircraft technician should start the inspection as soon as he sights the aircraft. Misalignment, asymmetrical shape, effect of

light reflection on a buckled surface and other discrepancies may be seen at a distance and yet be quite unnoticed at close range. Superficial irregularities spotted at the first glance will often lead to the discovery of internal or adjacent damage especially along the load path. Frequent inspection such as before flight, after flight and during work will minimize the risk of damage spreading. Routine examinations at which the aircraft structure must be specifically inspected are as follows:

(a) Inspection after report of suspected damage.

(b) Inspection after report of unsatisfactory performance.

(c) Inspection after report of hard landing, overweight landing, or after tire burst or shedding.

(d) Inspection after report of flight in turbulent air.

(e) Inspection at periodical intervals.

CAUTION

Damage such as cracks, buckling and other deformation of structure, which may be presumed to arise as a result of operating the aircraft in excess of design limits, must be immediately reported to the CTSO or his delegated representative.

COLLISION OR IMPACT DAMAGE

7 This damage in form of nicks, scratches, dents, tears, punctures, etc, can easily be detected by careful inspection of external structure. In addition to externally seen damage, always check adjacent internal structure for failure resulting from transmitted stress.

STRESS DAMAGE

8 This may be quite extensive and remotely located from the point of loading. It may result from operating the aircraft at loads in excess of those for which it was designed, e.g., during take-off or hard landing, during flight in turbulent air, and when moored in high wind. Such damage may occur at any point along load path between point of loading and the centre of mass of the aircraft or a component. The damage is usually in form of loose, tilted or sheared rivets, bolts or screws; cracks; wrinkled or torn skin; deformed structure and misaligned parts.

FATIGUE DAMAGE

9 This will usually appear more frequently as time accumulates in service at points subjected to vibration, flexing and reversal of load. In particular light gauge skins, fittings, and any point on load-bearing members where fittings are attached, or the cross section changes abruptly (bends, joggles, cut-outs, dimples, etc) are subject to this damage. The damage generally starts as a crack at a rivet or bolt hole, or at bend line in formed members. Careful inspection is required to locate the damage while it is still small and before failure occurs.

CORROSION DAMAGE

10 Corrosion takes place to some extent at all times at points where aluminum and steel alloy parts are exposed to moisture, or dissimilar metals are in direct contact. Inspect suspected areas at regular intervals and at any time the area is open for other work, and attempt to arrest corroding action before replacement is required.

FIRE DAMAGE

11 Damage can be caused by fire or excessive heat radiating from defective exhaust system or heating appliances. A careful inspection of structure adjacent to burnt area is required to establish effect of excessive heat on hardness of material and its strength and the extent of this type of damage.

IMPORTANCE OF DAMAGE LOCATION

12 The location of a damaged part is a prime factor in the evaluation of its importance. A similar damage which might be classified as negligible at one location, may be of serious consequence at another location and will have to be classified as repairable or replaceable. Factors which must be considered in this evaluation are structural strength, function, shape and operation of parts.

13 Classification of structural parts, with respect to their importance, is shown in applicable aircraft -3 EO. Locate the damage and establish whether the damage is in primary, secondary, or tertiary structure. Refer to Paragraph 4, preceding, for the definition of classification of structure. In any border-line cases, or instances of damage in two areas, the higher classification must be taken.

LOSS OF STRUCTURAL STRENGTH

14 Any damage along normal load path is always important. A force applied to an aileron control tab will be transmitted in turn to its hinges, aileron and aileron hinges and supports, wing interspar structure, wing to fuselage attachment fittings, and fuselage main frames. Members of this type constitute the primary structure of the aircraft. Any change in shape or cross section (scratches, nicks, holes or cracks) affects the load-bearing ability of the structure.

LOSS OF FUNCTIONAL CAPACITY

15 A small hole in the skin will have varying importance, depending on location. In fairings or trailing edge it would be relatively unimportant. In the thermal anti-ice leading edge it would be very important when flying under icing conditions. The same size hole in a fuel tank might lead to destruction of the aircraft.

CHANGE OF AERODYNAMIC SHAPE

16 Damage which changes the shape of parts of the aircraft varies in importance with location. The most important locations are the forward part of the wing and the control surfaces.

OPERATIONAL INTERFERENCE

17 Binding or irregular motion of movable parts may indicate a hidden distortion or failure. Operate all movable parts which might be affected by the known or suspected damage to locate interference and to evaluate its effect. Check the rigging of parts.

CHECKING EXTENT OF DAMAGE

18 Extent of inspection depends on the cause of damage. Collison or impact damage leaves externally evident signs, and investigation of this type of damage will usually be confined to the obvious damage and transmitted damage to adjacent structure. Stress and fatigue damage may occur at any location with or without the external evidence. To detect such damage and its extent, a thorough inspection, first of aircraft exterior and then of internal structure, must be carried out.

EXTERNAL INSPECTION

19 Examine all aircraft stressed skins for wrinkling, buckling and cracks. Check the exterior for signs of loose, tipped or sheared rivets and for signs of fuel leakage. Any signs of damaged rivets or buckle patterns on surface skin, especially where heavy fittings are attached, are sufficient reason for inspection of adjacent internal structure. Inspect fairings, fillets, covers, doors, escape hatches, etc, for tears, cracks, buckles and misalignment. Anything unusual about their appearance, fit or alignment may indicate a warped or sprung structure, and will be cause for inspection of the structure they cover. When possible, actuate control surfaces, flaps and other movable parts. Observe these units closely throughout their travel, checking that they operate freely and without binding or chafing. In the neutral or closed positions, check the units for proper alignment with adjacent members.

INSPECTION OF OBVIOUS DAMAGE

20 Investigate the extent of damage by cutting away broken, bent, burnt, or otherwise defective structure. Carefully inspect all areas adjacent to the obvious damage. Inspect forgings, fittings and other machined parts for cracks and for evidence of having been moved. This can often be done by observing the paint around the edges, by tipped bolt or rivet heads, or by a slight space at the edge of faying surfaces. When possible remove two bolts from a suspected fitting and examine them for signs of shearing or bending. Check bolt holes for elongation.

21 Inspect carefully not only the area immediately adjacent to the damage, but also supporting structure to which loads may have been transmitted. Secondary damage may also occur owing to fatigue following weakening of the structure by the initial damage. Examine the structure for signs of cracks, tears,

buckles, wrinkles and bowing. Check for sheared, loose and stretched rivets, bolts and screws, and elongated rivet and bolt holes. Rivets which have stretched or failed leaving the heads intact can often be detected by using a feeler gauge. In cases where fractured rivets are suspected but not visible, drill out several rivets around the area of damage and examine them. Traces of fluid spreading from rivet heads are usual indications of loose rivets or defective bearing. Where the surface is painted, rivets which are wholly or partially sheared can sometimes be detected by disturbance of the paint in the region of the skin joint and around the rivet heads.

22 During investigation look for signs of corrosion as its extent will have an important bearing on the methods and extent of repair. Continue the inspection throughout the dis-assembly and repair of the aircraft. During this time, indications of unsuspected damage are often revealed. As each defect is found it must be ringed with chalk so that there is no possibility of any damage being overlooked during repair operations. When new parts being installed do not fit properly, do not force them into position, but determine the cause. Check alignment with adjacent members using a straight-edge or other means, and placing the tool on solid members such as spar webs, frame webs and bulkheads. Deformation of structure may result in a large scale of distortion to major components. If such possibility exists, check the aircraft for symmetry and/or alignment before and after repairs.

23 When an aircraft has been damaged or damage is suspected, a close examination is justified for all areas where major components are joined, or where heavy weights are supported. The principal areas of this nature are as follows:

(a) Wing to fuselage attachment points.

(b) Horizontal stabilizer to fuselage attachment points.

(c) Vertical stabilizer to fuselage attachment points.

(d) Aileron, elevator and rudder hinge points.

(e) Engine mount.

(f) Landing gear trunnion and bracing.

24 When the full extent of damage is determined, make a survey of time, cost and availability factors to determine whether to repair the damage or install replacement.

FIRE DAMAGE INSPECTION

GENERAL

25 Inspection of aircraft affected by fire or excessive heat generated from exhaust system, heating appliances and wheel brakes must be treated individually, but certain typical indications can be used to reduce the inspection work required. All load carrying members are heat-treated for added strength and protected against corrosion. The main test for suspected heat damage to these parts is therefore a hardness check. However, external appearance can sometimes be used as a guide whether a hardness test need be made or not.

26 Discolouration of primer on aluminum alloys and protective plating on steel parts may be sufficient indication of the damage by annealing. If cadmium plating shows signs of melting, steel parts will have been heated to 320°C (610°F) or above. Temperatures above 315°C (600°F) can soften heat-treated steel and a hardness test will confirm the weakened condition. However, a greater danger exists if evidence of molten cadmium is discovered on highly stressed steel parts. At temperatures high enough to melt cadmium, the cadmium will diffuse into the steel. This diffusion embrittles steel parts and leads to their failure. Therefore, if steel parts are discovered showing signs of melted cadmium plating, it is recommended that they be replaced. If the cadmium plated parts have been heated above 260° to 275°C (500° to 525°F), cadmium will turn dark straw colour; if improperly applied, blistering of cadmium will occur which exposes material to corrosion. Steel parts having blistered but not melted cadmium plating should be stripped, hardness tested for conformance to drawing requirements, and replated.

27 A temper colour in steel parts is another indication of overheating and the parts should be checked for hardness. When parts are heat-

treated to high strength, they may be subject to fatigue cracking induced by notching. Therefore, test points should be kept away from edges and the number of hardness checks should be kept to a minimum.

28 To ensure a more accurate inspection of areas affected by fire and to prevent the structure from corrosive action of certain fire extinguishants, thoroughly clean the areas covered with fire extinguishing agents.

REMOVAL OF FREON $13B_1(CF_3Br)$

29 Freon $13B_1$ (CF_3Br) is a volatile extinguishant evaporating quickly and not requiring a special cleanup. In the presence of water it has corrosive effect only on magnesium and magnesium alloys with more than 2% of magnesium. It also tends to dissolve natural rubber products.

REMOVAL OF DRY CHEMICAL POWDER

30 This type of extinguisher uses a specially prepared grade of sodium bicarbonate as the extinguishing agent. Heat causes the bicarbonate to decompose, releasing carbon dioxide gas and water vapour to smother the fire. A powdery residue of sodium carbonate will usually remain on and around the heat-affected area.

31 Dry sodium bicarbonate is non-abrasive and non-corrosive. In water solution it will cause mild corrosion of most metals by either electrolytic or chemical means. However, its rate of corrosion is so slow that it can be cleaned with little chance of damaging delicate parts. The decomposition product, sodium carbonate, will cause little damage if kept dry, but in solution with water is strongly caustic and will rapidly attack many common aircraft materials. For this reason, when water is used to clean up after a fire, thorough rinsing is absolutely necessary to eliminate any pockets of strong carbonate solution from the aircraft.

WARNING

Care should be taken to prevent sodium carbonate dust from entering the eyes, nose, or mouth during cleanup procedure.

32 In areas of the aircraft which are free of electrical equipment, or where it is hermetically sealed, such as in wheel wells, blow any powder residue away with compressed air. Wash the area thoroughly with fresh water and then dry with clean cloth and compressed air. When non-sealed electrical and electronic equipment is present, the decision to use water should be determined by how readily this equipment can be removed and dried. (Large bundles of wire will have to be loosened and blown dry.) If it is decided that water would be harmful to any of the aircraft equipment, a satisfactory removal of chemical powder can be accomplished by a combination of brushing, vacuum cleaning and careful blowing with compressed air. When the powdery residue sticks to hydraulic oil or grease, it should be removed with solvent approved for removing oil or grease alone.

REMOVAL OF FOAM EXTINGUISHANT

33 This foam extinguishing agent is harmless to all materials not damageable by water alone. It is normally used on major fires that will damage the aircraft extensively. The foam may be removed with a high velocity jet of fresh water and scrubbing with a fibre brush. Dry the aircraft thoroughly with clean cloths and compressed air. Remove all affected, non-sealed electrical and electronic components immediately. Dry and prepare them for overhaul in accordance with AMCHQ directives.

REMOVAL OF OTHER FIRE EXTINGUISHANTS

34 Carbon dioxide and carbon tetrachloride evaporate rapidly and normally require no cleanup. Chlorobromomethane is highly corrosive, it evaporates rapidly, but if any of the substance is trapped in pockets and/or in system tubing, it must be blown out or purged, using compressed dry nitrogen. Cleaning should be carried out within a few hours from the time of discharge, otherwise corrosion may set in. For cleaning methyl bromide extinguishant, use cleaner fluid (Item 1, Figure 71).

VISUAL INSPECTION FOR BUCKLING AND WARPING

35 In visually inspecting an aircraft, the search for buckles or oil canning is the

primary concern. It is possible that an area of internal structure unaffected by the fire directly may have been buckled enough to receive a permanent set. This is especially important when the fire has been in the wing area.

36 Large (or thick) aluminum alloy parts, such as forgings, are not so quickly affected by heat as are thinner and smaller components. However, when heat has been great enough to injure sheet and extruded parts, all heavy fittings in the area should be hardness tested by portable or stationary testers as the case may dictate. Similar parts from unaffected areas may be used for a comparison.

37 It is often necessary to remove a sample disk from sheet metal parts in order to test them on a bench-type hardness tester. Discs for this purpose should be removed with a 1-inch hole saw. If the part is to be retained in use, make repairs as directed in the applicable aircraft -3 EO or this EO.

ZINC CHROMATE PRIMER DISCOLOURATION

38 Determining the extent of fire damage by zinc chromate primer comparison can be reliable when used carefully. A clean sample of the primer known to be unaffected by heat is compared with chromate in the heated area. The sample should be from the same general area of the structure in question. The suspected area must be free of dirt, oil and smoke stains.

39 Untinted chromate primer is slightly greenish yellow. When exposed to above 205°C (400°F) of heat for a few minutes, it turns a light tan colour. Temperatures which discolour chromate primers will change the physical properties of 24S-T4, 24S-T3 and 75S-T6. The 75S which is in the T6 condition will be softened and weakened. The 24S-T4 and 24S-T3 will be artificially aged and hardened when the temperature reaches 190°C (375°F), then, with increased heat, this metal also softens and weakens. When the temperature of 24S-T4 and 24S-T3 is raised to 150° to 260°C (300° to 500°F) for a short period under uncontrolled conditions, as in the case of aircraft fire, the inherent corrosion-resisting properties are seriously affected.

40 When the slightest discolouration of the primer is evident, 24S-T4, 24S-T3 and 75S-T6 are of questionable value and should be subjected to more accurate methods of testing. If chromate primer discolouration indicates that heat has affected the material, it should be replaced or a specimen removed and sent to a laboratory for tension and corrosion susceptibility tests.

41 If the decision is made to retain in use a section of 24S-T4 or 24S-T3 which has undergone slight mechanical change due to fire, every effort should be made to protect the metal against corrosion.

PORTABLE HARDNESS TESTING

42 Material to be tested must be free of paint and foreign material and must be thick enough to prevent bulging on the reverse side. Anodizing which is hard and cladding which is soft, must be removed at the point of penetrator contact, otherwise the readings will be inaccurate. Access hole covers in the fire area are excellent samples for hardness sampling. They also provide an easily replaceable part for destructive testing.

Hardness Testing of Parts on the Aircraft

43 Parts which cannot be easily removed from the aircraft may be hardness tested with either a Barcol portable hardness tester (Barber-Coleman Co., Rockford, Ill), or an Ernst portable hardness tester, Models RAR and RBR (Newage International, Inc., 235 East 42 Street, New York 17, N.Y.) which reads directly for Rockwell A and B scales. (See Figure 1, Sheet 1.) Material hardness is determined by measuring the depth of penetration of a spring-loaded diamond penetrator on the Ernst tester and a steel ball penetrator on the Barcol tester. The Ernst Model RAR is used for testing hardened steel and hard alloys. The Ernst Model RBR and the Barcol testers are used for checking unhardened steel and most non-ferrous metals. By obtaining test readings on samples of known materials, tests may be made to isolate weakened areas on materials with the use of the Barcol or Ernst portable hardness tester. Wherever possible, comparative readings should be made between the fire damaged part and same or like parts

unaffected by heat, or using samples of hardness not below the minimum values required. This comparison may be accomplished by heating one end of the spare part or sample with a welding torch. Rockwell test the part in accordance with Figure 2.

44 Mark the area between heat damaged end and unaffected end where Rockwell value is at a minimum limit. Using either a Barcol or Ernst tester, test the marked area and record the minimum acceptable reading. Test the damaged part on the aircraft and replace the part if the reading is below the recorded reading from the spare part.

45 Carry out the test as follows:

(a) Clean the area to be tested. Select a smooth, scratch-free area on the accessible surface of the part.

(b) Check calibration of tester on a test plate provided with the instrument, in accordance with the manufacturers instructions.

(c) The instrument must be held so that the penetrator is at right angles to the surface to be tested.

(d) Take several readings over area around damaged section of structure to determine extent of damage.

(e) Replace all parts weakened below minimum acceptance values. (See Figure 2.)

Hardness Testing of Parts Removed from Aircraft

46 Aircraft structural parts that can be easily removed from the aircraft may be accurately tested for proper hardness with a Riehle portable hardness tester as shown in Figure 1, Sheet 2. The Riehle tester is supplied with a diamond penetrator for hardened or heat-treated steel, and a 1/16-inch ball penetrator for non-ferrous material, or materials softer than C-20 on the Rockwell scale. The instrument readings are in Rockwell C, A, B and F scales. Test blocks are supplied with the tester which should be used frequently to check the performances of the instrument. It is advisable to run a test on a hardness block between each series of tests and at any time when hardness readings are not normal. The use of Riehle hardness tester is described in Figure 1, Sheet 2.

LABORATORY TENSION TESTING

47 Aircraft structural parts affected by heat, the hardness test of which does not show conclusive results, should be tension tested before deciding to retain them in use on the aircraft. Samples removed from sheet metal parts for laboratory testing should measure 1 by 7 inches. However, pieces measuring 1 by 5 inches are acceptable. They should be cut with the long edges parallel to the grain direction wherever possible. When parts or samples are sent to a laboratory for analysis, information as to the type and duration of fire should be included.

DAMAGE INSPECTION TECHNIQUES

GENERAL

48 When investigating suspected damage, the use of approved mechanical, chemical, optical and electrical devices will greatly assist the naked eye to detect and determine the extent of small defects. (Refer to EO 105-1-2B.)

BREAKS IN CLADDING

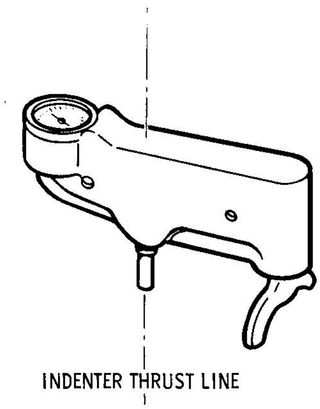
49 Breaks in the cladding of aluminum alloys may be detected by the following method:

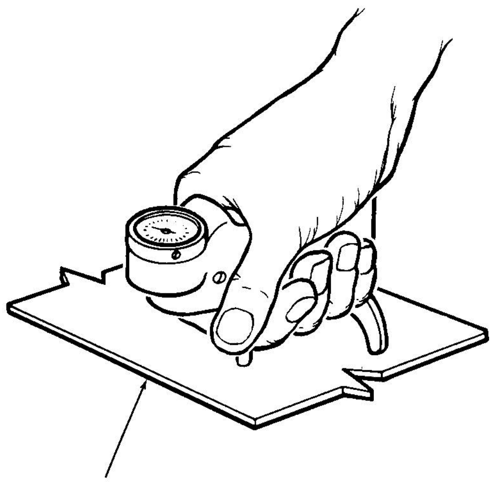
(a) Clean the surface to be tested with trichloroethane 1-1-1 (Item 2, Figure 71) or other suitable grease removing solvent. It is very important that all traces of grease and dirt appearing as dark lines in scratches should be removed.

(b) By means of an eye-dropper apply a few drops of caustic soda (Item 3, Figure 71) and water solution, prepared in proportion of 20 grams caustic soda (NaOH) to 80 grams of water, to the scratch. On the fuselage and underside skins a cup made from plasticene should be used to hold the solution in contact with the surface.

(c) Allow solution to react for five minutes for 24S and two minutes for 75S materials.

BARCOL PORTABLE HARDNESS COMPARATOR



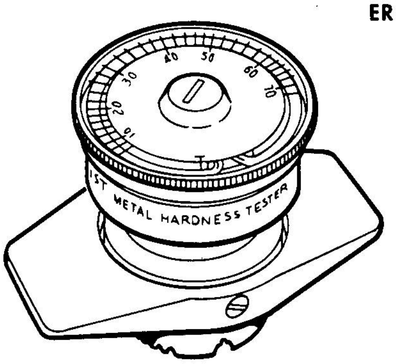


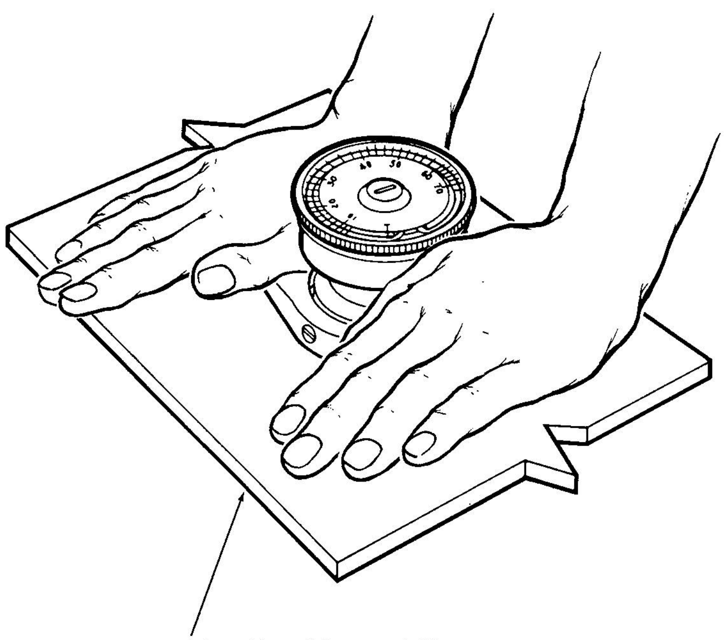
Material must be solidly supported from behind. Apply a steady even pressure at right angles to material to obtain an accurate reading.

NOTES

1. Do not allow tester to slide on material.
2. Barcol comparator has hardened steel penetrator and reads in Barcol impress or numbers.

ERNST PORTABLE HARDNESS TESTER





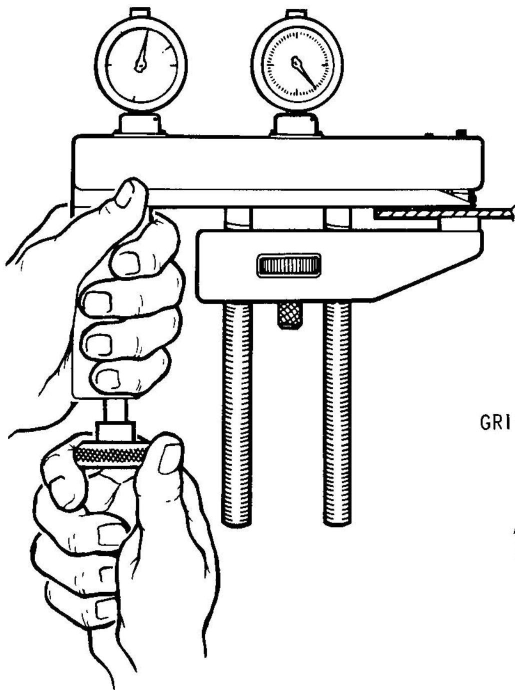
NOTE

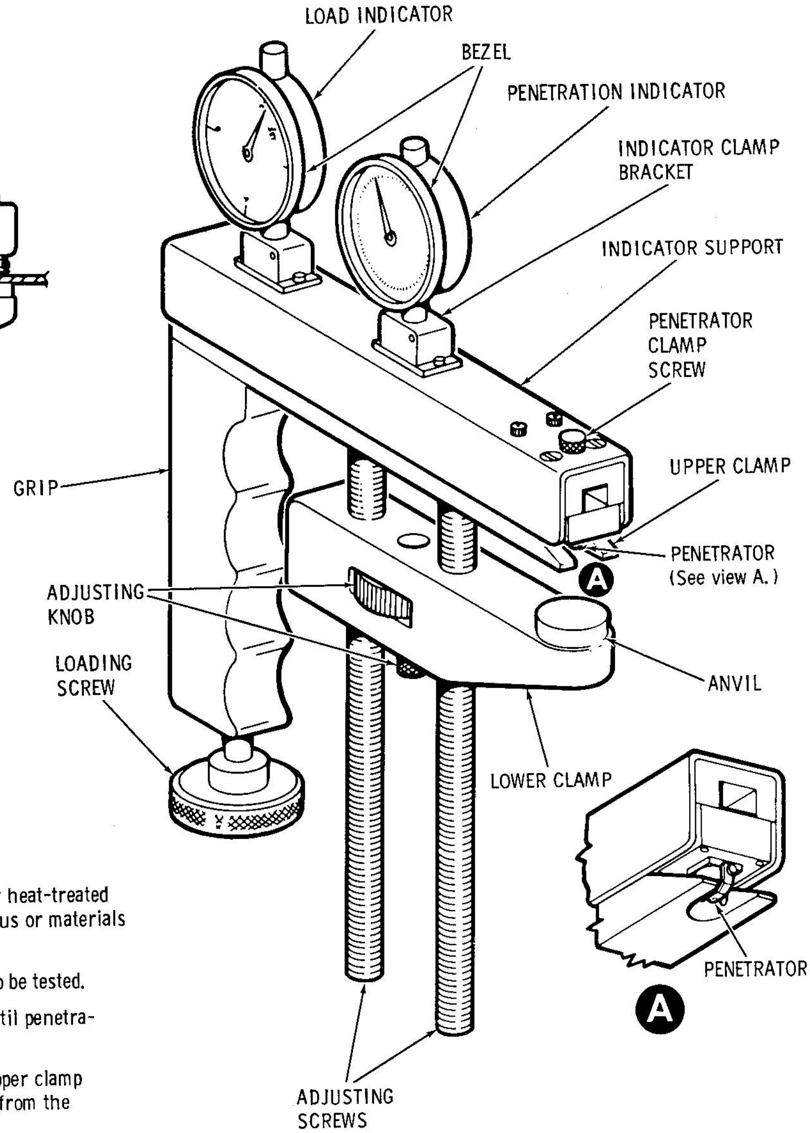
The tester has diamond-tipped penetrator, and reads in Rockwell or Brinell scales.

Material must be solidly supported from behind. Press down with a steady even force to obtain accurate reading.

13-24-126

Figure 1 (Sheet 1 of 2) Portable Hardness Tester (Barcol and Ernst)





OPERATING PROCEDURE

STEPS

1 Select penetrator to be used.

NOTE

Use a diamond penetrator for hardened or heat-treated steel. Use a ball penetrator for non-ferrous or materials softer than a Rockwell reading of C-20.

2 Select proper anvil to suit shape of part to be tested.

3 Turn loading screw counter-clockwise until penetrator does not project beyond upper clamp.

4 Place the material to be tested between upper clamp and anvil so that test may be made as far from the edge as possible.

5 Clamp material to be tested between upper clamp and anvil by turning adjusting knob on lower clamp clockwise.

CAUTION

Do not force.

6 Set load indicator dial for zero setting by rotating bezel until pointer is over small black dot.

7 Apply a 10 kg minor load by turning loading screw clockwise until pointer of load indicator dial is over set.

NOTE

Instrument must be held steady to obtain an accurate reading.

8 Rotate bezel on penetration indicator dial until pointer is on 0 of the black scale.

9 Apply major load by turning screw clockwise.

NOTE

Normal settings for major loads as indicated on load indicator dial are as follows, C scale (150 kg) or A scale (60 kg) for diamond penetrator and B scale (100 kg) for ball penetrator.

10 Remove major load and reduce to minor load by turning loading screw counter-clockwise until pointer of load indicator dial moves back to set.

11 Hardness of material being tested will be indicated on penetration indicator dial.

NOTE

Read black figures when using diamond penetrator. Read red figures when using ball penetrator.

12 Remove instrument by turning adjusting knob counter-clockwise.

13-24-127

Figure 1 (Sheet 2 of 2) Portable Hardness Tester (Riehle)

ALLOY		FORM	SEE NOTES	MINIMUM ROCKWELL HARDNESS VALUE
TYPE	TEMPER			
2S	-H14	Sheet		H-70
3S	-H14	Sheet		H-80
17S	-T4	Bare Sheet over 0.024 inch	(1)	H-105
24S	-T3 and -T4	Clad Sheet under 0.064 inch	(1)	E-91
		Clad Sheet from 0.064 to 0.091 inch	(1)	E-93
		All Bare Products	(2)(3)	B-69
	-T42	Bare Plate	(1)(3)	E-95
		Bar, Rod and Shapes	(1)	E-95
		All Bare Products	(2)(3)	B-69
26S	-T4	All	(4)	B-65
	-T42	All	(4)	B-65
	-T6	All	(4)	B-78
	-T62	All	(4)	B-78
50S	-T6	Extruded Shapes		E-70
55S	-T4	All		H-73
	-T6	All		H-92
57S	-H34	Sheet		H-95
65S	-T4	All		H-88
	-T6	All		E-85
75S	-T6	Clad Sheet under 0.037 inch		E-102
		Clad Sheet 0.037 to 0.062 inch		E-104
		Clad Sheet 0.063 to 0.089 inch		E-102
		Bare Sheet	(3)	B-84
		Bare Plate	(3)	B-84
		Bar, Rod and Shapes		B-84
79S	-T6	All		B-81

NOTES:
(1) After 24 hours aging at room temperature for -T4 and -T42 tempers.
(2) After 96 hours aging at room temperature.
(3) Where values for 24S and 75S clad products are not shown, the cladding should be removed and the values for bare products should be used.
(4) All the values shown in the table for 26S alloy apply to bare products only. Where values for clad material are required the cladding should be removed and the values for the bare products should be used.

Figure 2 Table of Minimum Rockwell Hardness Acceptance Values for Aluminum Alloys

(d) Blot the solution with a filter paper pad and rinse off the surface generously with water and allow to dry.

(e) Using a magnifying glass, inspect the bottom of scratches for a black deposit, which will indicate that the cladding has been penetrated and that aluminum core is exposed. If no black is visible and only a whitish residue remains in the scratch, the scratch has not penetrated the cladding.

(f) Make sure that all the caustic soda solution is thoroughly rinsed from the metal and scratches.

(g) Neutralize the caustic soda solution by applying drops of 10% chromic acid (Item 4, Figure 71) solution generously to the whole of the etched area.

(h) Wash off excess of chromic acid solution with water and dry the area with a soft absorbent cloth.

WARNING

Handle the caustic soda solution with extreme care. In case of accidental contact with human skin, rinse the affected area immediately with cold water.

CAUTION

The caustic soda testing solution will cause corrosion of aluminum alloys under certain conditions. Do not use this solution where its use cannot be controlled in such a manner as to prevent entrapment under rivet heads and other attaching devices, or in faying surfaces. It should not be used excessively and must not be used more than once in the same area.

BREAKS IN ANODIC FILM

50 Breaks in anodic film on aluminum alloy sheet can be detected by testing the electrical conductivity of the film, using a 4.5 volt battery and bulb. The surface to be tested must be degreased, using approved cleaning solvents, such as trichloroethane 1-1-1 (Item 2, Figure 71). The ends of both test wires must be placed within the suspected area of damage. If the lamp is illuminated it indicates a break in the anodic film.

BREAKS IN CADMIUM PLATING

51 Breaks in cadmium plating on ferrous metals can be detected by the following method:

(a) Degrease the suspected area of damage with trichloroethane 1-1-1 (Item 2, Figure 71) or other suitable grease removing solvent.

(b) Apply a few drops of 1% hydrochloric acid (HCl) (Item 5, Figure 71) solution to the affected area.

(c) If bubbles of hydrogen appear within 10 minutes of applying the acid to the cadmium, plating has been removed or is porous.

(d) Wash the area with clean water and dry.

BREAKS IN CHROMIUM PLATING

52 Breaks in the chromium or nickel plating on ferrous metals can be detected by the following method:

(a) Degrease the suspected area of damage with trichloroethane 1-1-1 (Item 2, Figure 71) or other suitable grease removing solvent.

(b) Apply a few drops of acid copper sulphate (Item 6, Figure 71) solution to the suspected area. (Solution consists of 10% copper sulphate ($Cu\ SO_4$) and 10% by weight sulphuric acid (H_2SO_4) (Item 7, Figure 71) specific gravity 1.84 in water.)

(c) If a film of copper is produced (reddish pink colouration) the nickel or chromium plating has been removed.

(d) Wash the area with clean water and dry.

DYE PENETRANTS INSPECTION

53 Non-fluorescent and fluorescent methods are used to detect such defects as porosity, pin holes or surface cracks. Inspection may be carried out on any parts made from ferrous or non-ferrous metals and plastics, which will not be physically or chemically harmed by the penetrants. Inspection by dye penetrants is

one of the easiest, quickest and least expensive methods for field or shop use.

54 Parts to be inspected must be free from paint, welding flux and scale, and must be thoroughly cleaned using approved cleaning liquids. The temperature of the tested part whenever possible should be between 21.1° and 65.5°C (70° and 150°F) to open up flows and speed penetration. For detailed description of these inspections, refer to EO 05-1-3/20 and EO 105-1-2B.

MAGNETIC PARTICLE INSPECTION

55 Magnetic particle inspection is a non-destructive test on magnetizible metals for the detection of cracks, seams, laps and inclusions on or near the surface. This test is used particularly for all vital and highly-stressed parts as a major process inspection and as a required overhaul inspection for the detection of incipient service failures. (Refer to EO 05-1-3/20.)

PORTABLE X-RAY INSPECTION

56 Within certain limitations, portable X-ray equipment provides most essential and economical inspection for internal condition of materials. However, thorough understanding of the application of X-ray equipment and high skill in the interpretation of X-ray exposures are required to obtain accurate indication.

57 This inspection has been widely used for periodic checking of critical joints and fittings on aircraft which have accumulated a large number of flying hours, and for inspection of aircraft ivolved in hard landings or in flight through severe turbulence.

58 X-ray will reveal cracks in hidden sheet metal parts such as ribs and spar webs. Enlarged bolt holes, and sheared or partially sheared rivets, bolts and screws may also be detected. Cracks in extrusions and heavy fittings can be seen when some portion of the surfaces of separation are parallel to the X-ray beam axis. It must be noted, however, that cracks cannot be seen when the X-ray beam is at an angle to the separated surfaces.

59 In X-ray inspection of assembled aircraft components, various layers of unwanted mass enveloping the inspected part, through which penetration must be made, produce confused patterns on the film. To achieve clear indication on the film, other factors such as presence of liquids, sealants and paints must be either taken into account, or where possible may be drained, removed or cleaned.

CLASSIFICATION OF DAMAGE

GENERAL

60 Depending on the extent and location of damage, classify the damage as follows:

(a) Negligible damage.

(b) Repairable damage.

(c) Damage necessitating replacement.

NEGLIGIBLE DAMAGE

61 Damage which does not require the addition of structural repair material and can be corrected or arrested by minor measures, and is permitted to exist without rendering the aircraft unserviceable, may be defined as negligible. This class of damage is divided into two categories:

(a) Negligible damage which does not require any treatment and, after checking if within the limits, may be left in the existing state.

(b) Negligible damage which requires such treatment as stop drilling cracks, blending out nicks and scratches, fairing chipped edges, plugging holes and applying anti-corrosive treatment.

62 For limits of negligible damage, which may vary considerably for the same damage depending on the importance of structure, and methods of measuring and treating negligible damage, refer to Paragraphs 70 to 89 inclusive, following.

REPAIRABLE DAMAGE

63 Damage which is beyond the negligible limits will require the addition of structural repair material and must be repaired by patching or insertion (splicing) in accordance

with repair illustrations contained in applicable aircraft -3 EO or this EO.

REPAIR BY PATCHING

64 Repair of damage by patching requires reinforcements superimposed over damaged area. The usual form of damage in this classification are cracks and holes. The reinforcements and rivets must be designed and located to return the part to full structural strength and not interfere with its function.

REPAIR BY INSERTION

65 Repair of damage by insertion requires the substitution of damaged part by a new section of structural member in a manner which will enable the inserted part to carry structural loads. Both ends of the insertion are spliced to the existing undamaged structure by superimposing splicing members at each end in the same manner as in patch repair. The rivet requirements and pattern in insertion repair are the same for each end.

DAMAGE NECESSITATING REPLACEMENT OF PARTS

66 This type of repair is generally the simplest and most satisfactory from the engineering viewpoint. When correctly carried out, the strength, weight and appearance of the damaged area will be exactly the same as it was originally. Damaged parts which necessitate replacement are as follows:

(a) Parts which are damaged beyond economical or practical repair.

(b) Damaged members which are relatively short.

(c) Forged, cast and machined fittings damaged beyond negligible limits.

(d) Highly stressed members, the repair of which would leave an inadequate margin of safety.

(e) Parts found understrength by hardness check, in areas affected by fire.

TYPES OF REPAIRS

GENERAL

67 Repairs are classified as specific and typical. In addition to these types there may be a case where a special repair scheme will be required. The special repair will be individually assessed by the CTSO or his delegated representative and will be valid for one aircraft only. Similar damage on other aircraft must be individually assessed.

SPECIFIC REPAIRS

68 Specific repairs are specially designed and valid for the location named in the repair illustration title. They will be found in the applicable aircraft -3 EO and must be used in preference to typical repairs contained in this EO.

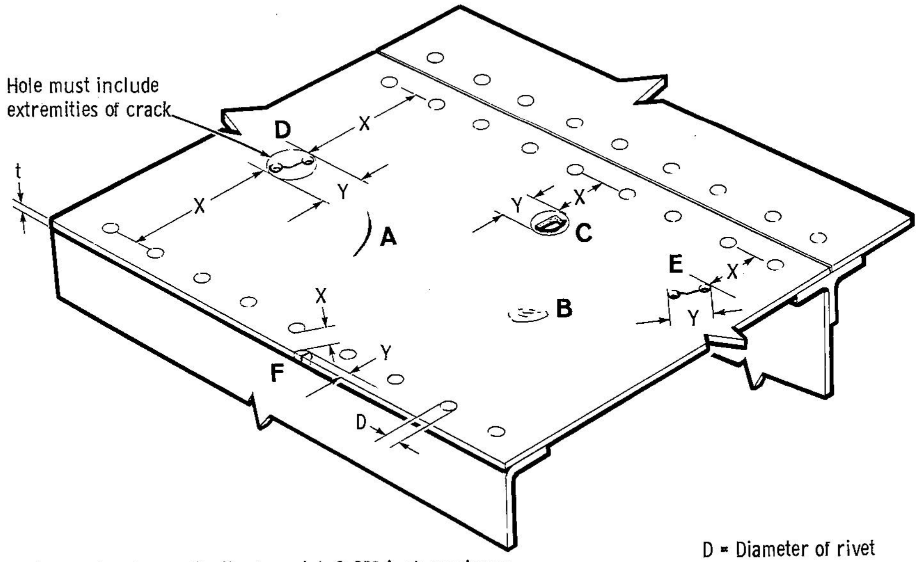
TEMPORARY REPAIRS

69 With the CTSO or his delegated representative approval, temporary repairs may be made to allow aircraft to return to base, providing only structural strength is affected. Effect of damage on other airworthiness characteristics, such as anti-icing, fuel or cargo loading, pressurization, flying control operation, etc, must be assessed by the CTSO or his delegated representative, and applicable flight limitations imposed. Temporary repairs must not be used on restricted areas. Repair members in form of external skin patches or simple reinforcings for internal structure may be employed. Rivet requirements must be calculated from applicable Rivet Table, however, screws or blind rivets may be used in lieu of solid rivets, providing the chosen diameter and pattern is laid out as for permanent repair. All temporary repairs must be reworked before aircraft is released for normal operational duty.

TREATMENT OF NEGLIGIBLE DAMAGE

GENERAL

70 As described in Paragraph 61, preceding, some negligible damage requires treatment. The amount of treatment required will vary depending on the type and location of damage. The maximum and minimum dimensions of negligible damage for the same structural member vary depending on location of damage and the role of the aircraft. Since this EO is applicable to many types of aircraft, the limits of negligible damage given in Figure 3 are only of general nature. Reference should be made to



D = Diameter of rivet
t = Material thickness

A SCRATCHES - In primary structure - Depth of scratch 0.003 inch maximum.
In pressurized section of fuselage scratch must not penetrate below cladding.

In secondary structure - In material thickness not exceeding 0.056 inch: Maximum depth of scratch 10% t.
- In material thickness 0.063 inch and over: Maximum depth of scratch 5% t.

B DENTS - Only small indentations free from cracks and abrasions.

In material thickness not exceeding 0.056 inch: Maximum depth: t.
In material thickness 0.063 inch and over: Maximum depth: t/2.

C PUNCTURES CLEANED UP TO A SMOOTH ROUND HOLE - Not permitted in pressurized section of fuselage, integral fuel tank structure and anti-icing leading edges.

D CRACK CLEANED UP TO A SMOOTH ROUND HOLE - Not permitted in pressurized section of fuselage, integral fuel tank structure and anti-icing leading edges.

E CRACK STOP DRILLED AT EXTREMITIES - Not permitted in pressurized section of fuselage, integral fuel tank structure and anti-icing leading edges.

F DAMAGE AT EDGE CLEANED UP TO SMOOTH CONTOUR

NOTES

1 All dimensional limits apply to damage after it has been cleaned up to a smooth radius or stop drilled as applicable.

2 After damage has been cleaned out, anti-corrosion treatment must be applied (refer to EO 05-1-3/23). To prevent entry of water into structure, negligible damage holes must be plugged.

3 For negligible damage limits specific to an aircraft, refer to applicable aircraft -3 EO.

4 For method of trimming out negligible damage, see detail in Sheet 4.

AIRCRAFT COMPONENTS	TYPE OF DAMAGE AND MAXIMUM AND MINIMUM LIMITS							
	C		D		E		F	
	X MIN	Y MAX	X MIN	Y MAX	X MIN	Y MAX	X MIN	Y MAX
WING AND EMPENNAGE: Leading Edges	NONE		NONE		NONE		2D	D
Interspar Skins	1-1/2	1/2	1-1/2	1/2	NONE		2D	D
Tips	1	1/2	1	1/2	NONE		2D	D
Flight Control Surfaces and Flaps	NONE		NONE		NONE		2D	D
Trailing Edges and Shrouds	1	3/4	1	3/4	1-1/2	1/2	2D	1/4
FUSELAGE: Pressurized Section	NONE		NONE		NONE		NONE	
Unpressurized Section	1-1/2	1/2	1-1/2	1/2	NONE		2D	D
Tail Cone	1	3/4	1	3/4	1-1/2	1/2	2D	1/4
ENGINE NACELLES: Primary Structure	1-1/2	1/2	1-1/2	1/2	NONE		2D	D
Secondary Structure	1	1/2	1	1/2	1-1/2	1/2	2D	1/4
LANDING GEAR DOORS	1	1/2	1	1/2	1-1/2	1/2	2D	1/4
FAIRINGS (Non structural)	1	1	1	1	1	3/4	2D	1/4
FILLETS (Structural)	NONE		NONE		NONE		NONE	

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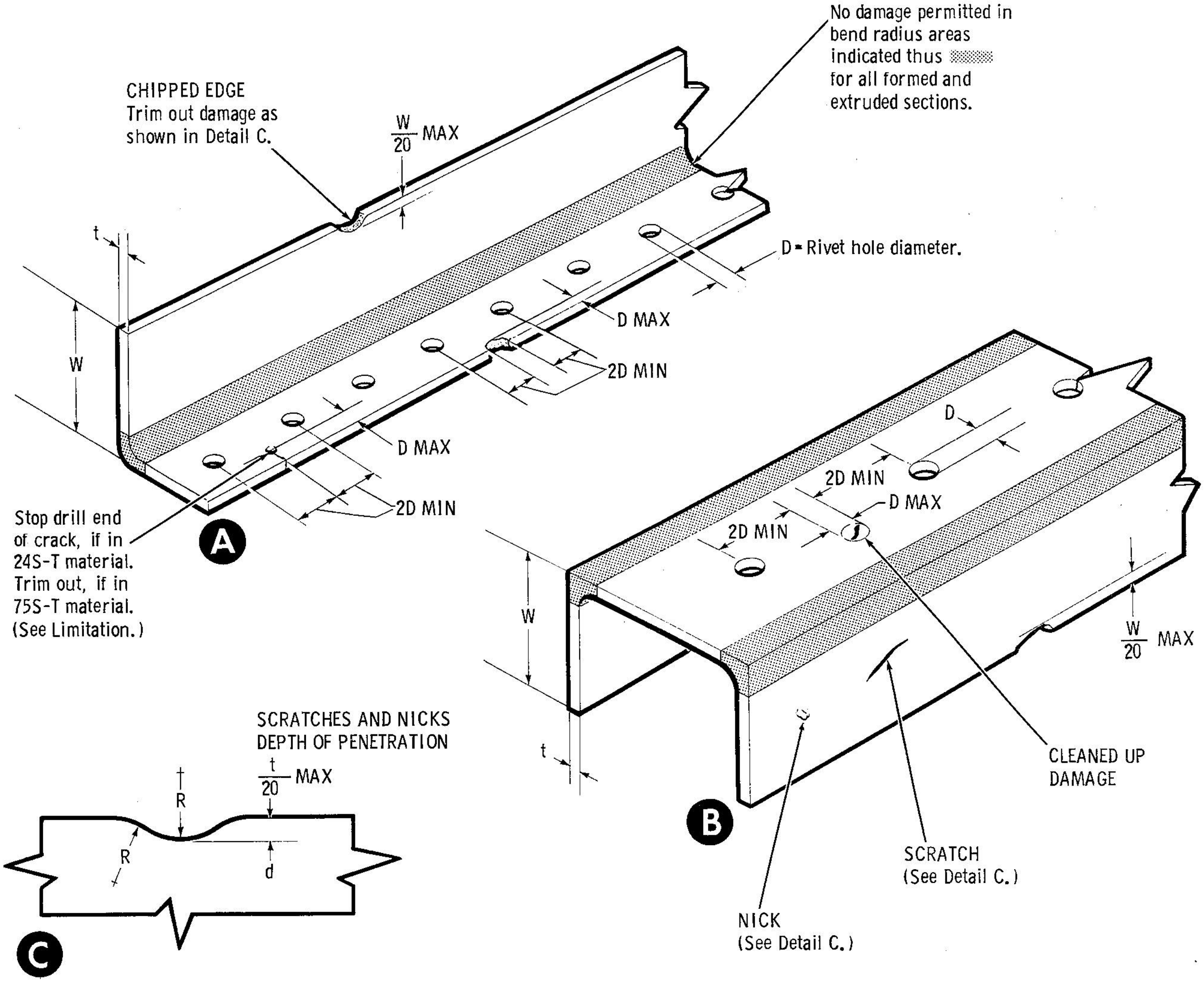
Figure 3 (Sheet 1 of 4) Negligible Damage Limits - Skin



R = 10d MIN d = Depth of penetration.
Scratches, nicks and chipped edges must be trimmed out and smoothed to contour shown.

LIMITATION

Cracks of any length are not permitted in members of primary structure and restricted areas.

NOTES

1. All dimensional limits apply to damage after it has been cleaned up to a smooth radius or stop drilled as applicable.
2. Damage permitted to only one component in any one cross-section.
3. No reduction in section permitted in components where original does not contain attachment holes, or where cross-section has already been reduced by drilling or trimming.
4. Dents without any sign of cracking are permitted in formed sections only to a depth equal to the thickness of material.
5. After damage has been cleaned out, anti-corrosion treatment must be applied. Refer to EO 05-1-3/23.
6. For negligible damage limits specific to an aircraft, refer to applicable aircraft -3 EO.

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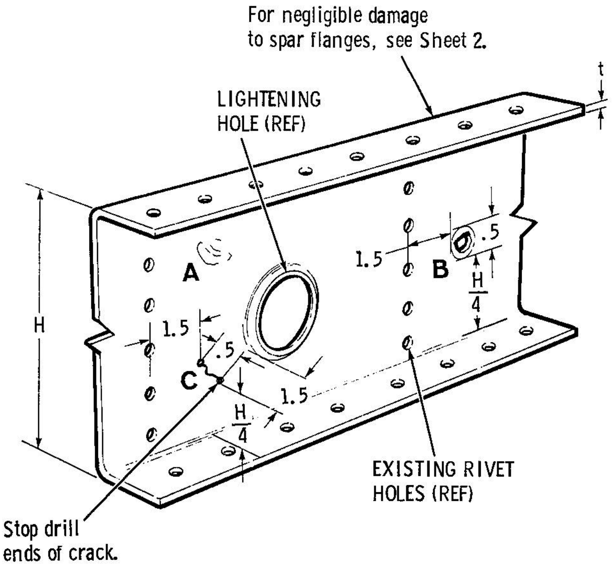
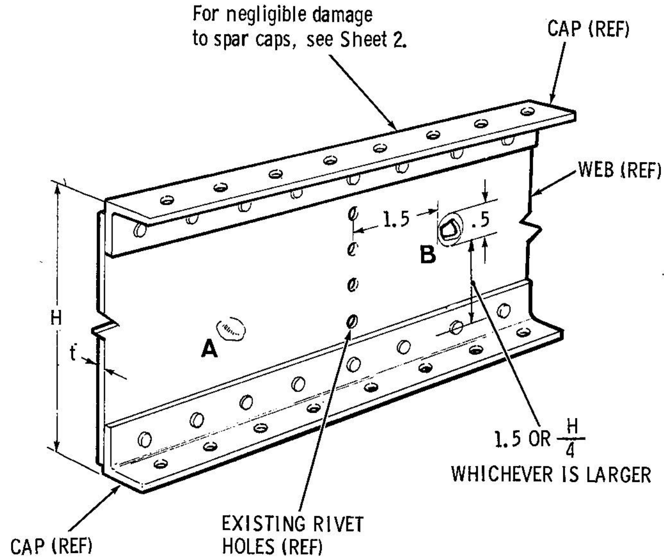
Figure 3 (Sheet 2 of 4) Negligible Damage Limits - Formed and Extruded Sections



TYPE 1
SHEET METAL FORMED SPARS
(Flanges integral with webs)



TYPE 2
BUILT-UP SPARS
SHEET METAL WEBS
AND EXTRUDED
AND SEPARATE CAPS

A DENTS - Small indentations must not exceed web thickness (t) in depth. Only smooth dents with a minimum of 5t radius, free from sharp corners and abrasions are permissible.

B HOLE OR PUNCTURE CLEANED UP TO SMOOTH ROUND SHAPE - Not permitted in pressurized section of fuselage, integral fuel tank structure and anti-icing leading edges.

C CRACK STOP DRILLED - CAUTION: Stop drilling cracks not permissible in Type 2 spars.. Cracks not permitted in pressurized section of fuselage, integral fuel tank structure and anti-icing leading edges.

NOTES

1 All dimensional limits apply to damage after it has been cleaned up to a smooth radius or stop drilled as applicable.

2 After damage has been cleaned out, anti-corrosion treatment must be applied (refer to EO 05-1-3/23). To prevent entry of water into structure, negligible damage holes must be plugged.

3 For negligible damage specific to an aircraft, refer to applicable aircraft -3 EO.

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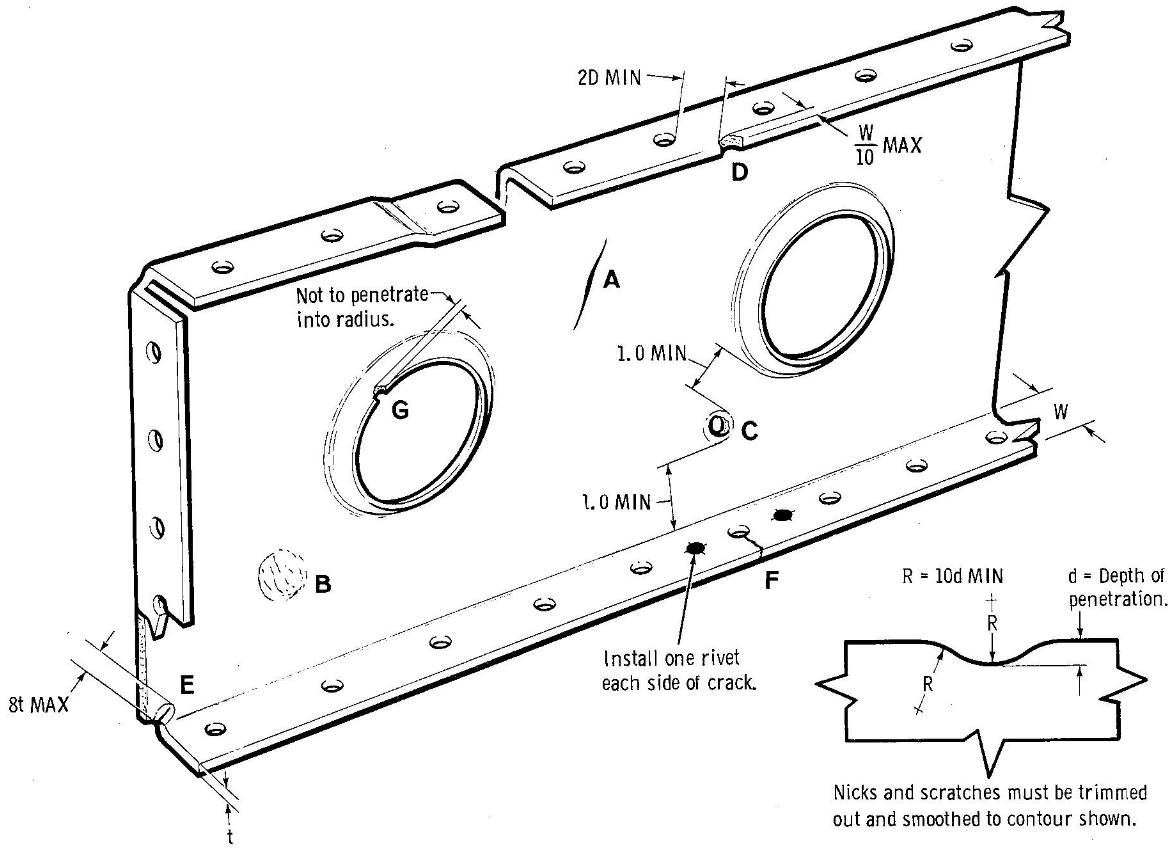
Figure 3 (Sheet 3 of 4) Negligible Damage Limits - Spars



A SCRATCHES - In material gauges up to 0.050 inch scratch depth not to exceed 10% of material thickness. In heavier gauges, not to exceed 5% of material thickness. Scratches must be away from attachment holes, stringer cut-outs and lightening holes.

B DENTS - In material gauges up to 0.050 inch depth of dents not to exceed thickness of material. In heavier gauges, not to exceed 1/2 thickness of material.

C HOLES OR PUNCTURES - Holes or punctures cleaned up to smooth shape not to exceed 1/2 inch in diameter, and must be at a minimum distance of 1.0 inch from attachments, radii, cut-outs and lightening holes.

D NICK IN FLANGE - Must not penetrate farther than 1/4 inch into flange, providing there is a minimum edge distance of 2 rivet diameters.

E CRACK IN CORNER - Maximum length 8 thicknesses of material after trimming. (See appropriate repair illustration for details of trimming.)

F CRACK FROM RIVET HOLE - Isolated crack only. Install one rivet on each side of crack, if spacing permits, otherwise a suitable repair is required.

G NICK IN LIGHTENING HOLE - Not permitted in primary structure. In secondary and tertiary structures the nick must not penetrate into bend radius after blending, and only one such damage per lightening hole.

NOTES

1 All dimensional limits apply to damage after it has been cleaned up to a smooth radius or stop drilled as applicable.

2 No reduction in section permitted where cross-section has already been reduced by drilling or trimming.

3 After damage has been cleaned out, anti-corrosion treatment must be applied. Refer to EO 05-1-3/23.

4 For negligible damage limits specific to an aircraft, refer to applicable aircraft -3 EO.

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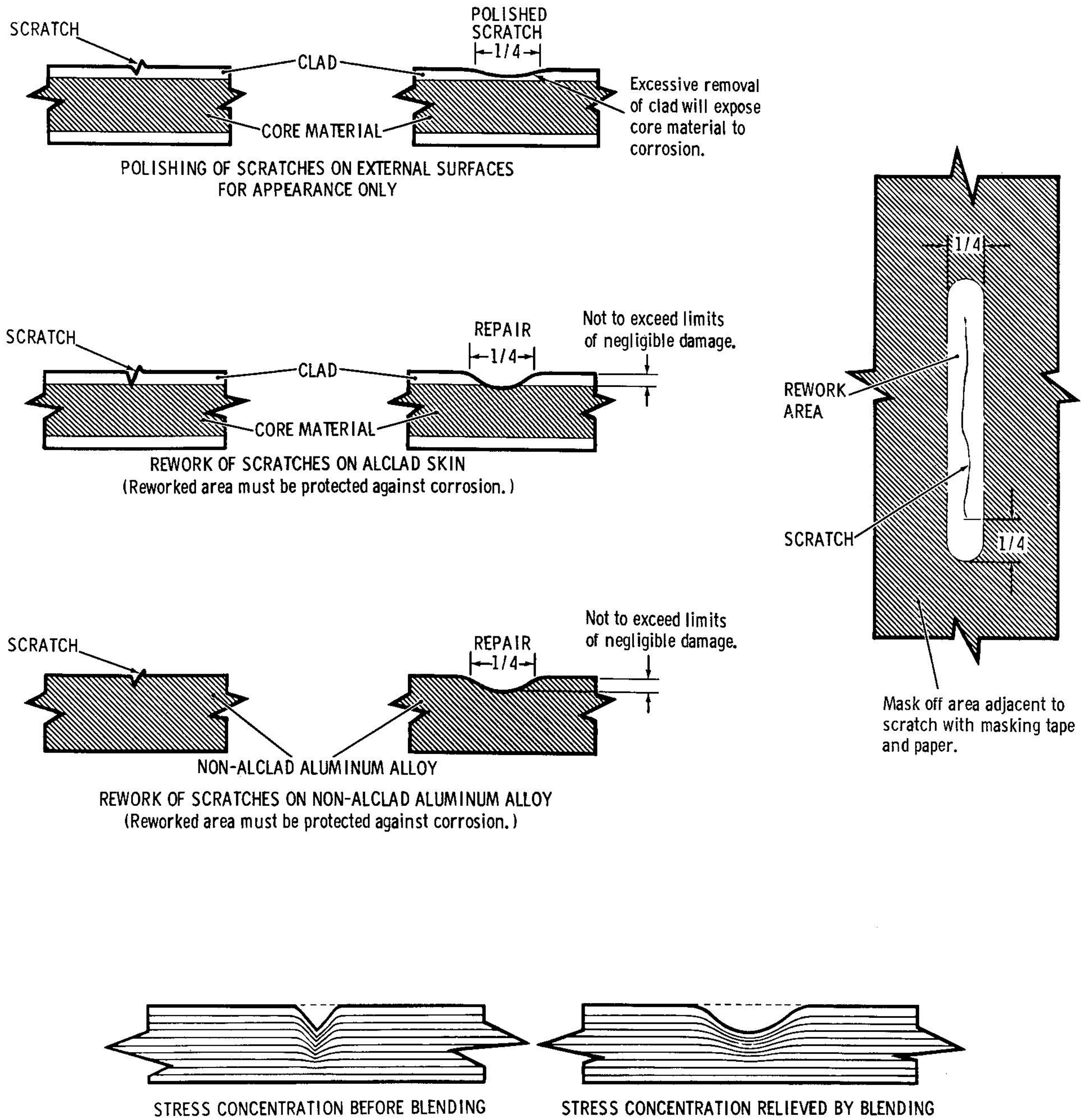
Figure 3 (Sheet 4 of 4) Negligible Damage Limits - Ribs and Frames



NOTES

1 Scratches exceeding limits of negligible damage must be considered as cracks.

2 All negligible limits apply to damage that has been cleaned out as shown.

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Figure 4 Polishing Scratches on Aluminum Alloys applicable aircraft -3 EO for specific limits of negligible damage to all structural components.

CAUTION

Any rework that causes sudden changes in cross-sectional area or thickness is not permitted in either primary or secondary structure owing to reduction of fatigue life.

SCRATCHES

71 Scratches are the most common type of damage and are detrimental, as the cross-sectional area of the member is reduced, producing a localized stress concentration which may lead to fatigue cracking. All scratches at the edge of a rivet pattern or at right angles to applied loads are especially dangerous.

72 All alclad materials furnished under Specification QQ-A-362 in gauges greater than or equal to 0.064 inch, have an average thickness of cladding on each side not less than 2% of the total thickness of the sheet. On gauges less than 0.064 inch, the average thickness of cladding on each side is not less than 4% of the total thickness of the sheet. All alclad material furnished under Specification QQ-A-287 in gauges greater than 0.064 inch or less than 0.187 inch, have an average thickness of cladding on each side not less than 2% of the total thickness of the sheet. On gauges less than 0.064 inch, the average thickness of cladding on each side is not less than 3-1/4% of the total thickness of the sheet. On gauges greater than 0.187 inch, the average thickness of cladding on each side is not less than 1-1/4% of the total thickness of the sheet. For method of determining if scratch has penetrated the cladding, refer to Paragraph 49, preceding.

NOTE

Burnishing of scratches (cold flow) is prohibited, as it will form pockets in which corrosion can begin.

POLISHING OUT SCRATCHES

73 Scratches on external surfaces which do not penetrate the cladding and show no signs of corrosion may, if desired to improve the appearance of the scratched area, be polished in the following manner: (See Figure 4.)

NOTE

Do not use steel wool for polishing out scratches on aluminum alloy, because dissimilar metals will cause corrosion.

(a) Using Durite paper No. 150 (Item 8, Figure 71), deburr the scratch by sanding against the scratch. Using the same grit paper, blend in the scratch by sanding in direction of the grain.

(b) The width of the sanded area must be approximately 1/4 inch.

(c) Using Durite papers Nos. 150, 320 and 500 (Item 8, Figure 71) in sequence, smooth the abraded area by rubbing in the direction of the grain. As the final sanding operation, feather the edges of the scratch repair area using Durite paper No. 500 (Item 8, Figure 71), rubbing in the direction of the grain.

(d) Wipe clean the sanded area using tissue paper (Item 9, Figure 71).

NOTE

All sanding operations must be carried out using Velocite Oil (Item 10, Figure 71) as a lubricant, and a felt block 1/4 x 2 x 4 inches applying even pressure and straight even strokes.

It is imperative that the depth of sanding be kept to the absolute minimum required to blend the scratch.

(e) Final polishing of the repaired aluminum surface must be done by finger buffing using Tripoli, Polish Compound (Item 11, Figure 71) as follows:

(1) Apply a smear of Tripoli (Item 11, Figure 71) to a dry cotton flannel cloth and wrap the cloth around the index finger with the soaked area on the outside.

(2) Rubbing in the direction of the grain, remove all previous abrasion marks from the scratched repair area. Circular motions should be avoided and the polished area should be held

to the scratch repair area. A small amount of Tripoli may be left on the scratch repair area for the next operation.

(f) Blend the scratch repair area as follows:

(1) Remove the glossy finish in the scratch repair area by rubbing with brown wrapping paper saturated with Velocite oil (Item 10, Figure 71) in the direction of the grain until a satin finish appears. Remove the oil with tissue paper (Item 9, Figure 71).

(2) Apply a thin film of aluminum metal polish (Item 12, Figure 71) to the scratch repair area. Using a folded pad of tissue paper (Item 9, Figure 71), rub the polish on the metal until the repair area appears to have a high lustre.

(3) Remove the masking paper and remove any residue left by the masking tape using soft cotton flannel dampened with dry cleaning solvent. Rub very lightly in the direction of the grain.

(g) Apply protective coating to the repaired area as follows:

(1) If a scratch is repaired on an unpainted clad surface, apply a 5% solution by weight of chromic acid (Item 4, Figure 71) to the scratch repair area. Within 10 minutes thoroughly rinse the area with cold water.

(2) If a scratch is repaired on a painted clad surface, apply a chemical film protection in accordance with EO 05-1-3/20 and /23. Touch-up with paint as required.

(3) If a scratch is repaired on an anodized, iridited or painted surface of non-clad aluminum alloy, apply a chemical film protection in accordance with EO 05-1-3/20 and /23. Touch-up with paint as required.

BLENDING OUT SCRATCHES

74 Scratches which have penetrated the cladding and scratches on non-clad aluminum alloy are not considered negligible damage until after they have been blended out. The length and depth of scratches after blending must not exceed negligible damage limits. Limitations regarding the length and depth of scratches and nicks vary in different locations throughout the aircraft. In certain highly stressed areas it is necessary to use a dye penetrant check after blending to reveal any cracks which may be undetected. Nicks and scratches exceeding limits of negligible damage must be treated as cracks and repaired accordingly.

75 Rework the scratches which have penetrated the cladding or scratches on non-clad aluminum alloy as follows: (See Figure 4.)

(a) Before commencing sanding, mask off the area immediately adjacent to the scratch using masking tape and brown paper. Leave a working area of approximately 1/4 inch wide with the scratch in the centre and 1/4 inch longer than the length of the scratch.

(b) Using Durite paper No. 100 (Item 8, Figure 71), deburr the scratch by sanding against the scratch. Using the same grit paper, blend in the scratch by sanding in the direction of the grain.

(c) The width of the sanded area must be approximately 1/4 inch.

(d) Continue polishing operation as in Paragraph 73(c) to (g) inclusive, preceding.

NICKS

76 This type of damage is similar to scratches except that the direction of failure has not been established. A nick not located near an edge, radius, fillet or hole and if sharp edges are faired out, has an effect similar to the cross-sectional loss of a bolt or rivet hole. The treatment of nicks is similar to that of scratches.

DENTS

77 When a dent is formed the overall cross-sectional area is not affected as the metal is merely relocated. Dents may decrease the aerodynamic efficiency or the flow of gases, cause misalignment or interference with other parts and reduce the strength, especially under compression loads. Internal structure along load paths must be investigated for possible transmitted damage, especially where the damaged part is heavy gauge.

78 Small dents, if free from cracks and abrasions, may be left in existing state. Dents with signs of cracking and with smaller radii than five thicknesses of material must be considered as punctures and treated accordingly.

79 Large radius dents, in 24S-T skins or formed sheet members may be dressed to the correct profile, using a mallet and a block of soft wood, after adjacent rivets have been removed. Straightened dents must be checked with a magnifying glass for possible damage to the material. See Figure 3, for limitations of maximum damage. Bumping out dents in 75S-T or magnesium alloy parts should not be attempted. Dents in extrusions, which distort the opposite face, should be treated as holes.

CRACKS

80 This type of damage reduces the cross-sectional area and terminates at a point of zero radius. Cracks are especially dangerous as they always originate at edges, holes, radii, points where concentrated loads are applied or where the cross-sectional area changes. This already constitutes a partial failure at these points. The farther the crack progresses the greater the stress concentration at the terminal point, and the more progress of cracking with the same load.

81 Damage of this nature must never be left without rework. Retarding measures, such as stop drilling (see Figure 21, Sheet 4) or fairing, must be employed. Where the end of a crack cannot be readily established, or where the structure is suspected to be cracked, use the methods described in Paragraphs 53 to 59 inclusive, preceding, to ascertain the extent of damage. Stop drilled cracks should be inspected frequently for possible spreading beyond negligible limits.

82 Cracks in welds must be dressed until an unbroken metallic surface is obtained. If the crack has penetrated the component the part must be stop drilled.

HOLES

83 Holes reduce the cross-sectional area of a part and create areas of elevated stress and also interfere with the normal function of air or liquid-tight installation. A hole of a diameter not larger than that of existing bolt or rivet holes in the area may be considered negligible, but the following limitations will apply. The distance from edges, radii or fillet not less than twice the diameter of the hole and four times the diameter from any other hole and when combined with another hole the cross-sectional area must not be less than the permissible minimum.

84 All holes must be dressed to a regular shape, circular being preferable. Rough edges and sharp corners must be dressed into smooth curves and the hole edges must be slightly rounded. To maintain pressure tightness and to prevent entry of water into structure, negligible damage holes must be plugged as illustrated in Figure 5.

85 For patching small holes in non-stressed skin areas, Tinnerman Patch Plates (see Figure 6) may be used. These patches may also be used as inspection hole covers or for sealing holes after removal of equipment for modification. Repairs to skin using Tinnerman patches are temporary, and these patches should be replaced by approved repairs at the earliest opportunity.

86 If it is necessary to plug a hole, which is within limits of negligible damage, with a doped fabric patch, see Figure 7.

CHIPPED EDGES

87 Chipped edges reduce the cross-sectional area of the part and when near attachment holes of fittings can be dangerous. This type of damage must always be reworked, if within negligible limits, by blending or fairing the rough edges to a smooth surfaced depression. Care must be exercised that the blended area is free from cracks.

BUCKLING AND BOWING

88 Skins, webs, struts and tubes are susceptible to buckling and bowing damage. In all cases the internal structure, along the load paths, must be investigated for possible transmission of damage. A decrease in aerodynamic efficiency, misalignment or interference with other parts and a reduction in strength especially under compression loads are the

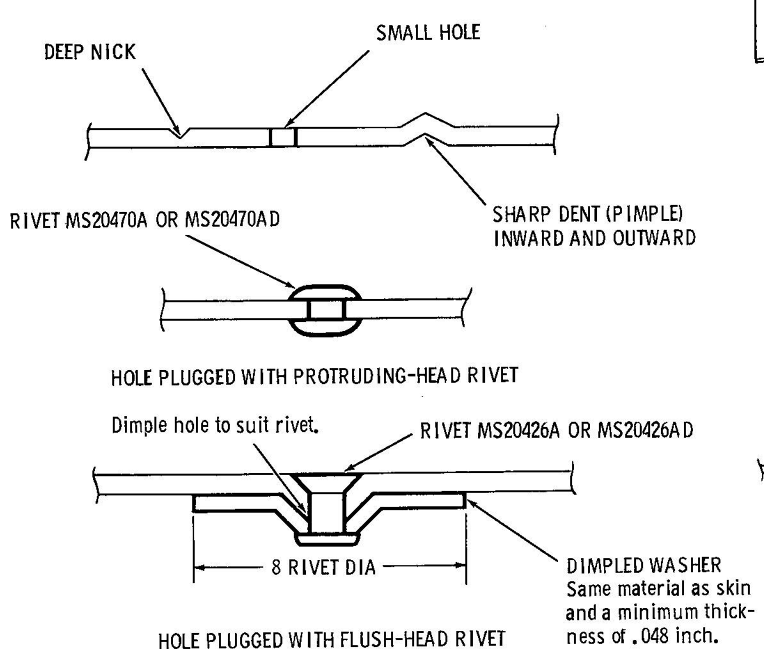
PLUGGING SMALL HOLES WITH RIVETS

To prevent entry of water into structure or leakage in pressurized section of fuselage, small punctures, deep nicks and sharp dents (pimples) drilled out, in isolated cases only, may be permanently plugged by installation of appropriate size rivet. See Table for maximum diameter of plugging rivet.

MATERIAL THICKNESS	MAXIMUM DIAMETER OF PLUGGING RIVET
UP TO .022	APPLY PATCH REPAIR
.025 TO .032	1/8
.036 TO .056	5/32
.063 AND OVER	3/16

NOTE

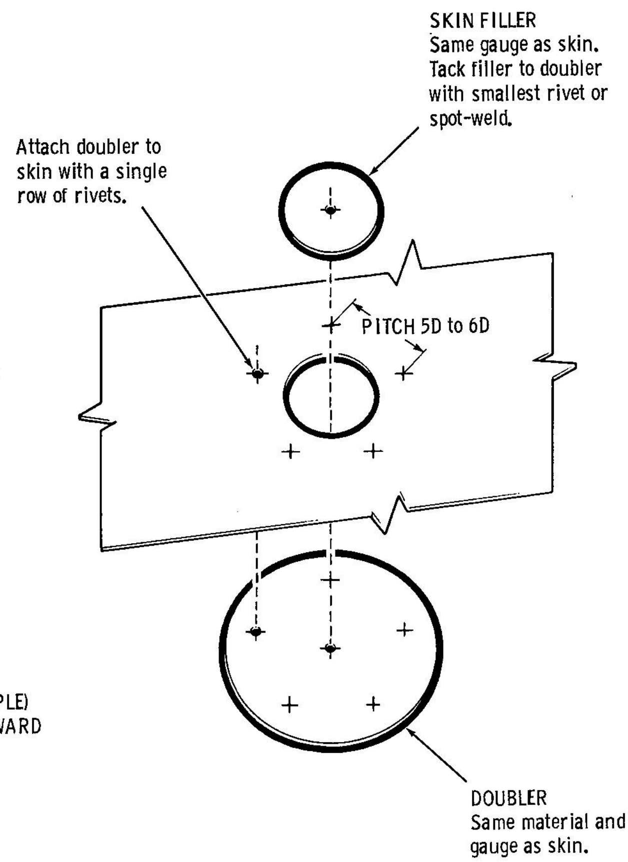
Larger holes than those listed in the Table and within limits of negligible damage, may be covered with fabric patch or Tinnerman plates as a temporary measure. Permanent plugging with a doubler and skin filler as illustrated in Detail B, must be done at the earliest opportunity.

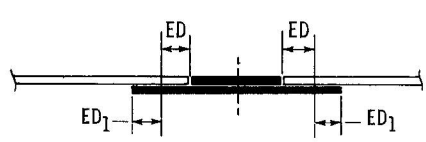


A

PLUGGING NEGLIGIBLE DAMAGE HOLES WITH SKIN FILLER AND DOUBLER

Cleaned-up larger holes within limits of negligible damage must be permanently plugged using a doubler and skin filler of the same material and gauge as damaged skin. Install doubler and skin filler as illustrated.





NOTE

For edge distance ED and ED_1, see Illustration: Edge Distance and Rivet Spacing.

B

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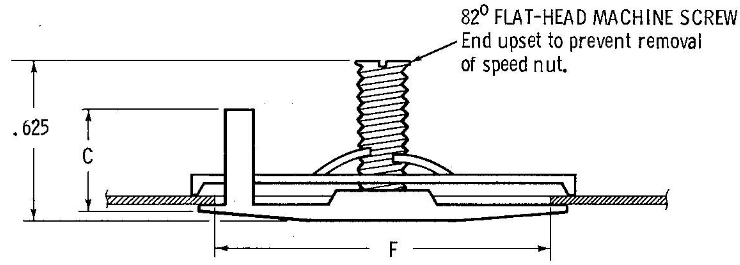
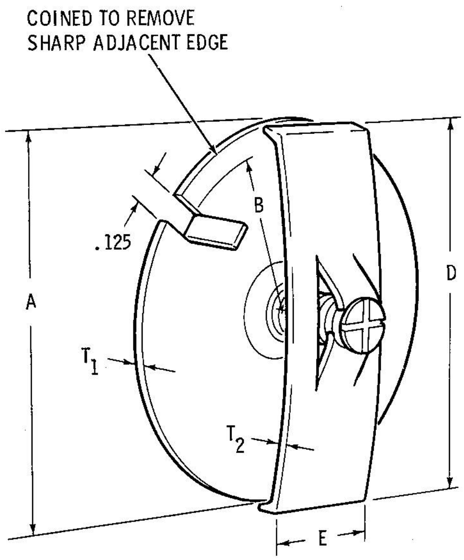
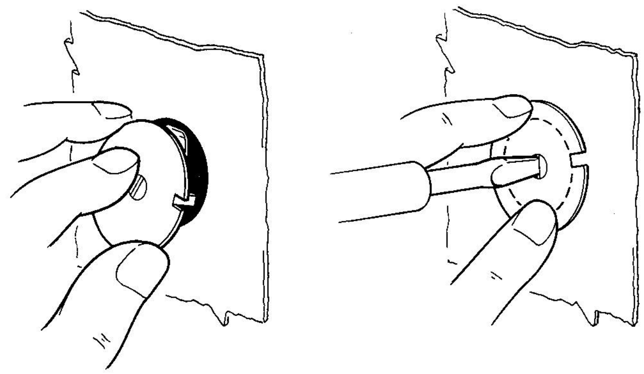
Figure 5 Plugging Holes Within Limits of Negligible Damage





TINNERMAN PATCH PLATE

Material: Special aircraft spring steel, heat-treated, unless otherwise specified.
Finish : See page on Finishes, Engineering Data Section.



INSTALLATION

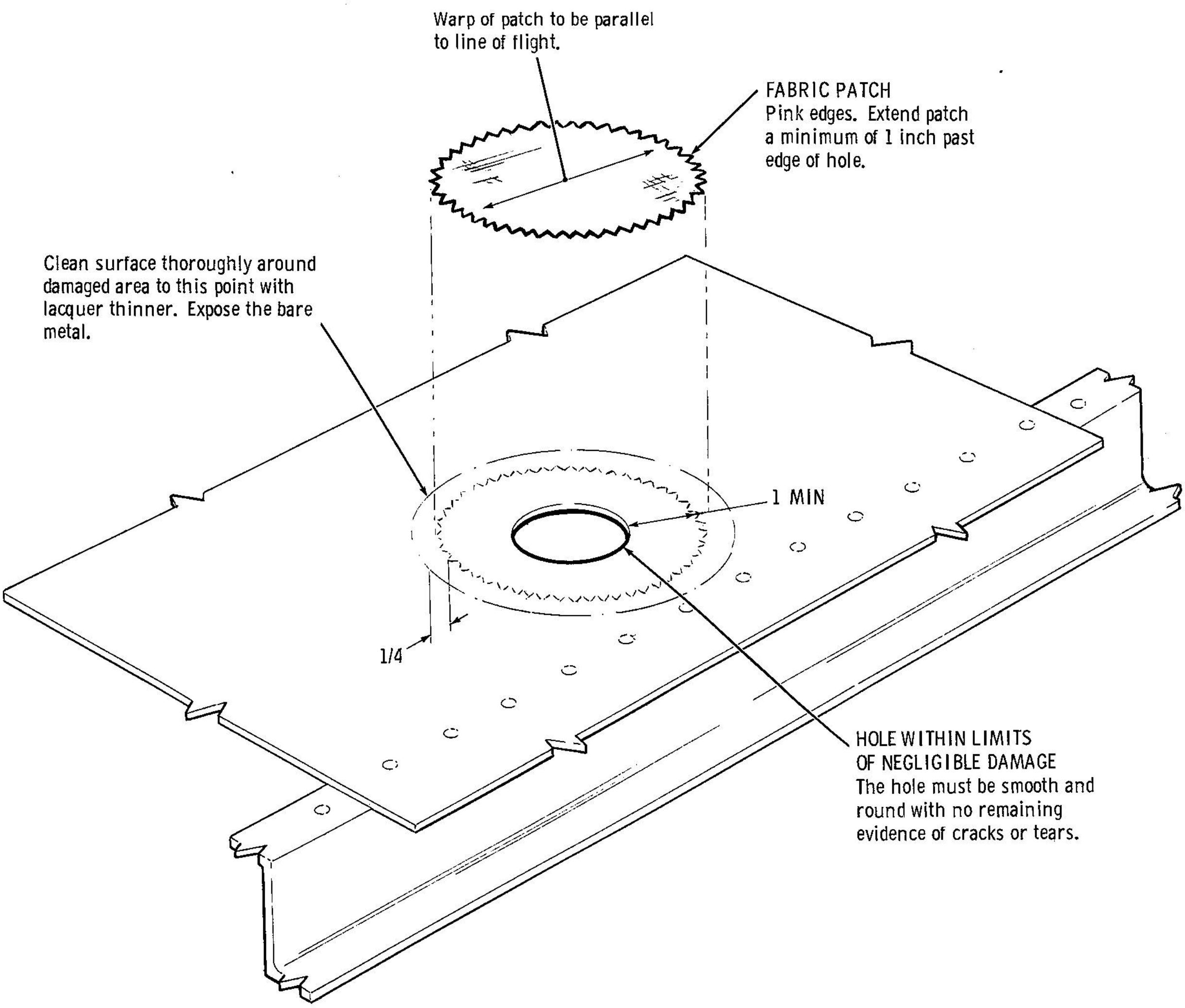
NOTE

Tinnerman patch plates were approved for covering bullet holes in the skin of aircraft. However, they may be used with equal success as inspection hole covers or for sealing holes left after removal of equipment at modification centres, change of design, etc. Complete installation is made from one side, and the coined edge of the washer prevents scratching of alclad surfaces.

PART NO.	SCREW SIZE	F HOLE DIAMETER IN SKIN	A	B	C	D	E	T_1	T_2	WEIGHT LBS PER 1000
A6912-832-1	8-32	.906	1.062	.406	.437	1.062	.500	.020	.017	11.20
A6913-1024-1	10-24	1.125	1.312	.531	.437	1.312	.500	.022	.022	16.85
A6914-1024-1	10-24	1.687	1.687	.718	.437	1.687	.625	.025	.022	25.70

13-24-108

Figure 6 Tinnerman Patch Plates



STEPS

1 Paint surface about damaged area with a heavy coat of nitrate dope.

2 Saturate patch with dope, apply over hole and smooth flat.

3 Apply 4 or 5 coats of dope over patch, allowing dope to dry between each application. Smooth the surface between each coat with fine sandpaper.

NOTE

Dope must overlap patch at least 1/4 inch to prevent edge from curling

4 When last coat is dry and patch is drawn tight, apply finish lacquer to match adjacent paint.

NOTE

Fabric patch repairs are subject to the following limitations:

(a) Patch applied only to prevent entry of water into structure.

(b) Cleaned-up damage must be within limits of negligible damage as defined for each type of aircraft. Refer to applicable aircraft -3 EO.

(c) Permanent repair must be made at the earliest opportunity.

13-24-89

Figure 7 Negligible Damage Holes - Temporary Fabric Patch main factors of this kind of damage. Any damage, outside the negligible limits, will necessitate repair or replacement of the affected parts.

CORROSION

89 When damage is a result of corrosion, the corroded metal must be cleaned or cut away, before assessing the damage. Steps must be taken to ascertain the cause and to prevent its recurrence. For methods of treating corrosion, refer to EO 05-1-3/23 and EO 05-1-2AH.

REPAIR INSTRUCTIONS

GENERAL

90 The primary consideration in planning repairs is the restoration of the part to its original strength. Secondary considerations are aerodynamic cleanness (where applicable), and weight control. 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. Repair illustrations included in this EO show typical repairs to damage in various parts of the 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. Where damage involves several structural parts (e.g., skin, stiffener and rib), single repair figures adapted to the particular location and dimensions, and carried in proper sequence should be an adequate solution to a complex damage. General structural repair data given in EO 05-1-3 Series must be used, where applicable, in conjunction with the typical repairs.

REQUIREMENTS OF REPAIR

91 A repair must meet the following requirements:

(a) The repaired structure must be equal to, or greater in strength than the original. Repairs of fatigue type failures especially should be stronger than the original to preclude the possibility of recurrence.

(b) The repaired structure must perform its special function, such as fuel or air tightness.

(c) If external, it must conform as nearly as possible to the original aerodynamic shape. If a supporting member, the rigging of the involved parts must conform to specifications.

(d) It must not interfere with or restrict the operation of any moving part.

(e) Normal precautions against corrosion must be carried out such as priming of faying surfaces and insulating dissimilar metals.

CAUTION

Remember that an overstrength repair is usually harmless; an understrength repair can be disastrous.

CONTROL OF DRAG IN REPAIRS

92 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.

93 When planning a repair on any part of the aircraft exposed to the airflow, keep any drag increase to the lowest possible level. Figure 8 shows some comparisons and proportions of drag caused by air leakage, protruding drain pipes and non-flush patches.

CONTROL OF WEIGHT IN REPAIRS

94 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 imbalance.

95 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 9). Lead washers are a convenient means of adding the required weight, and should be added as near as possible to the plane of the repair. For a method of measuring static imbalance of control surfaces, refer to EO 05-1-3/18.

SUPPORT OF STRUCTURE DURING REPAIR

96 Damaged structural assemblies and components must be returned to their original contour and relative position during repair operations. Therefore, before any structural member which is essential to the rigidity of the complete structure is removed, or before any attempt is made to clean out or restore damaged area, the structure should be supported so that the component or area to be removed or repaired is relieved of its load.

97 It is often helpful to install a control surface or other stabilizing device on a temporary basis while the structural repair is in progress. It will aid in the alignment of parts being repaired or replaced and may also reveal unnoticed damage.

PROVISION OF ACCESS FOR REPAIR

98 To carry out repairs in certain areas, it may be necessary or desirable to release an area of skin plating, or to provide an access hole in the skin or web. The method of releasing the existing skin joints and bending back the skin should be practised wherever possible. Care must be taken to prevent skin from buckling or kinking, and when the released skin is installed the rivets and attachments must be the same as originally used. Cutting out an access hole in skin or web should be avoided unless it is absolutely necessary. Where an access hole must be made, it should be of the smallest possible size and, after use, must be closed by suitable repair scheme. The various detachable panels and doors which may be used to gain access to the interior of the aircraft are detailed in the applicable aircraft -2 EO.

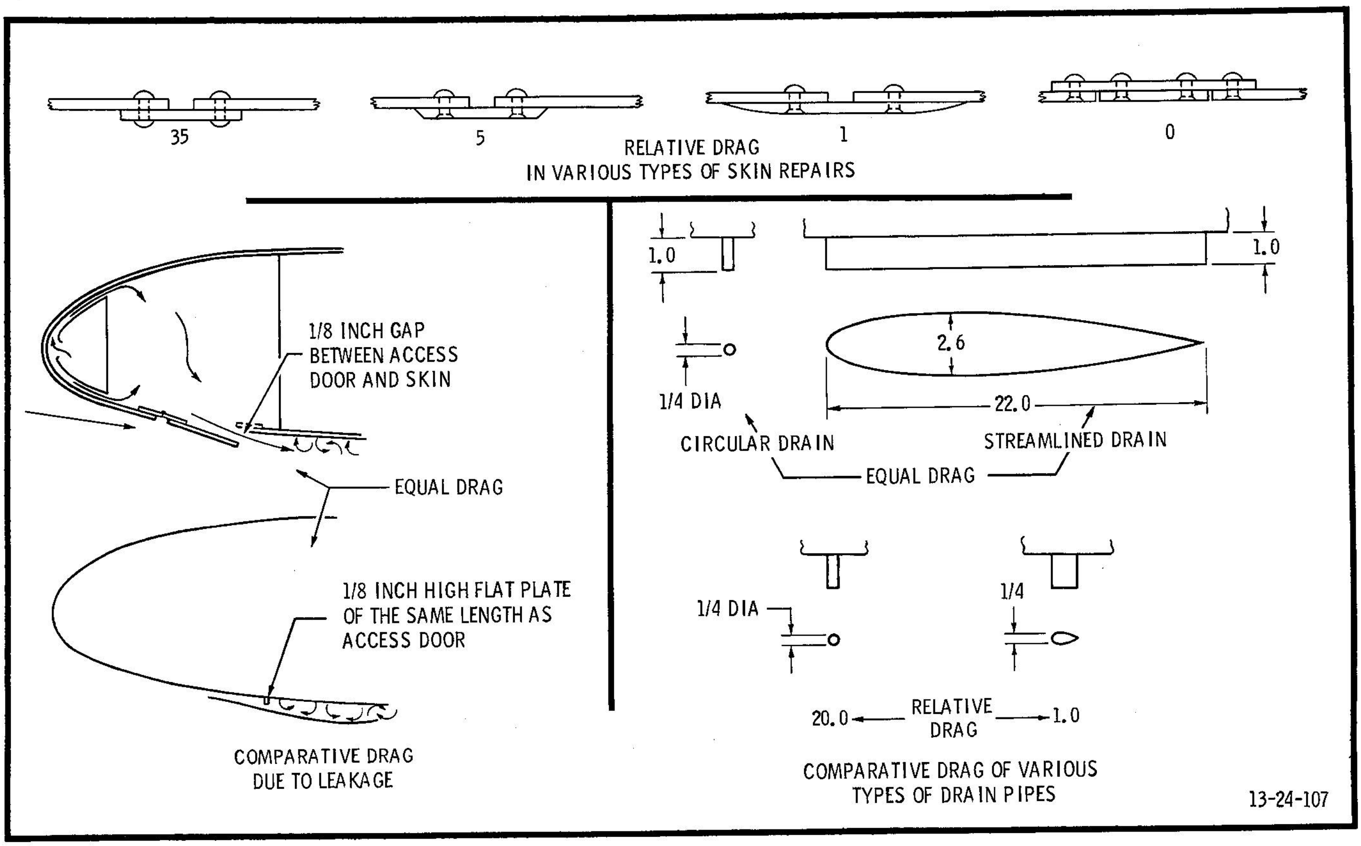
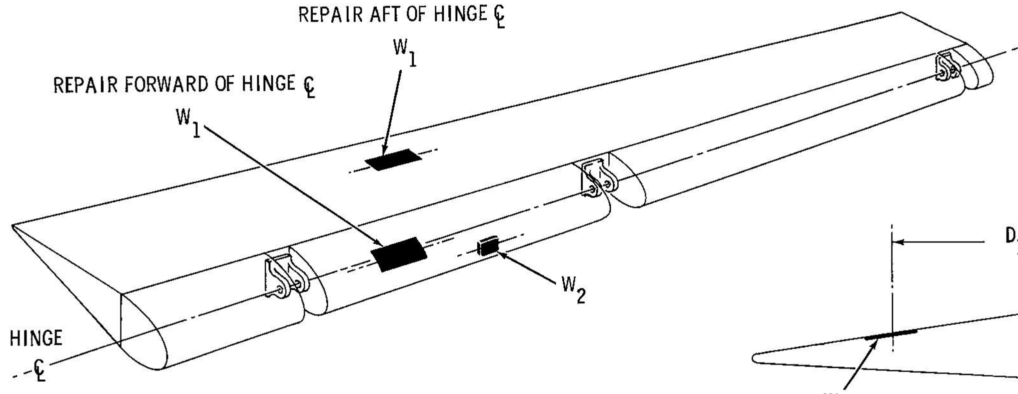
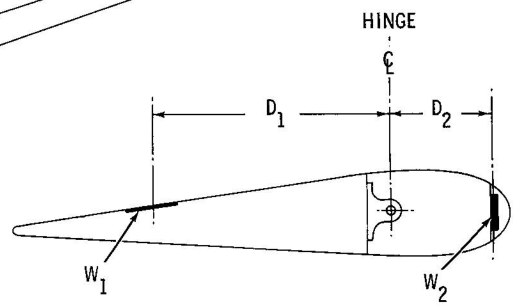
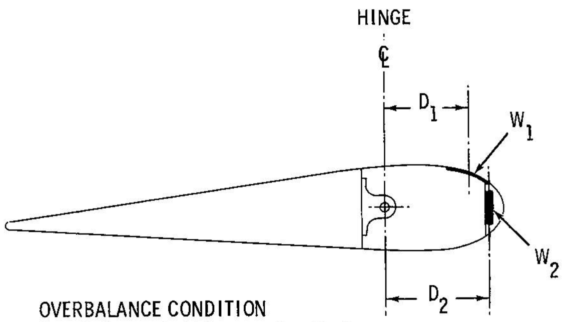


Figure 8 Comparative Drag Types





UNDERBALANCE CONDITION
(Repair aft of hinge centre-line)



OVERBALANCE CONDITION
(Repair forward of hinge centre-line)

EFFECT OF REPAIR ON CONTROL SURFACES

To determine effect of repair on control surface, multiply W_1 (weight) by D_1 (distance).

EXAMPLE : $W_1 = 0.5$ pound
$D_1 = 12$ inches

Effect of repair would be :
0.5 pound x 12 inches = 6 inch-pounds

NOTE

When the effect of repair causes overbalance, use the same equation as for underbalance in which W_2 will be the amount of weight to be removed from the existing balance weight.

CORRECTION OF BALANCE

When the effect of repair causes underbalance, use the following equation to determine the weight required for rebalancing :

$$W_2 = \frac{W_1 \times D_1}{D_2}$$

EXAMPLE : $W_1 = 0.5$ pound
$D_1 = 12$ inches
$D_2 = 4$ inches

$$W_2 = \frac{0.5 \times 12}{4} = 1.5$$ pounds required to balance control surface.

LEGEND

D_1 = Distance in inches from centre of gravity of repair to hinge centre-line.

D_2 = Distance in inches from centre of gravity of rebalancing weight to hinge centre-line.

W_1 = Net weight of repair materials (gross weight of added repair materials minus weight of damaged material removed).

W_2 = Required weight for rebalancing control surface. (See Note.)

13-24-106

Figure 9 Mathematical Balance Check of Flight Control Surfaces

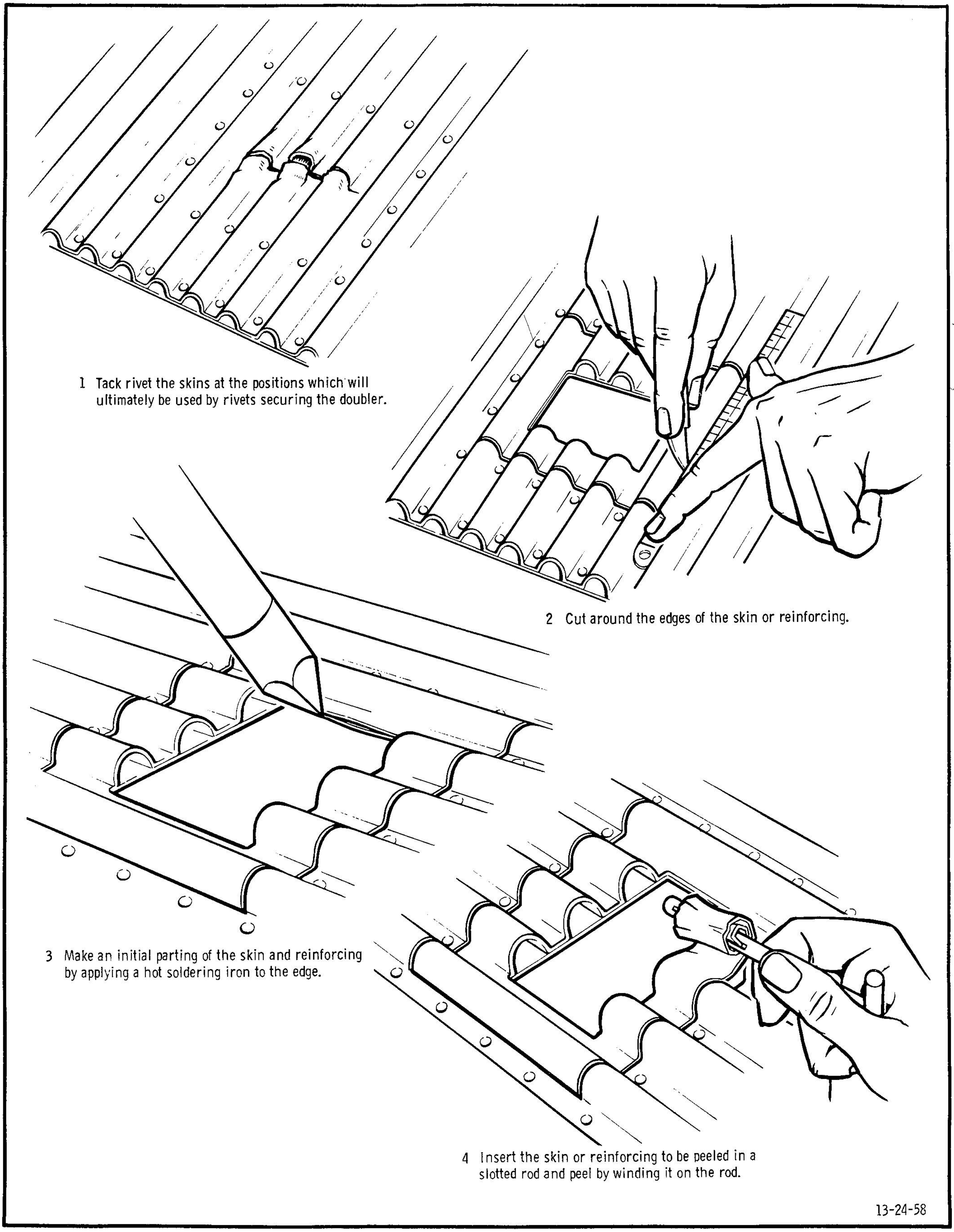


Figure 10 Method of Peeling Resin-bonded Parts

CLEANING UP DAMAGE

99 All damage must be cleaned up to a regular contour, circular shape being preferable for small damage, leaving a clean hole bounded by undamaged material. Any damage cleaned out to a rectangular shape must have a minimum radius of 1/2 inch at corners, and the contour must be parallel to existing edges. When cutting out damage in skin attached to substructure, use suitable shields to protect the adjacent structure. When trimming riveted members cut back damage to midway between original fasteners. If repair members are clamped together during drilling, disassemble and remove drill swarf.

100 All cracks must be stop drilled as detailed in Figure 21, Sheet 4. Make certain that the drill hole engages the extremity of the crack. Cracks in 75S-T alloy and titanium should, if possible, be removed by cutting out material with a generous radius in preference to stop drilling.

PEELING OF RESIN-BONDED PARTS

101 Where damage occurs to either a resin-bonded skin or skin reinforcement, it may be necessary to peel a limited area of one bonded part away from the other outside the area of damage as shown in Figure 10. To eliminate the possibility of excessive peeling, the skin and reinforcement must be tack-riveted at positions which will ultimately be used by rivets securing the patch. Where possible the tack rivets must be one size smaller in diameter than those used for the repair. Cut the portion of skin or reinforcement to a depth not exceeding its thickness.

PROTECTION OF ADJACENT PARTS

102 All equipment, pipes, ducts, cables, insulation, etc, in the vicinity of the damaged area must be removed or adequately protected to avoid damage during the execution of repair. For detailed information on removal and installation of components, refer to applicable aircraft -2 EO.

DRAINAGE HOLES AND AIR FLOW PASSAGES

103 Drainage holes provided in the structure, which is apt to accumulate liquids, must not be obstructed by any material added in making the repair. If this has happened the drainage holes must be continued through the additional material, providing this will not cause structural weakness; alternatively new drainage holes should be cut as near as possible to the original positions. The efficiency of all drainage in a repaired component must be checked during work on the repair. Furthermore, if drainage holes or air flow passages were present in any part of the airframe which has been removed, they must be duplicated in the replacement part.

MACHINED PARTS AND FITTINGS

104 Machined parts and fittings must not be repaired except for blending out negligible damage. Location of fittings, hinges and brackets must not be changed by the repair. If it is necessary to remove a fitting, bracket or hinge that may interfere with the repair, correct dimensions of the original position must be taken to prevent mislocation of the part during installation.

PROTECTIVE TREATMENT

105 Ensure that the parts that will become hidden during the repair operation have had the appropriate protective treatment applied. When carrying out a repair, care must be taken to prevent damage to existing protective coatings. If existing protective film does become damaged, the affected area should be cleaned and a new coating applied. For information on protective treatments, refer to EO 05-1-3/23.

SEALING AFTER REPAIR

106 Repairs to integral fuel tank areas in the wing structure and fuselage pressurized areas will require structural sealing of all faying surfaces, joints, crevices and voids. For information on sealing after repair and repair to existing defective sealing, refer to applicable aircraft -2 or -3 EO and EO 05-1-3/15.

REPAIR MATERIALS

GENERAL

107 The basic materials used in the construction and to be considered for repair of the aircraft are 24S-T and 75S-T aluminum alloys. With the exception of extrusions, fittings and

forgings, only alclad material is used. Where their special characteristics are required, other materials such as corrosion-resistant steel, magnesium alloys and titanium may also be used. For detailed information on heat-treatment, forming, machining, etc, of aluminum alloys, refer to EO 105-10-1 and EO 05-1-3/20. For information on titanium and other metals, refer to EO 05-1-3/20.

WROUGHT ALUMINUM ALLOYS

108 Wrought aluminum alloys in this manual are designated by the code of Aluminum Co. of Canada (Alcan). For conversion table of Alcan alloy to Alcoa alloy designations, refer to EO 05-1-3/3.

SELECTION OF MATERIAL FOR REPAIR

109 It is desirable to use repair material of the same type and heat-treatment as the original part. The material of original parts, its heat-treatment and thickness are listed in structural illustrations of applicable aircraft -3 EO.

110 All 24S and 75S repair materials are to be in the hard condition when repair is completed. The selection of material for repair with respect to its shape and heat-treatment temper, will depend on the amount and severity of the forming involved, as follows:

(a) Where forming can be done in the T condition, complying with the bend radii given in EO 05-1-3/25, use 24S in the T3 and 75S in the T6 conditions. This will be the usual procedure and the temper after forming remains the same.

(b) When forming is severe and not possible in the T condition:

(1) Use 24S-0 material solution heat-treat and quench. Form within 20 minutes. Natural age-hardening follows and the temper is then known as T4.

(2) Use 75S-0 material, solution heat-treat and quench. Form within one hour. Artificially age-harden. Temper is then known as T6.

NOTE

The natural hardening process may be arrested by refrigeration at -15° to -34°C (5° to -30°F) immediately after quenching. The period of time during which the material can be worked will commence on removal from refrigeration.

(c) When forming is not possible in the T condition and cannot be completed within the time periods of 20 minutes for 24S and one hour for 75S proceed as follows:

(1) Use 24S-0 material and form in this condition. Solution heat-treatment and quench. Parts may be warped after quenching so that a small amount of straightening may be required before assembling parts on the aircraft. The temper will become T4.

(2) Use 75S-0 and form in this condition. Solution heat-treat and quench. Artificially age-harden and assemble. The temper will be T6.

CAUTION

If a repair member made from 24S material heat-treated and quenched, as in (b)(1) and (c)(1), is assembled on an aircraft primary structure, the four-day period of natural age-hardening must elapse before aircraft may fly.

111 Where forming or straightening of 24S-T3 and 75S-T6 alloys is required in the solution heat-treated and fully aged condition, and the degree of forming or straightening causes cracking at room temperature, the operation may be done at an elevated temperature without effecting heat-treatment properties.

112 Material may be heated in linseed oil bath, in air furnace, through contact with hot table or heated dies and tools. The temperature must be rigidly controlled by use of Tempil-sticks or pyrometers. The materials should be heated to the following temperatures:

24S-T3 alloy: 135° to 163°C (275° to 325°F)

75S-T6 alloy: 121° to 149°C (250° to 300°F)

113 The time at these temperatures is cumulative and must not exceed a total of one hour for all operations. For minimum bend radii in these conditions, refer to EO 05-1-3/25 column marked Bent Hot.

114 Forming of aluminum alloy in the 0 (annealed) condition with subsequent heat-treatment should be avoided, if possible, because of distortion during quenching.

115 Reheat-treatment of clad alloys should also be avoided because the core alloying elements tend to diffuse into the cladding, thereby reducing its resistance to corrosion, (e.g., do not anneal T3 to the 0 condition for subsequent reheat-treatment to the T4 condition).

116 Quenching must be done as rapidly as possible after removal from oven or saltbath. The time being dependent on sheet thickness in inches as follows:

Up to 0.031	5 seconds maximum
0.032 to 0.039	7 seconds maximum
0.040 and over	10 seconds maximum

117 Parts heat-treated in salt bath must be washed well and dried. Anti-corrosion treatment must be applied before assembly.

CAUTION

Never heat-treat assembled parts as the salt will penetrate into crevices and between contacting surfaces and will cause severe corrosion.

MATERIAL SUBSTITUTION

118 Substitution of original material by alternate materials should be strongly discouraged and every effort should be made to procure the correct material for repair. When substitutions are unavoidable, stronger materials may be substituted for weaker ones using the same cross-sectional area. Weaker materials may be substituted for stronger ones, providing that the cross-sectional area is increased by the factor shown in Figure 11 and that such substitution will not interfere with any function of the repaired part or change the aerodynamic efficiency of the aircraft.

119 Consideration should be given to the maximum structural temperature in the region and to the wide range of temperature in the normal course of operation. Substitute material with a different coefficient of expansion may cause structural failure owing to abnormal thermal stresses. Consideration should also be given when material substitution causes dissimilar metals to be in contact. Protection should be made to prevent electrolitic action when the potential difference of metals is large. (Refer to EO 05-1-3/23.)

PROTECTION OF REPAIR MATERIAL AGAINST CORROSION

120 All repair parts and surrounding area affected by cleaning must be suitably treated against corrosion (refer to EO 05-1-3/23), and have the original finish restored in accordance with EO 05-1-3/20. In most cases two coats of zinc chromate primer (Item 13, Figure 71) applied to each surface will furnish sufficient protection for doublers and similar non-exposed repair parts.

STANDARD SHEET METAL GAUGES

121 The services and aircraft industry have introduced a new standard for sheet metal gauges. To facilitate interchangeability, the old and new standard sheet metal gauges for aluminum, magnesium and steel are shown in Figure 12.

RIVET AND BOLT INSTALLATION

GENERAL

122 It is desirable to use the same rivets for repair as employed in manufacture of the part. However, this is not always possible and the rivets used will depend on their availability, repair accessibility and riveting tools available. Rivet types and designation, riveting and inspection procedures are detailed in EO 05-1-3/5 to which reference must be made. In typical repairs solid shank rivets of the following materials are used:

(a) B Rivets: Material 56S-F magnesium alloy, non-heat treatable. Used only in non-stressed locations for attachment of magnesium to magnesium and magnesium to aluminum alloy.

(b) AD Rivets: Material A17S-T3, heat-treated. Driven in as-received condition. Most commonly used rivets are 3/32, 1/8 and 5/32 inch diameters.

ORIGINAL MATERIAL	SUBSTITUTE											
	24S			26S		75S		CRS		CRS	TITANIUM	
	T3	T4		T6		T6		301		321 or 347	AMS	
	Clad	Clad	Extr	Clad	Extr	Clad	Extr	1/4H	1/2H	Ann-ealed	4900	4901
65S-T4 Sheet	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
65S-T6 Sheet	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
65S-T6 Extruded	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
24S-T4 Clad	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
24S-T4 Extruded	1.00	1.02	1.00	1.00	1.00	1.00	1.00					
24S-T3 Clad	1.00	1.07	1.06	1.00	1.00	1.00	1.00					
26S-T6 Extruded	1.00	1.07	1.06	1.00	1.00	1.00	1.00					
26S-T6 Clad	1.12	1.20	1.18	1.00	1.12	1.00	1.00					
75S-T6 Clad	1.20	1.29	1.26	1.08	1.20	1.00	1.00					
75S-T6 Extruded	1.30	1.40	1.37	1.18	1.30	1.09	1.00					
CRS 302 1/4H								1.00	1.00			
CRS 301 1/4H								1.00	1.00	2.50		1.41
CRS 301 1/2H								1.20	1.00			
TITANIUM AMS 4900								1.00	1.00	1.33	1.00	1.00
TITANIUM AMS 4901								1.00	1.00	1.78	1.33	1.00

To find the minimum thickness of substitute, proceed as follows:

(1) Locate the horizontal row containing the symbol of the original material.

(2) Locate the vertical column containing the symbol of the substitute.

(3) Multiply the thickness of the original material by the factor found at the intersection of row and column found by steps (1) and (2).

EXAMPLE:		
	Original material	75S-T6 Clad
	Substitute	24S-T4 Clad
	Substitution factor	1.29
	Thickness of original material	0.032 inch
	Thickness of substitute	0.032 x 1.29 = 0.0413 Use 0.045 inch thickness

Figure 11 Table of Material Substitution Factors

Aluminum and Magnesium Standards		Steel Standards	
Old	New	Old	New
	0.006	0.010	0.010
	0.008	0.012	0.012
0.010	0.010	0.016	0.016
0.012	0.012	0.018	0.018
0.016	0.016	0.020	0.020
	0.018	0.025	0.025
0.020	0.020	0.028	0.028
	0.022	0.032	0.032
0.025	0.025	0.035	0.036
	0.028	0.036	0.036
0.032	0.032	0.040	0.040
	0.036	0.042*	0.040
0.040	0.040	0.045	0.045
	0.045	0.050	0.050
0.051	0.050	0.060	0.060
	0.056	0.063	0.063
0.064	0.063	0.065*	0.063
0.072	0.071	0.071	0.071
0.081	0.080	0.078	0.080
0.091	0.090	0.080	0.080
0.102*	0.100	0.083*	0.080
	0.112	0.090	0.090
0.125	0.125	0.093*	0.090
	0.140	0.094*	0.090
0.156	0.160	0.100	0.100
	0.180	0.109	0.112
0.188	0.190	0.112	0.112
	0.200	0.125	0.125
	0.244	0.156	0.160
		0.187	0.190

NOTE

Reading across, thicknesses may be interchanged except as noted. *Thicker material may be substituted for thinner, but substitution of thinner for heavier material must be approved by Chief Technical Services Officer (CTSO) or his delegated representative.

Figure 12 Table of Standard Sheet Metal Gauges

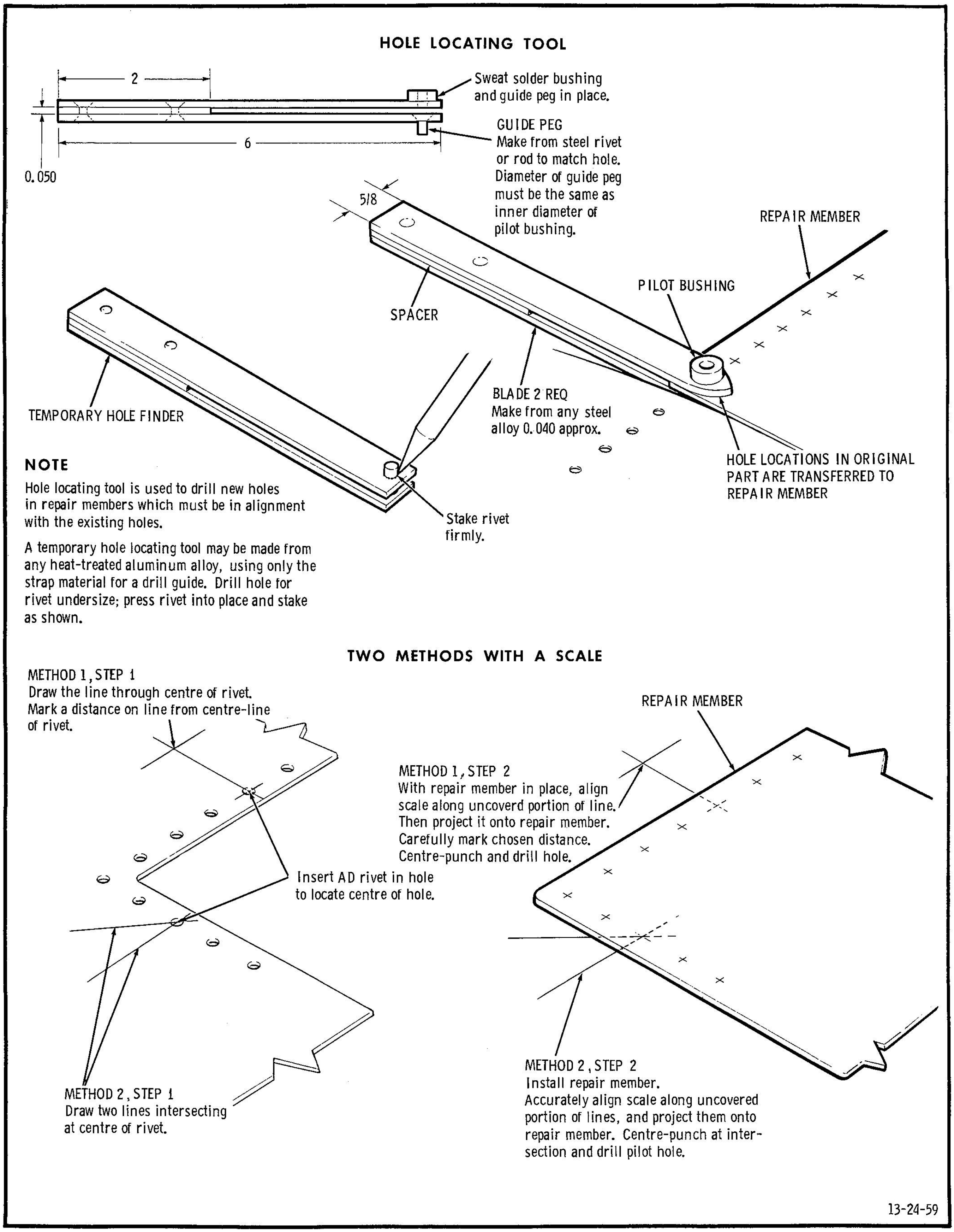


Figure 13 Locating Blind Rivet Holes

(c) D Rivets: Material 17S-T3 heat-treated. Driven in hard, as-received condition to produce extra strength. Used where intermediate strength between AD and DD rivets is required, in 3/32, 1/8 and 5/32 inch diameters.

(d) DD Rivets: Material 24S-T31, heat-treated. Driven in the soft condition within 20 minutes after heat-treatment. Period of softness may be prolonged by refrigeration. Used in highly stressed parts of heavier gauge. Rivets of smaller diameters than 3/16 inch are not used.

(e) M Rivets: Material monel. Used in as-received condition for attachment of titanium to titanium, titanium to corrosion-resistant steel and aluminum alloy, and corrosion-resistant steel to corrosion-resistant steel.

NOTE

Monel rivets must be cadmium plated and aluminum rivets made from A17S-T3, 17S-T3, 24S-T31 and 56S-F must be anodized.

DRILL AND HOLE SIZES

123 For drill and hole sizes, refer to EO 05-1-3/5 and 05-1-3/6.

RIVETING INSTRUCTIONS

124 The following instructions must be adhered to when carrying out repairs by riveting:

(a) Proper edge distance and rivet spacing must be maintained in all cases. (Refer to Paragraph 142, following.)

(b) Where aerodynamic cleanness is not critical, protruding-head rivets (MS20470) are to be used.

(c) The use of 17S-T3 (D) rivets especially in thin material should be avoided, where possible, because of difficulty in bucking rivet and possibility of cracking dimples or rivet holes.

(d) Where bolts or other steel rivets are used in a repair along with light alloy rivets, the bolt holes must be reamed.

(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) Rivets must not be used where they would be placed only in tension tending to pull the heads off.

(h) When adding or replacing rivets adjacent or near to 17S-T3 (D) or 24S-T (DD) rivets which have been installed previously, great care should be exercised or the older rivets will be loosened or may fail due to sharp vibrations in the structure caused by the action of the rivet gun and bucking bar. In every case all adjacent rivets must be carefully examined after the repair is finished to ascertain that they have not been damaged by operations in adjacent areas.

(j) For drilling rivet holes in external reinforcement which must align with the existing holes in structure, see Figure 13.

BLIND RIVETS

125 Blind rivets may only be used where specifically stated on repair illustrations and for skin repairs in secondary and tertiary class structures where accessibility does not permit the use of standard riveting equipment for solid rivets. For detail instructions on blind rivets, refer to EO 05-1-3/5.

NOTE

Since blind rivets are primarily shear-type rivets, they must not be used in applications where appreciable tensile loads on the rivet will exist, or in any fitting regardless what load it is carrying or in other heavily stressed locations.

WARNING

Blind rivets must not be used under any circumstances in pressurized and fuel-tight areas.

126 Owing to limited expansion of blind rivet shank, rivet holes must be drilled to close tolerance. At least one hole in each pattern of rivets is to be measured for the actual grip length, using a grip length selector gauge. When all members of the repair are dimpled, the rivet grip must include the depth of protruding

dimple on the reverse side. Holes which are out of tolerance may be redrilled to take oversize blind rivets.

127 When using blind rivets for flush (dimpled) riveting final rivet hole must be drilled after the parts have been coin dimpled using a pilot hole. Minimum and maximum sheet thickness for dimpling and countersinking is the same as those for solid conventional rivets. (Refer to EO 05-1-3/5.)

128 In blind riveting it is essential that the adjacent surfaces of riveted parts are clean and free of drill swarf. The mating parts must be pulled tight together and held by clamps or other suitable means while the rivets are expanded. All holes should be checked with Go and No Go gauge before installing rivets. When milling of flush-head rivets is required to obtain flushness, the rivet heads must not protrude more than 0.010 inch above the skin prior to milling.

BOLTS AND SCREWS

129 The minimum diameter of a structural bolt or screw in shear is 3/16 inch and No. 10 respectively, and in tension 1/4 inch. Fasteners smaller than No. 10 must be of the coarse thread series. Fasteners No. 10 and larger must be of the fine thread series. Bolts and screws 1/4 inch in diameter and smaller, used with self-locking nuts must be without cotter-pin holes. Corrosion-resistant bolts and screws may be used only with corrosion-resistant steel nuts. For general information on bolts and screws, refer to EO 05-1-3/6.

130 Where possible all bolts and screws must be installed head upward or forward. When installing nuts and protruding-head bolts or screws a minimum of one washer must be used under the head or nut, whichever part is turned during the tightening. Materials 24S-T and 75S-T must be hot dimpled for screw installation, and only coin dimpling, using special tools for deep drawing, may be used. Refer to EO 05-1-3/6 for minimum and maximum thickness for dimpling, countersinking and subcountersinking.

131 Bolt and screw hole sizes for different types of fits are listed in EO 05-1-3/25. The oversize and clearance fits are used as required on all non-structural applications and on most floating nut plate applications. The close fit is used on all general structural applications and on some floating nut plate applications. The precision fit which is a reaming operation is restricted to applications which are held to very close tolerances.

TORQUING

132 For torquing values on standard bolts and nuts, refer to EO 05-1-3/25. Torque values for special bolts are detailed in applicable aircraft -2 EO.

RIVET AND BOLT SUBSTITUTION

133 The substitution of existing solid rivets with blind rivets is restricted to isolated or specific cases only. Where the use of blind rivets is required and authorization in this EO is not given, it must be approved by the CTSO or his delegated representative. When replacing solid rivets with blind rivets, the blind rivet must, in general, be one size larger than the standard solid shank rivet.

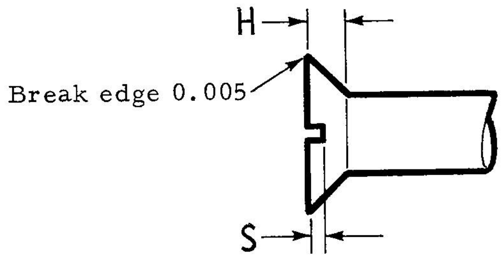
CAUTION

> Blind rivets must not be used in an existing joint to replace such a considerable number of solid rivets that overstressing of the remaining solid rivets may result.

134 Although D-type or DD-type rivets may be substituted for AD-type rivets, AD-type rivets must never be substituted for either D-type or DD-type, unless specifically authorized.

135 Do not substitute bolts for rivets unless specifically authorized by repair illustrations in applicable -3 EO. Where bolt-for-rivet substitution is permitted, bolt holes must be drilled and reamed to provide close tolerance fit as detailed in EO 05-1-3/25.

136 Replacement of bolts must be of equivalent dimensions, material, heat-treatment and finish to original bolts. AN series bolts, NAS221 series screws and Huckbolts may be used as substitutes for Hi-shear rivets if approved by the CTSO or his delegated representative.



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

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 EO 05-1-3/23).

(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 EO 05-1-3/20).

Figure 14 Screw Replacement Details

NOTE

NAS bolts and screws are of superior strength to AN bolts and screws, and must not be replaced by the latter.

SCREW REPLACEMENT FOR FLUSH HI-SHEAR RIVET

137 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 14. The use of the slotted or recessed type head is optional.

OVERSIZE RIVETS AND BOLTS

138 When existing rivets are removed and their holes are found elongated or oversize, the holes may be redrilled and next size solid rivets, or oversize blind rivets may be installed, providing the conditions in the following paragraph are observed.

139 When bolt or screw hole is oversize, special (salvage) bolt or screw with 0.015 or 0.030 inch greater diameter than original may be installed if the following conditions are fulfilled:

(a) New edge distance and rivet or bolt pitch are not below the minimum permissible.

(b) Rivet or bolt head will not ride on radii of bends or fillets.

(c) Rivet or screw head (flush) will nest in dimple or countersink.

(d) Interchangeability of part or assembly is not affected.

(e) For fatigue reasons number of oversize holes must be restricted to absolute minimum.

(f) Original fit for bolts and screws is provided. If original fit is not available, refer to hole sizes in EO 05-1-3/25.

140 Oversize holes for conventional driven rivets may be used as is, if they are not oversize more than shown in the accompanying

table, 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 maximum oversize hole diameters is provided for reference.

Rivet Size	3/32	1/8	5/32	3/16	1/4
Maximum hole diameter for AD and DD rivets	.106	.140	.174	.209	.276
Maximum hole diameter for D (Hard-driven) rivets		.135	.170	.205	.270

141 Special diameter bolts and maximum diameter salvage bolts must not be replaced by oversize bolts without the approval of the CTSO or his delegated representative. Interchangeable parts must not be fitted with oversize bolts. In case of excessive wear, bushes should be installed, but only if approved by the CTSO or his delegated representative. Salvage bolt diameters must be within tolerance specified, on their nominal diameter, for close tolerance bolts.

EDGE DISTANCE AND RIVET SPACING

142 Since the strength and fatigue life of a riveted joint depends partially on the edge distance and rivet spacing, it is mandatory in typical repairs, where these dimensions are not specified, that strict adherence be made to Figure 15 in which minimum edge distance and minimum and maximum rivet spacing are given.

FLUSH RIVETING

143 Application of flush riveting in skins of light gauges, in which countersinking is not permitted, must be accomplished by dimpling. Two methods of dimpling are employed in the aircraft skin riveting: Coin dimpling and radius dimpling. Radius dimpling is only used as a production facility for skin-to-stringer riveting in manufacturing skin panel assemblies with Erco machine which punches, dimples and rivets automatically. Coin dimpling, which requires individual dimpling of adjoining parts, is used for joining skin panels and skin-to-skin as a standard method of dimpling. For repair purposes where newly drilled holes are to be dimpled, coin dimpling only must be used, and parts to be joined must be dimpled separately. For minimum and maximum thickness for dimpling, countersinking and sub-countersinking, refer to EO 05-1-3/5 and EO 05-1-3/6.

HOT DIMPLING

144 Sheet material 75S-T6 must be hot dimpled. Corrosion-resistant steel and other aluminum alloys may be dimpled at room temperature. Hot dimpling involves local heating of the material by the use of heated dies before dimpling to prevent cracking of the material. The temperature may be determined by the use of Tempilaq (Item 18, Figure 71) applied to the metal adjacent to the hole to be dimpled. Tempilaq is a special lacquer that melts at a predetermined temperature, and for this purpose must be rated to melt at 163°C (325°F) for 75S aluminum alloy. Tests should be made on scrap material to ensure the die is functioning satisfactorily. Hot dimpling equipment consists of stationary units automatically timed to an operating dwell time and controlled by the operator, or simple portable equipment, depending entirely on the use of Tempilaq for each dimple to determine the correct temperature. Tempilaq should also be applied at intervals to check the accuracy of setting on stationary dimpling equipment. Table of coin dimpling temperature is given in EO 05-1-3/5.

ERCO DIMPLING

145 When making repair that will pick up existing Erco dimples, the following restrictions must be observed:

NOTE

Erco dimpling must not be used for repair purposes.

(a) Primary and secondary Erco dimples may be assembled in that order only.

(b) A coin dimple cannot nest into a secondary Erco dimple.

(c) An Erco dimple, primary or secondary cannot nest into a coin dimple.

(d) Where a repair member picks up on secondary Erco dimples, radius dimple the repair member. Where an external doubler picks up on primary Erco dimples, coin dimple the doubler.

(e) Where a doubler is joggled under an Erco dimpled stringer, either of the following methods may be used:

(1) Sub-countersink the doubler. Make several trial cuts on scrap material of the same thickness as the doubler, using either a 100° countersunk cutter or a large drill ground at 118°. The depth of the countersinking should not exceed 2/3 of the doubler thickness.

(2) Radius dimple the doubler, using a radius dimple die or an MS20426 rivet, preferably the die. Make several trial dimples in scrap material until a dimple is obtained that will nest with the stringer dimple.

DRAW DIMPLING

146 Draw dimpling as described in EO 05-1-3/5 may be used where approved dimpling equipment cannot be applied. Great care must be exercised to dimple the hole at right angles to the surface.

DIMPLING RESTRICTIONS

147 The following restrictions on dimpling must be observed:

(a) Dimpling of extruded material of any alloy, temper or thickness is prohibited.

(b) Dimpling must not be followed by heat-treatment.

(c) Redimpling of one type into another and reworking of the existing small size into next greater size dimples may be done only if specified on repair illustration, or if approved by the CTSO or his delegated representative.

(d) Stop drilling of cracked dimples is not allowed. Where dimples are found cracked a suitable repair scheme must be applied (see Figure 63).

(e) Dimpling is prohibited on parts metal-to-metal bonded, unless specified on repair illustration.

RIVETING OF GLASS FABRIC

148 Where glass fabric parts are in contact with the upset heads of rivets in joints of glass fabric to glass fabric and glass fabric to metal, an aluminum alloy washer must be placed between the glass fabric part and the head of the rivet to be upset prior to driving. Similarly, this applies to Versalite and Darvic parts. AN960D washers should be used, -3 size for 3/32, -6 size for 1/8 and -8 size for 5/32 inch diameter rivets.

FILLING DIMPLED OR COUNTERSUNK RIVET HOLES

149 Where a repair member is to be located over dimpled or countersunk holes, a filler made from a countersunk rivet as illustrated in Figure 16 may be used to fill the countersunk hole.

TYPICAL REPAIR PROCEDURE

GENERAL

150 Before attempting any repair, the steps of this procedure, to which a reference is made on most of the repair illustrations, must be closely followed.

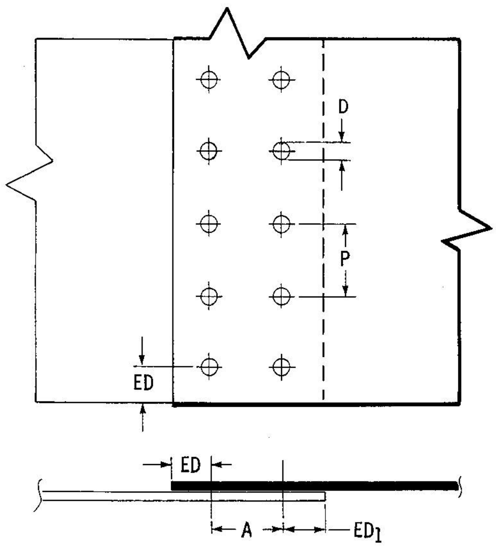
(a) Determine whether the damage is in restricted area or in primary, secondary or tertiary class structure. (Refer to Paragraphs 3 and 4, preceding.)

(b) Investigate and fully assess the damage. (Refer to Paragraph 5 to 24 inclusive, preceding.)

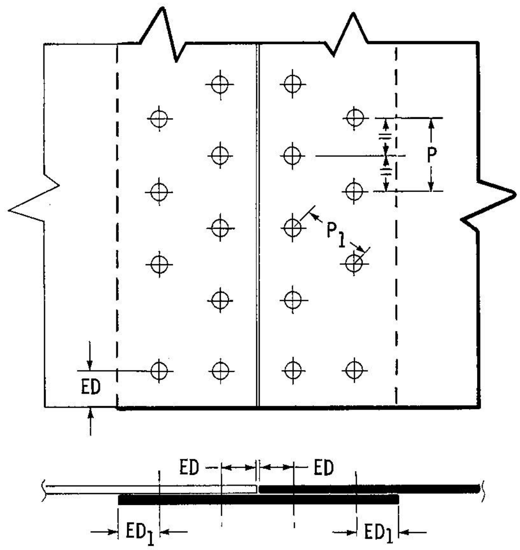
(c) Clean up damage to regular shape as instructed in Paragraph 99, preceding.

(d) Identify the material and thickness of damaged structure from appropriate skin diagram or structural illustration. (Refer to applicable aircraft -3 EO.)

(e) Determine whether damaged area is loaded in tension or shear, or in combined load of tension and shear. (Refer to Paragraph 153, following.)



DOUBLE ROW RIVET PATTERN



DOUBLE ROW STAGGERED RIVET PATTERN

STANDARD EDGE DISTANCE AND SPACING FOR DIMPLED AND COUNTERSUNK RIVET HOLES

RIVET DIAMETER	MINIMUM EDGE DISTANCE (See Note 2.)	SPACING	
		MINIMUM	MAXIMUM
3/32	1/4	7/16	1-1/2
1/8	5/16	9/16	1-1/2
5/32	3/8	23/32	1-1/2
3/16	7/16	27/32	1-1/2
7/32	1/2	1	1-1/2
1/4	9/16	1-1/8	1-1/2

NOTES

1 Standard edge distances are classified as Visible and Invisible. A Visible edge is any edge that can be checked and inspected after the riveting operation. An Invisible edge is any edge that cannot be checked or inspected after the riveting operation.

2 Standard edge distance for countersunk rivet holes is the same as that for dimpled rivet holes (see Table). The minimum edge distance values given in the Table apply equally to both visible and invisible edges.

3 Engineering approval must be obtained for any values smaller than those specified. When riveting external seams, especially in the thinner gauge materials, care must be exercised 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 riveted. When this occurs, serious corrosion inevitably follows; this is especially true in seaplanes which are always in contact with salt water.

4 Edge distance is measured from the centre of the rivet hole to the edge of material, and rivet spacing is measured from the centre to the centre of the rivet hole.

STANDARD EDGE DISTANCE AND SPACING FOR PROTRUDING-HEAD RIVETS

ED = Visible Edge Distance 2D MIN

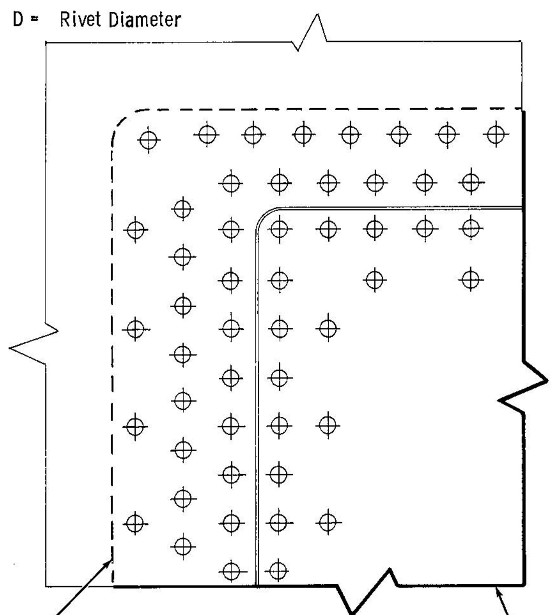
ED_1 = Invisible Edge Distance 2D + 1/16 inch MIN

P = Rivet Pitch 4D MIN, 1-1/2 inch MAX

P_1 = Diagonal Rivet Pitch 4D MIN

A = Distance Between Rows 4D MIN

D = Rivet Diameter



RIVET PATTERN FOR 2 OR 3 ROWS OF STAGGERED RIVETS
(One corner of repair shown.)

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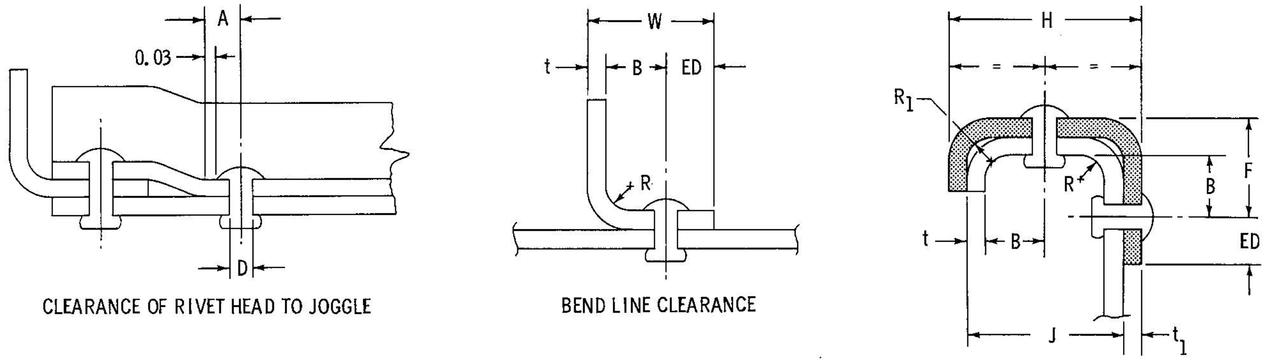
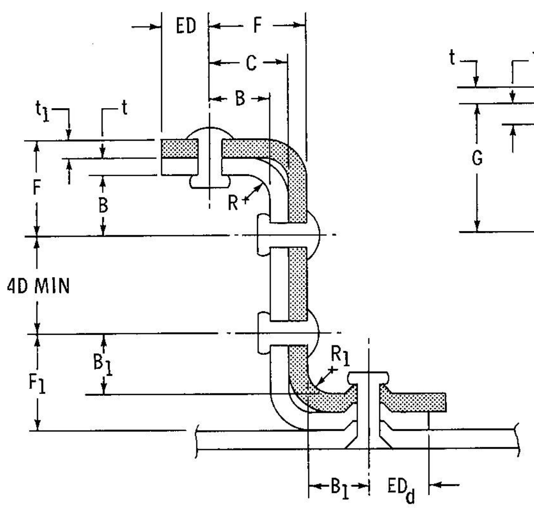
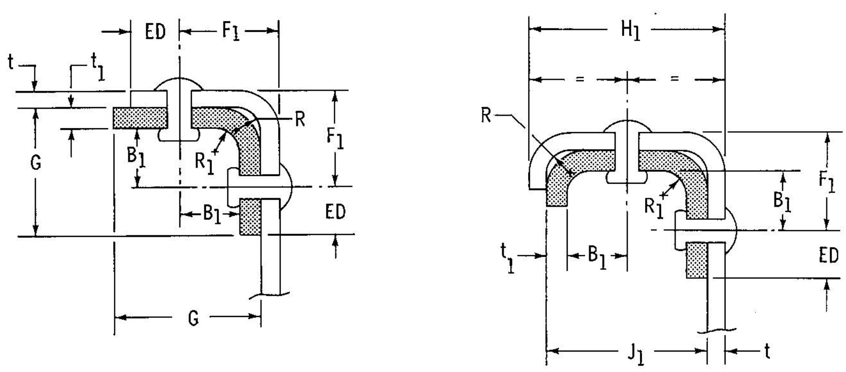
Figure 15 (Sheet 1 of 2) Edge Distance and Rivet Spacing







MINIMUM RIVET SPACING AND REPAIR DIMENSIONS

LEGEND

- A = (D + 0.03) MIN
- B = (D + 0.03 + R) MIN
- B_1 = (D + 0.03 + R_1) MIN
- C = (D + 0.03 + R + t) MIN
- D = Rivet Diameter
- ED = Edge Distance for protruding-head rivets, 2D MIN
- ED_d = Edge Distance for dimpled rivet holes (See Sheet 1)
- F = (D + 0.03 + R + t + t_1) MIN
- F_1 = (D + 0.03 + R_1 + t + t_1) MIN
- G = (3D + 0.03 + R_1 + t_1) MIN
- H = (2D + 0.06 + 2R + 2t + 2t_1) MIN
- H_1 = (2D + 0.06 + 2R_1 + 2t_1 + 2t) MIN
- J = (2D + 0.06 + 2R + 2t) MIN
- J_1 = (2D + 0.06 + 2R_1 + 2t_1) MIN
- R = Bend Radius of existing member
- R_1 = Bend Radius of reinforcing member
- t = Thickness of existing member
- t_1 = Thickness of reinforcing member
- W = Minimum Width of flange
  (3D + 0.03 + R + t) MIN for protruding-head rivets
  (3D + 0.10 + R + t) MIN for dimpled rivet holes

NOTE

For standard edge distance and rivet spacing see Sheet 1.

13-24-111

Figure 15 (Sheet 2 of 2) Edge Distance and Rivet Spacing

(f) Select appropriate type of repair that satisfies conditions of (a) and (e), preceding.

(g) Select suitable rivet table corresponding to the type of rivet head (flush or protruding) and damaged material. (Refer to Paragraphs 151 and 152, following.)

(h) From appropriate column of rivet table in Figure 17 or Figure 18, determine the number of rivets required for damage dimensions.

(j) Lay out rivet pattern using proper edge distance, rivet pitch and spacing between rows of rivets. (Refer to Paragraph 142, preceding, and Paragraph 154, following.)

(k) Prepare reinforcements to fit the damaged area. Drill, dimple or countersink repair members as applicable. Apply anti-corrosion treatment as required and attach repair members in place.

(m) Restore repair area to the original finish requirements by applying chemical films or paints as applicable.

RIVET TABLES

151 For repair of damage in members made from sheet metal, rivet tables are given in Figure 17, and for extruded members in Figure 18. Rivet tables are entitled according to the type of rivet and the material for which they are to be used. Rivet requirements in Figure 17 have been calculated for loads in TENSION and loads in SHEAR, giving number of rivets for one inch of damage. Rivet requirements in Figure 18 are for loads in tension and compression. To find the actual rivet requirements for the damage, multiply the number in the table by the length of damage, and the amount so obtained use on one side of the damage only.

NOTE

For members loaded in compression, tension column must be used.

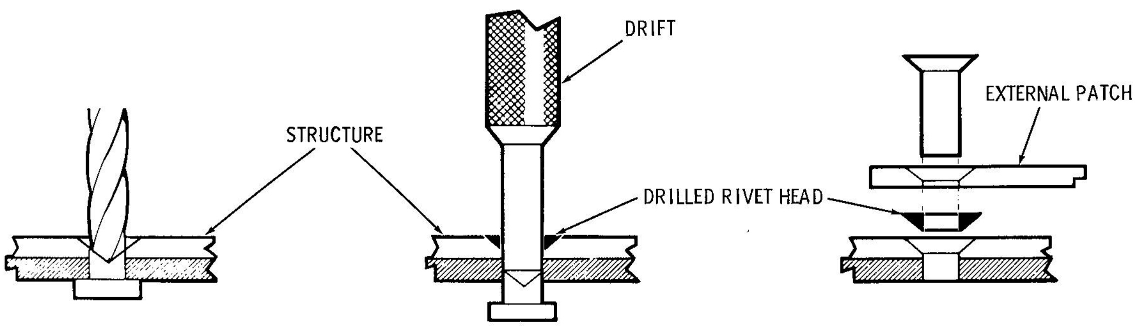
SELECTION OF REQUIRED RIVET

152 The diameter of a rivet for joining aluminum sheets should not, in general, be less

METHOD FOR FILLING DIMPLED OR COUNTERSUNK HOLES

NOTE

When installing a heavy gauge patch which picks up a machine countersunk or dimpled hole in the original member use method shown below.



Remove rivet head using drill of the size prescribed for installation of the rivet. Take care to centre on and not to drill beyond the rivet head.

Using a drift remove the rivet and save the head.

Use the rivet head as a tapered filler. Cement in place with Epon 828 resin adhesive.

13-24-125

Figure 16 Filling Dimples or Countersunk Holes than three times the thickness of the heavier sheet. For extruded sections the diameter should be between two and three times the thickness of the section, but not greater than 1/4 of the width of a flange or web. In skin and web repairs, it is best to match the type and size of rivet that is in general use in the area. Because of space limitations where adjacent structure is close to the cleaned-up damage, several calculations may be necessary to determine the suitable rivet and the shape of reinforcing.

THE USE OF TENSION AND SHEAR COLUMNS

153 For correct method of using TENSION and SHEAR columns, see Figure 19. For repair purposes, all stringers riveted to skin are considered to be loaded in tension; so that the direction of tension load in the skin will run along direction of stringers. The direction of shear will be at right angles to the tension. Spar, frame and rib webs only are considered to be loaded in shear. Use SHEAR column when calculating requirements for web patch repairs. For skin and web stiffeners and for rib and spar capping, use TENSION column. If direction of stress cannot be established, rivet requirements from TENSION column must be used for the whole repair.

RIVET PATTERN LAYOUT

154 After the type and size of rivet have been chosen, the rivet pattern layout will be simpler and more accurate if the repair is laid out on paper and then transferred to the damaged area. For repair of damage adjacent to, or over substructure, rivet pattern may be modified to pick up existing rivets, providing the required number of repair rivets is maintained. Rivet layout determines the size and shape of repair doubler. Rivet rows must be parallel to the edges of the hole, minimum edge distance, and minimum and maximum rivet spacing must be observed to maintain the required strength in the repair.

RECTANGULAR REPAIR

155 Damage cleaned up to rectangular shape has two directions of break, at 90° to each other. Each direction must be treated separately and the number of rivets, calculated from rivet table, is the number that is required for each side of the break. See Figure 21, Sheet 1, for rivet distribution pattern and an example of rectangular repair.

CIRCULAR REPAIR

156 Damage cleaned up to a circular shape is considered to have only one break, its circumference. To calculate the length of damage, in order to determine the required number of rivets, multiply the diameter of cleaned-up hole by 3. For damage in primary and secondary structures use only TENSION column, and in tertiary structure SHEAR column in rivet tables. Rivets must be distributed evenly around the cut-out using staggered pattern. See Figure 21, Sheet 2, for rivet distribution pattern and an example of circular repair.

OVAL REPAIR

157 The length of damage cleaned up to oval shape will consist of two parallel sides and two semi-circles. Rivets required for this shape of damage should be calculated using the principles laid down for rectangular and circular repairs respectively. See Figure 21, Sheet 3, for rivet distribution pattern and example of oval repair.

CRACK REPAIR

158 A crack in sheet metal may have one or two directions. When a crack develops in a straight line, consider it as having one straight dimension of damage, and distribute the number of rivets on each side of the break. When the path of the crack deviates from a straight line, consider it as having two directions of break, and treat it as a rectangular or oval repair. The area of skin inside rivet pattern becomes the filler material and may be tacked to the repair doubler with small structural-type rivets, as a filler would be. For crack stopping and repair method, see Figure 21, Sheet 4.

OVERLAP JOINT (SPLICE)

159 For members being repaired by an overlap joint, the rivets required for the break are distributed within the overlap area, the break being the dimension of the damage. (See Figure 21, Sheet 6.)

MATERIAL THICKNESS		TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE ONLY			
			24S-T		26S-T AND 75S-T	
SKIN OR WEB	DOUB-LER		TENSION	SHEAR	TENSION	SHEAR
.018	.028	MS20470AD3	6.7	4.3	6.3	3.8
		MS20600AD4	6.4	4.2	7.6	4.6
.020	.028	MS20470AD3	6.7	4.3	6.9	4.2
		MS20470AD4	5.0	3.4	4.2	2.5
		MS20600AD4	6.4	4.1	7.6	4.6
.022	.028	MS20470AD3	6.7	4.3	7.5	4.5
		MS20470AD4	5.0	3.3	4.4	2.7
		MS20600AD4	6.4	4.1	7.5	4.5
.025	.032	MS20470AD3	7.0	4.5	8.3	5.0
		MS20470AD4	5.0	3.3	5.0	3.0
		MS20600AD4	6.4	4.1	7.5	4.5
.028	.036	MS20470AD3	7.8	5.0	9.2	5.6
		MS20470AD4	5.0	3.3	5.4	3.3
		MS20600AD4	6.6	4.3	7.8	4.7
.032	.040	MS20470AD4	5.1	3.3	6.0	3.6
		MS20470D4	4.0	2.6	4.7	2.8
		MS20600AD4	6.9	4.4	8.1	4.9
		MS20600AD5	5.2	3.3	6.1	3.7
.036	.045	MS20470AD4	5.6	3.6	6.7	4.0
		MS20470D4	5.1	3.3	6.0	3.6
		MS20470AD5	4.1	2.6	4.5	2.7
		MS20600AD4	7.1	4.6	8.5	5.1
		MS20600AD5	5.4	3.5	6.4	3.9

Figure 17 (Sheet 1 of 12) Rivet Table - Protruding-head in 24S-T, 26S-T and 75S-T

MATERIAL THICKNESS		TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE ONLY			
			24S-T		26S-T AND 75S-T	
SKIN OR WEB	DOUB-LER		TENSION	SHEAR	TENSION	SHEAR
.040	.050	MS20470AD4	6.2	4.0	7.5	4.5
		MS20470D4	5.1	3.3	6.2	3.7
		MS20470AD5	4.2	2.7	5.1	3.0
		MS20470DD6	3.4	2.2	2.7	1.6
		NAS178-6	3.4	2.3	2.7	1.7
		MS20600AD4	7.4	4.8	9.0	5.4
		MS20600AD5	5.6	3.6	6.8	4.1
		ALPP-T6	3.0	2.1	2.8	1.7
.045	.056	MS20470AD5	4.6	3.0	5.6	3.4
		MS20470D5	3.7	2.4	4.5	2.7
		MS20470DD6	3.4	2.2	3.0	1.8
		NAS178-6	3.4	2.3	2.8	1.7
		MS20600AD4	7.6	4.9	9.3	5.6
		MS20600AD5	5.8	3.7	7.0	4.2
		ALPP-T6	3.0	2.1	2.8	1.7
.048	.063	MS20470AD5	4.8	3.1	5.9	3.5
		MS20470D5	3.8	2.5	4.7	2.8
		MS20470DD6	3.4	2.2	3.1	1.9
		NAS178-6	3.4	2.0	2.8	1.7
		MS20600AD5	5.9	3.8	7.2	4.3
		MS20600AD6	4.6	3.0	5.7	3.4
		ALPP-T6	3.0	2.1	2.8	1.7
.050	.063	MS20470AD5	5.0	3.2	6.1	3.7
		MS20470D5	4.0	2.6	4.9	3.0
		MS20470DD6	3.4	2.2	3.2	1.9
		NAS178-6	3.6	2.3	2.7	1.7
		MS20600AD5	6.0	3.9	7.3	4.4
		MS20600AD6	4.7	3.0	5.7	3.4
		ALPP-T6	3.0	2.1	2.8	1.7

Figure 17 (Sheet 2 of 12) Rivet Table - Protruding-head in 24S-T, 26S-T and 75S-T

MATERIAL THICKNESS		TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE ONLY			
			24S-T		26S-T AND 75S-T	
SKIN OR WEB	DOUB-LER		TENSION	SHEAR	TENSION	SHEAR
.056	.071	MS20470AD5	5.6	3.6	6.8	4.1
		MS20470D5	4.5	2.9	5.4	3.3
		MS20470DD6	3.4	2.2	3.5	2.1
		NAS178-6	3.5	2.3	2.8	1.7
		MS20600AD5	6.2	4.0	7.5	4.5
		MS20600AD6	4.9	3.1	5.9	3.6
		ALPP-T6	3.0	2.1	2.8	1.7
.063	.071	MS20470AD5	6.3	4.1	7.6	4.6
		MS20470D5	5.0	3.3	6.0	3.7
		MS20470DD6	3.4	2.2	3.9	2.3
		NAS178-6	3.4	2.2	2.7	1.7
		MS20600AD5	6.3	4.1	7.6	4.6
		MS20600AD6	5.0	3.2	6.1	3.6
		ALPP-T6	3.0	2.1	2.8	1.7
		ALPP-T8	2.3	1.6	2.1	1.3
.071	.080	MS20470D5	5.9	3.8	6.8	4.2
		MS20470DD6	3.8	2.4	4.4	2.6
		MS20470DD8	2.6	1.7	2.5	1.5
		NAS178-6	3.6	2.3	2.7	1.7
		NAS178-8	2.8	1.8	2.1	1.3
		ALPP-T6	3.0	2.0	2.8	1.7
		ALPP-T8	2.3	1.5	2.1	1.3

Figure 17 (Sheet 3 of 12) Rivet Table - Protruding-head in 24S-T, 26S-T and 75S-T

MATERIAL THICKNESS		TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE ONLY			
			24S-T		26S-T AND 75S-T	
SKIN OR WEB	DOUBLER		TENSION	SHEAR	TENSION	SHEAR
.080	.090	MS20470DD6	4.2	2.7	4.9	3.0
		MS20470DD8	2.6	1.7	2.8	1.7
		NAS178-6	3.6	2.3	2.8	1.7
		NAS178-8	2.8	1.8	2.1	1.3
		ALPP-T6	3.0	2.0	2.8	1.7
		ALPP-T8	2.3	1.5	2.1	1.3
.090	.100	MS20470DD6	4.8	3.1	5.6	3.3
		MS20470DD8	2.7	1.7	3.1	1.9
		NAS178-6	3.6	2.4	3.1	1.9
		NAS178-8	2.8	1.8	2.1	1.3
		ALPP-T6	3.0	2.0	2.8	1.7
		ALPP-T8	2.3	1.5	2.1	1.3
.100	.112	MS20470DD6	5.3	3.4	6.2	3.7
		MS20470DD8	2.9	1.9	3.4	2.1
		NAS178-6	3.6	2.4	3.4	2.1
		NAS178-8	2.8	1.8	2.1	1.3
		ALPP-T6	3.0	2.0	2.8	1.7
		ALPP-T8	2.3	1.5	2.1	1.3

NOTES

1 Refer to text and appropriate repair examples for method of using Rivet Tables.

2 Doubler thickness applies to skin and web repairs only.

3 NAS178 is a protruding-head Hi-shear rivet.

4 ALPP is a protruding-head Huckbolt.

Figure 17 (Sheet 4 of 12) Rivet Table - Protruding-head in 24S-T, 26S-T and 75S-T

MATERIAL THICKNESS		TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE ONLY			
			24S-T		26S-T AND 75S-T	
SKIN OR WEB	DOUB-LER		TENSION	SHEAR	TENSION	SHEAR
.018	.028	MS20426AD3	5.5	3.6	6.6	4.0
		MS20601AD4	8.3	5.3	9.7	5.8
.020	.028	MS20426AD3	5.7	3.7	6.8	4.1
		MS20426AD4	4.0	2.6	4.7	2.8
		MS20601AD4	8.0	5.1	9.4	5.6
.022	.028	MS20426AD3	6.0	3.9	7.1	4.3
		MS20426AD4	4.0	2.6	4.7	2.8
		MS20601AD4	7.9	5.0	9.2	5.5
.025	.032	MS20426AD3	6.3	4.1	7.5	4.5
		MS20426AD4	4.1	2.7	4.6	2.8
		MS20601AD4	7.7	4.9	9.0	5.4
		MS20601AD5	6.5	4.2	7.6	4.6
.028	.036	MS20426AD3	6.8	4.4	8.0	4.8
		MS20426AD4	4.4	2.8	4.8	2.9
		MS20601AD4	8.0	5.1	9.3	5.6
		MS20601AD5	6.3	4.0	7.4	4.4
.032	.040	MS20426AD4	4.6	3.0	5.0	3.0
		MS20426AD5	3.4	2.2	3.8	2.3
		MS20601AD4	8.2	5.2	9.6	5.8
		MS20601AD5	6.1	3.9	7.1	4.3
.036	.045	MS20426AD4	5.0	3.2	5.3	3.2
		MS20426AD5	3.6	2.3	4.0	2.4
		MS20601AD4	8.5	5.4	9.9	6.0
		MS20601AD5	6.4	4.1	7.4	4.5
		MS20601AD6	5.3	3.4	6.1	3.7

Figure 17 (Sheet 5 of 12) Rivet Table - Dimpled Holes in 24S-T, 26S-T and 75S-T

MATERIAL THICKNESS		TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE ONLY			
			24S-T		26S-T AND 75S-T	
SKIN OR WEB	DOUB-LER		TENSION	SHEAR	TENSION	SHEAR
.040	.050	MS20426AD4	5.3	3.4	5.8	3.5
		MS20426AD5	3.8	2.4	4.2	2.5
		MS20426DD6	2.6	1.7	3.0	1.8
		MS20601AD4	8.8	5.6	10.5	6.3
		MS20601AD5	6.6	4.2	7.9	4.8
		MS20601AD6	5.2	3.3	6.2	3.7
.045	.056	MS20426AD4	5.7	3.7	6.2	3.7
		MS20426AD5	4.1	2.6	4.5	2.7
		MS20426DD6	2.7	1.7	3.1	1.9
		MS20601AD5	6.8	4.3	8.1	4.9
		MS20601AD6	5.5	3.5	6.6	3.9
.048	.063	MS20426AD4	6.0	3.9	6.5	3.9
		MS20426AD5	4.2	2.7	4.6	2.8
		MS20426DD6	2.7	1.8	3.2	1.9
		MS20601AD5	6.9	4.4	8.3	5.0
		MS20601AD6	5.5	3.5	6.6	3.9
.050	.063	MS20426AD5	4.3	2.8	4.7	2.8
		MS20426DD6	2.7	1.8	3.2	1.9
		MS20426DD8	2.3	1.5	2.2	1.3
		MS20601AD5	6.9	4.4	8.3	5.0
		MS20601AD6	5.5	3.5	6.6	4.0
.056	.071	MS20426AD5	4.7	3.0	5.1	3.1
		MS20426DD6	2.9	1.9	3.4	2.1
		MS20426DD8	2.3	1.5	2.3	1.4
		MS20601AD5	7.1	4.5	8.6	5.1
		MS20601AD6	5.7	3.6	6.9	4.1

Figure 17 (Sheet 6 of 12) Rivet Table - Dimpled Holes in 24S-T, 26S-T and 75S-T

MATERIAL THICKNESS		TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE ONLY			
			24S-T		26S-T AND 75S-T	
SKIN OR WEB	DOUBLER		TENSION	SHEAR	TENSION	SHEAR
.063	.071	MS20426AD5	5.1	3.3	5.5	3.3
		MS20426DD6	3.1	2.0	3.7	2.2
		MS20426DD8	2.2	1.4	2.3	1.4
		*NAS177-6	2.9	1.9	2.8	1.7
		MS20601AD5	7.4	4.7	8.8	5.3
		MS20601AD6	5.9	3.7	7.1	4.2
.071	.080	*MS20426AD5	5.9	3.8	6.0	3.6
		MS20426DD6	3.5	2.3	3.9	2.4
		MS20426DD8	2.4	1.6	2.5	1.5
		*NAS177-8	2.3	1.5	2.3	1.4
.080	.090	MS20426DD6	3.8	2.4	4.2	2.6
		MS20426DD8	2.5	1.6	2.6	1.6
		*NAS177-8	2.3	1.5	2.3	1.4
.090	.100	*MS20426DD6	4.1	2.7	4.6	2.8
		MS20426DD8	2.7	1.7	2.8	1.7
.100	.112	*MS20426DD8	2.8	1.8	3.0	1.8

NOTES

1 Refer to text and appropriate repair examples for method of using Rivet Tables.

2 Doubler thickness applies to skin and web repairs only.

3 NAS177 is a countersunk-head Hi-shear rivet.

4 Dimple skin and sub-countersink doubler for rivets marked *

Figure 17 (Sheet 7 of 12) Rivet Table - Dimpled Holes in 24S-T, 26S-T and 75S-T

MATERIAL THICKNESS		TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE ONLY			
			24S-T		26S-T AND 75S-T	
SKIN OR WEB	DOUB-LER		TENSION	SHEAR	TENSION	SHEAR
.050	.063	MS20426AD4	8.8	5.6	10.6	6.4
.056	.071	MS20426AD4	9.5	6.0	11.1	6.8
.063	.071	MS20426AD5	7.6	4.6	8.8	5.3
		NAS177-6	4.6	2.6	4.5	2.7
.071	.080	MS20426DD6	4.7	3.1	5.5	3.3
		NAS177-6	4.6	3.0	4.4	2.6
		NAS177-8	3.6	2.4	3.5	2.1
.080	.090	MS20426DD6	5.1	3.3	5.9	3.5
		NAS177-6	4.6	3.0	4.2	2.5
		NAS177-8	3.5	2.3	3.5	2.1
		F164	4.5	3.0	4.7	2.8
.090	.100	MS20426DD6	5.4	3.6	6.4	3.8
		NAS177-6	4.6	3.0	4.0	2.4
		NAS177-8	3.5	2.3	3.4	2.0
		F164	4.5	3.0	4.7	2.8
		F200	4.1	2.6	4.2	2.5
		AN509-10R	3.3	2.1	3.7	2.3
.100	.112	MS20426DD6	5.8	3.8	6.8	4.1
		MS20426DD8	3.6	2.3	4.2	2.5
		NAS177-6	4.6	3.0	3.6	2.1
		NAS177-8	3.5	2.3	3.3	2.0
		F164	4.5	3.0	4.6	2.8
		F200	4,1	2.7	4.2	2.5
		AN509-10R	3.4	2.2	3.9	2.4

NOTES

1 Refer to text and appropriate repair examples for method of using Rivet Tables.

2 Doubler thickness applies to skin and web repairs only.

3 NAS177 is a countersunk-head Hi-shear rivet.

4 F164 and F200 are countersunk-head Jo-bolts.

Figure 17 (Sheet 8 of 12) Rivet Table - Countersunk Holes in 24S-T, 26S-T and 75S-T

MATERIAL THICKNESS		TYPE AND DIAMETER OF RIVET	PROTRUDING NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE ONLY		TYPE AND DIAMETER OF RIVET	DIMPLED NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE ONLY	
SKIN OR WEB	DOUBLER		TENSION	SHEAR		TENSION	SHEAR
.020	.028	NAS508M4	6.7	3.6	MS20601MP4	8.1	4.3
		NAS508M5	5.4	2.9	MS20601MP5	6.8	3.6
		MS20600MP4	8.1	4.3			
.025	.032	NAS508M4	6.7	3.6	MS20601MP5	6.6	3.5
		NAS508M5	5.4	2.9	MS20601MP6	5.5	3.0
		MS20600MP4	8.2	4.4			
		MS20600MP5	6.6	3.5			
.032	.040	NAS508M5	5.4	2.9	MS20601MP5	7.2	3.9
		NAS508M6	4.5	2.4	MS20601MP6	5.6	3.0
		MS20600MP4	9.0	4.8			
		MS20600MP5	6.7	3.6			
		MS20600MP6	5.5	3.0			
.040	.050	NAS508M5	6.3	3.4	MS20601MP6	6.5	3.5
		NAS508M6	4.5	2.4			
		MS20600MP5	7.4	4.0			
		MS20600MP6	5.7	3.0			
.050	.063	NAS508M5	7.8	4.3	MS20601MP6	7.2	3.9
		NAS508M6	5.4	2.9			
		MS20600MP6	6.4	3.5			
.063	.071	NAS508M5	9.6	5.1	MS20601MP6	8.0	4.3
		NAS508M6	6.6	3.6			
		MS20600MP6	7.2	3.8			

NOTES

1 Refer to text and appropriate repair examples for method of using Rivet Tables.

2 Doubler thickness applies to skin and web repairs only.

Figure 17 (Sheet 9 of 12)
Rivet Table - Protruding-head and Dimpled Holes in Corrosion-resistant Steel 1/2 Hard

MATERIAL THICKNESS		PROTRUDING			COUNTERSUNK			DIMPLED		
		TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE		TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE		TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE	
SKIN OR WEB	DOUBLER		TENSION	SHEAR		TENSION	SHEAR		TENSION	SHEAR
.020	.028	NAS508M4	4.4	2.3				MS20427M4	3.8	2.1
.025	.032	NAS508M4	4.4	2.3				MS20427M4	4.0	2.1
.032	.040	NAS508M4	4.4	2.3				MS20427M4	4.1	2.2
		NAS508M5	3.6	1.9				MS20427M5	3.2	1.7
.036	.045	NAS508M4	4.6	2.4				MS20427M4	4.0	2.1
		NAS508M5	3.6	1.9				MS20427M5	3.1	1.7
		NAS508M6	3.0	1.6						
.040	.050	NAS508M4	5.0	2.6				MS20427M4	4.1	2.2
		NAS508M5	3.6	1.9				MS20427M5	3.2	1.7
		NAS508M6	3.0	1.6						
.048	.063	NAS508M5	3.9	2.1				MS20427M4	4.9	2.6
		NAS508M6	2.9	1.5				MS20427M5	3.3	1.8
								MS20427M6	3.0	1.6
.050	.063	NAS508M5	4.1	2.2	MS20427M4	8.0	4.2	MS20427M5	3.5	1.9
		NAS508M6	3.0	1.6				MS20427M6	3.0	1.7
.056	.071	NAS508M5	4.5	2.4	MS20427M4	7.8	4.1	MS20427M5	3.9	2.0
		NAS508M6	3.2	1.7				MS20427M6	3.1	1.7
.063	.071	NAS508M6	3.3	1.7	MS20427M4	7.7	4.1	MS20427M5	4.3	2.3
					MS20427M5	5.4	2.8	MS20427M6	3.1	1.7
.071	.080	NAS508M6	4.0	2.1	MS20427M5	6.3	4.0	MS20427M6	3.4	1.8
					MS20427M6	5.0	2.6			
.080	.090	NAS508M6	4.5	2.4	MS20427M5	6.9	3.7	MS20427M6	3.9	2.1
					MS20427M6	5.4	2.9			
.100	.112	NAS508M6	5.6	3.0	MS20427M6	6.2	3.3	MS20427M6	4.9	2.6

NOTES

1 Refer to text and appropriate repair examples for method of using Rivet Tables.

2 Doubler thickness applies to skin and web repairs only.

Figure 17 (Sheet 10 of 12)
Rivet Table - Protruding-head, Countersunk and Dimpled Holes in Titanium

MATERIAL THICKNESS		TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE ONLY			
			PROTRUDING-HEAD		COUNTERSUNK HOLES	
SKIN	DOUBLER		TENSION	SHEAR	TENSION	SHEAR
.016	.025	MS20470B3	6.3	2.9		
		MS20600B4	5.8	2.6		
.018	.025	MS20470B3	6.3	2.9		
		MS20470B4	4.7	2.2		
		MS20600B4	5.8	2.7		
.020	.025	MS20470B3	6.3	2.9		
		MS20470B4	4.7	2.2		
		MS20600B4	5.8	2.7		
.022	.028	MS20470B3	6.3	2.9		
		MS20470B4	4.7	2.2		
		MS20600B4	5.7	2.6		
.025	.032	MS20470B4	4.7	2.2		
		MS20600B4	5.9	2.7		
.028	.036	MS20470B4	4.7	2.2		
		MS20470B5	3.8	1.8		
		MS20600B4	5.8	2.7		
		MS20600B5	4.6	2.2		
.032	.040	MS20470B4	4.7	2.2		
		MS20470B5	3.8	1.8		
		MS20600B4	5.9	2.7		
		MS20600B5	4.8	2.2		
.036	.045	MS20470B4	4.7	2.2		
		MS20470B5	3.8	1.8		
		MS20600B5	4.8	2.2		

Figure 17 (Sheet 11 of 12)
Rivet Table - Protruding-head and Countersunk Holes in Magnesium Alloy AZ31B-H (FS1-H)

MATERIAL THICKNESS		TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF DAMAGE ONLY			
			PROTRUDING-HEAD		COUNTERSUNK HOLES	
SKIN	DOUBLER		TENSION	SHEAR	TENSION	SHEAR
.040	.050	MS20470B3			8.5	3.9
		MS20470B4	4.7	2.2		
		MS20470B5	3.8	1.8		
		MS200600B5	4.7	2.2		
.045	.050	MS20470B3			9.2	4.2
		MS20470B4	4.8	2.2		
		MS20470B5	3.8	1.8		
		MS20600B5	4.7	2.2		
.050	.056	MS20470B4	5.3	2.5	6.1	2.8
		MS20470B5	3.8	1.8		
		MS20470B6	3.2	1.5		
		MS20600B5	4.7	2.2		
		MS20600B6	3.9	1.8		
.056	.063	MS20470B4	6.0	2.8	6.5	3.1
		MS20470B5	3.9	1.9		
		MS20470B6	3.2	1.5		
		MS20600B5	4.9	2.2		
		MS20600B6	3.9	1.8		
.063	.071	MS20470B5	4.4	2.1	5.1	2.3
		MS20470B6	3.2	1.5		
		MS20600B5	5.1	2.1		
		MS20600B6	4.0	1.7		

NOTES

1 Refer to text and appropriate repair examples for method of using Rivet Tables.

2 Doubler thickness applies to skin and web repairs only.

Figure 17 (Sheet 12 of 12)
Rivet Table - Protruding-head and Countersunk Holes in Magnesium Alloy AZ31B-H (FS1-H)

THICKNESS OF EXTRUSION	TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF JOINT ONLY					
		ALUMINUM ALLOY				MAGNESIUM ALLOY	
		24S-T4	26S-T6	75S-T6	65S-T6	AZ61A	AZ80A
.040 to .044	MS20470AD4	6.5	6.9	8.9	4.4		
	MS20470D4	5.0	5.4	7.0	3.7		
	MS20470AD5	4.6	4.6	6.0	3.0		
	MS20470B4					6.2	6.6
	MS20470B5					5.0	5.3
.045 to .049	MS20470AD4	7.2	7.6	9.9	4.8		
	MS20470D4	5.7	6.0	7.8	3.8		
	MS20470AD5	4.8	5.1	6.6	3.2		
	MS20470DD6	2.5	2.6	3.4	2.5		
	MS20470B4					6.2	6.6
	MS20470B5					5.0	5.3
.050 to .054	MS20470AD4	8.0	8.4		5.3		
	MS20470D4	6.3	6.6	8.5	4.2		
	MS20470AD5	5.2	5.5	7.2	3.5		
	MS20470D5	4.1	4.4	5.7	3.0		
	MS20470DD6	2.7	2.9	3.7	2.5		
	MS20470B4					6.2	6.4
	MS20470B5					5.0	5.3
	MS20470B6					4.2	4.5
.055 to .059	MS20470AD4	8.7			5.8		
	MS20470D4	6.8	7.2	9.3	4.6		
	MS20470AD5	5.7	6.0	7.8	3.8		
	MS20470D5	4.5	4.9	6.1	3.0		
	MS20470DD6	2.9	3.1	4.0	2.5		
	MS20470B4					6.2	7.0
	MS20470B5					5.0	5.3
	MS20470B6					4.2	4.4

Figure 18 (Sheet 1 of 3) Rivet Table - Extruded Sections

THICKNESS OF EXTRUSION	TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF JOINT ONLY					
		ALUMINUM ALLOY				MAGNESIUM ALLOY	
		24S-T4	26S-T6	75S-T6	65S-T6	AZ61A	AZ80A
.060 to .064	MS20470AD4				6.3		
	MS20470D4	7.4	7.8		5.0		
	MS20470AD5	6.2	6.5	8.4	4.1		
	MS20470D5	4.9	5.1	6.7	3.3		
	MS20470DD6	3.2	3.3	4.3	2.5		
	MS20470B5					5.0	5.5
	MS20470B6					4.2	4.4
.065 to .069	MS20470AD5	6.6	7.0	9.1	4.4		
	MS20470D5	5.3	5.5	7.2	3.5		
	MS20470DD6	3.4	3.6	4.6	2.5		
	MS20470B5					5.0	5.9
	MS20470B6					4.2	4.4
.070 to .074	MS20470AD5	7.1	7.5	9.7	4.7		
	MS20470D5	5.6	5.9	7.7	3.8		
	MS20470DD6	3.6	3.8	4.9	2.5		
	MS20470DD8	2.1	2.2	2.8	1.9		
	MS20470B5					5.1	6.3
	MS20470B6					4.2	4.4
.075 to .079	MS20470D5	6.0	6.3	8.2	4.0		
	MS20470DD6	3.9	4.1	5.3	2.6		
	MS20470DD8	2.2	4.3	3.0	1.9		
	MS20470B5					5.4	6.7
	MS20470B6					4.2	4.7
.080 to .084	MS20470D5	6.4	6.7	8.7	4.3		
	MS20470DD6	4.1	4.3	5.6	2.7		
	MS20470DD8	2.3	2.4	3.2	1.9		
	MS20470B5					5.8	7.1
	MS20470B6					4.2	5.0

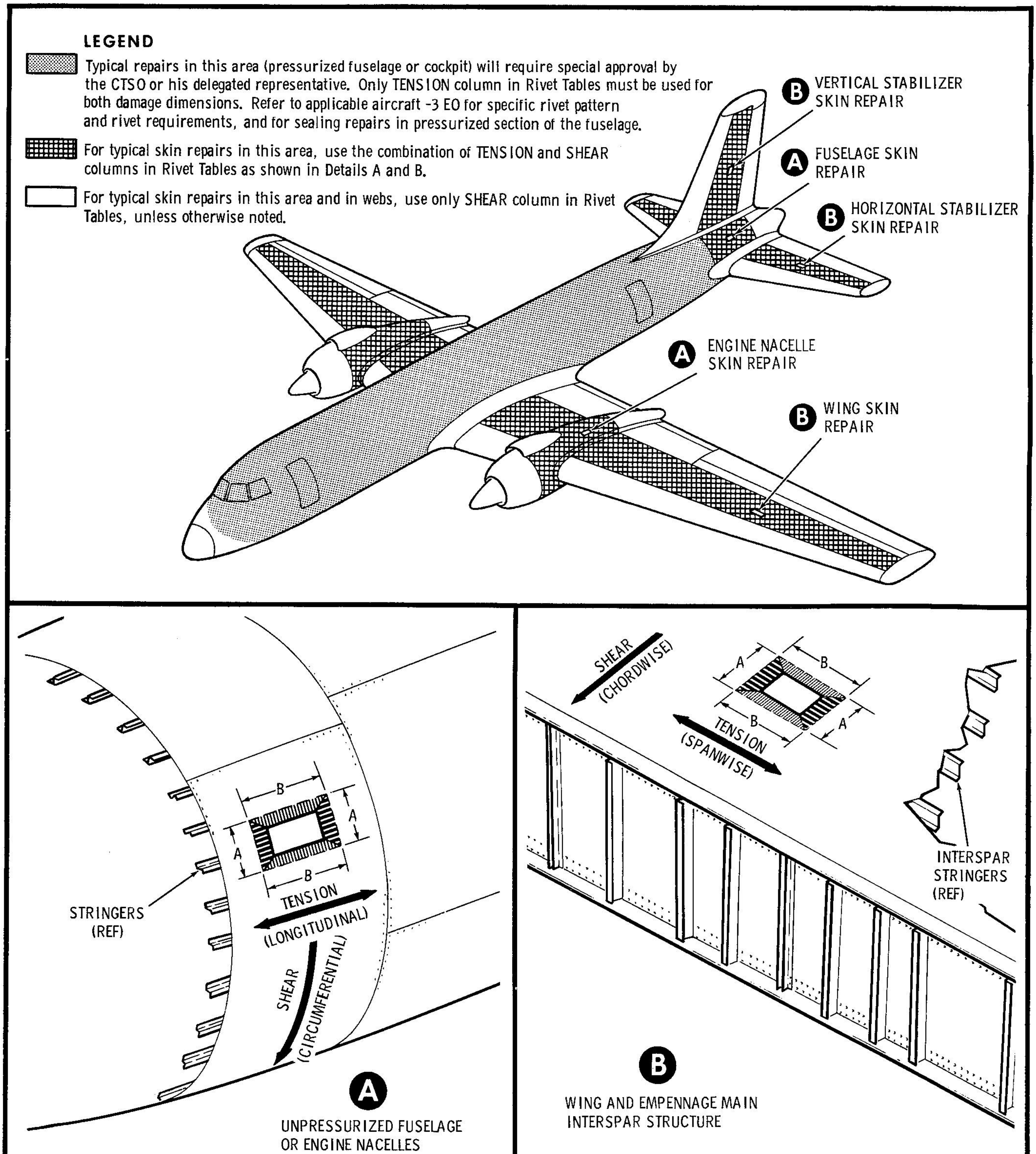
Figure 18 (Sheet 2 of 3) Rivet Table - Extruded Sections

THICKNESS OF EXTRUSION	TYPE AND DIAMETER OF RIVET	NUMBER OF RIVETS PER INCH OF DAMAGE FOR ONE SIDE OF JOINT ONLY					
		ALUMINUM ALLOY				MAGNESIUM ALLOY	
		24S-T4	26S-T6	75S-T6	65S-T6	AZ61A	AZ80A
.085 to .089	MS20470D5	6.8	7.1	9.2	4.5		
	MS20470DD6	4.3	4.6	5.9	2.9		
	MS20470DD8	2.4	2.6	3.3	1.9		
	MS20470B5					6.1	7.6
	MS20470B6					4.3	5.3
.090 to .094	MS20470DD6	4.6	4.8	6.3	3.1		
	MS20470DD8	2.5	2.6	3.4	1.9		
	MS20470B5					6.5	8.0
	MS20470B6					4.5	5.8
.095 to .099	MS20470DD6	4.8	5.1	6.6	3.2		
	MS20470DD8	2.6	2.8	3.6	1.8		
	MS20470B5					6.8	8.4
	MS20470B6					4.7	5.8
.100 to .104	MS20470DD6	5.0	5.3	6.9	3.4		
	MS20470DD8	2.8	2.9	3.8	1.9		
.105 to .109	MS20470DD6	5.3	5.6	7.3	3.6		
	MS20470DD8	2.9	3.1	4.0	2.0		
.110 to .114	MS20470DD6	5.5	5.7	7.5	3.7		
	MS20470DD8	3.0	3.2	4.2	2.0		
.115 to .119	MS20470DD6	5.8	6.1	7.9	3.9		
	MS20470DD8	3.2	3.3	4.3	2.1		
.120 to .125	MS20470DD6	6.1	6.4	8.3	4.1		
	MS20470DD8	3.4	3.6	4.6	2.3		

NOTE

Refer to text and appropriate repair examples for method of using Rivet Tables.

Figure 18 (Sheet 3 of 3) Rivet Table - Extruded Sections



NOTES

1 For damage dimensions marked A, use required number of rivets from TENSION column in Rivet Tables and distribute them in cross-hatched area A.

2 For damage dimensions marked B, use required number of rivets from SHEAR column in Rivet Tables and distribute them in cross-hatched area B.

3 For method of laying out rivets, see applicable illustrations: Rivet Distribution Pattern.

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Figure 19 How to Use TENSION and SHEAR Columns in Rivet Table

BUTT JOINT (SPLICE)

160 When joining two parts, using a butt strap, the required number of rivets, obtained from rivet tables for each side of the break, must be distributed evenly on each side of the joint. See Figure 21, Sheet 6, for rivet distribution pattern and an example of butt joint.

SKIN AND WEB REPAIRS

GENERAL

161 Typical repairs in this Engineering Order are applicable to stressed skins. Damage to non-stressed skin, which may be considered as tertiary structure, may be repaired using similar methods to those illustrated, except that rivet requirements do not have to be calculated from Rivet Tables. In most cases a double row of staggered rivets, of the same type, material and diameter as employed by the manufacturer, will be adequate for repair of damage. For typical repair procedure, refer to Paragraph 150, preceding.

TYPES OF SKIN REPAIR

162 Damage may occur in two types of skin: open or closed. Open skin is accessible for repair from both sides and solid type rivets must be used. Closed skin is accessible from one side only and the following repair methods may be used:

(a) External patch using blind rivets. This will be a field repair and although structurally adequate it should be reworked to a permanent flush repair when opportunity permits.

(b) Small flush repair using an internal doubler which can be inserted under the skin through a cleaned-up hole, and a skin filler. Both the doubler and the skin filler are riveted with blind rivets. (See Figures 37 and 39.)

(c) Large flush repair using internal open-centre doubler and skin filler. Solid rivets are used for attachment of the doubler to the skin. The open centre in the doubler must be just large enough to permit insertion of rivet bucking bar. Skin filler is secured to doubler with blind rivets. (See Figure 21, Sheet 5, and Figure 38.)

METHODS OF SKIN REPAIRS

163 Figures 24 to 39 inclusive, illustrate the principles of skin repair showing various methods of positioning skin repair doublers and distributing repair rivets depending on the location of damage. These repair examples, as they are, may be used only if the location and the extent of damage and the number of required rivets fall within the pattern shown, otherwise the repair scheme must be modified to conform with the actual damage.

WEB REPAIRS

164 Patch repair to spar, frame and rib webs are similar to open and closed stressed skin repairs, except that protruding-head rivets must be used where possible, and web filler is usually not necessary.

165 Rivet requirements for damage in web only should be calculated from rivet tables, using SHEAR column; for damage penetrating into flanges or into web area attached to capping, TENSION column must be used (see Figure 41).

166 Partial replacement or insertion repair of webs requires a specially shaped butt strap and irregular rivet pattern to counteract the bending moment (see Figure 42).

REPAIR DOUBLER

167 Since the full load in the repair area is transmitted to the repair doubler the material of the doubler and its properties must be at least equal to the original member. General practice is to use a repair doubler of one gauge heavier than the original to compensate for bending loads induced by the eccentric position of the doubler. There may be cases of repetitive damage requiring a doubler of heavy gauge, in which structural engineering approval from AMCHQ should be obtained to ascertain that overstrength repair will not transmit local loads to adjacent structure. For skin and web repairs, the thickness of doubler is given in rivet tables.

168 Dimensions of the repair doubler will be determined by rivet pattern. Final assembly of doublers is to be made with generous coat of wet zinc chromate primer between the mating faces to avoid corrosion. If flush rivets are

used with an external skin doubler, make the doubler of sufficient thickness to allow for countersinking.

SKIN FILLER

169 Skin fillers should be of the same material and thickness as the skin. There must be a clearance all round between the edge of the filler and the skin of 1/64 inch minimum and 1/16 inch maximum. Assemble the filler to the doubler using wet zinc chromate primer between mating surfaces. In skin repair where a solid doubler is used, the filler-to-doubler attachment is not subject to heavy loading. Secure filler to doubler with smallest structural-type rivets or spot-weld, using rivet pattern sufficient to hold the filler snug to the doubler.

170 In blind repair where a doubler with open centre is used, the strength of the filler and rivet pattern through filler and doubler must be adequate to rebuild the reduced strength of the doubler owing to removed material. Calculate the number of rivets from rivet tables, for dimensions of opening, and lay out rivet pattern according to direction of loading.

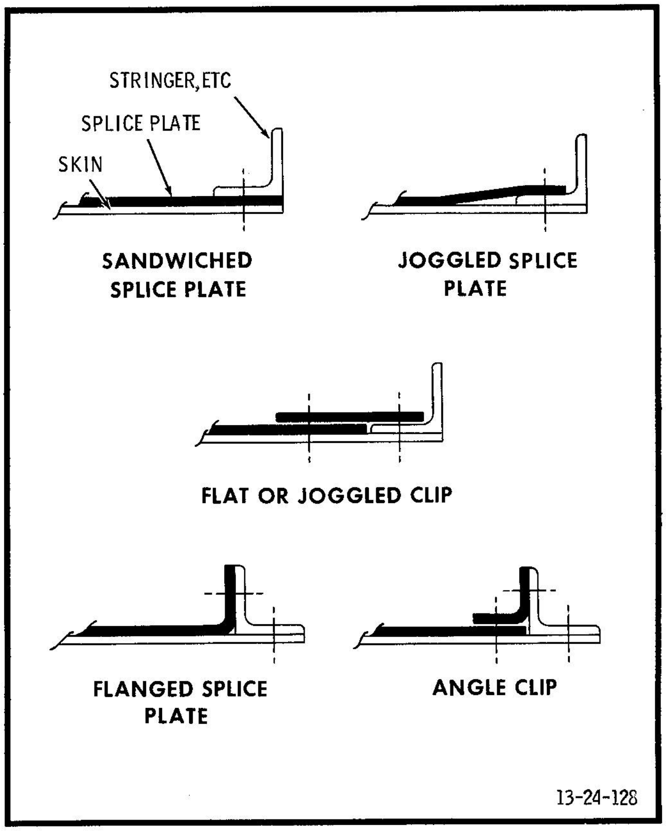


Figure 20 Splice Plate End Attachments

SKIN SPLICING

NOTE

The following does not apply to integral fuel tanks and pressurized section of the fuselage.

171 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.

172 There are three types of splices in common use, the lap splice, the butt splice and the joggle splice (see Figure 21, Sheet 6). 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.

173 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. A lap joint of thin sheet should be backed up by a stiffening section. 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 in Figure 20.

174 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.

175 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 Figure 15.

(d) 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 (refer to Paragraphs 118 and 119, preceding). The gauge of the splice plate must be at least as great as the gauge of the sheets for protruding-head and dimpled riveting. Suitable gauge must be used where rivet holes in the plate are to be sub-countersunk.

(e) Where sheet splicing requires calculation of repair rivets, see Figure 17.

RIB AND FRAME REPAIRS

GENERAL

176 Typical methods of repair to ribs, diaphragms and frames are illustrated in Figures 43 to 52 inclusive, covering damage to attach and free flanges, damage to flange and web, cracks at corners and at stringer cut-outs, and splicing. Although repair examples may not fall within requirement of actual damage, close study of the principles given and typical repair procedure in Paragraph 150, preceding, will facilitate the design of the required repair.

REPAIR TO FLANGES

177 Figures 43 to 45 inclusive, show typical repairs to various type and location of damage in ribs, diaphragms and frames. Selection of repair material, rivet requirement and distribution are detailed in Paragraphs 178 and 179, following. Not less than two rivets must be used in flanges on each side of damage.

REPAIR TO FLANGE AND WEB

178 Repair to damage in flange and web is illustrated in Figure 43. Rivet requirements must be separately calculated for damage in flange using TENSION column and for damage in web SHEAR column in Rivet Tables (see Figure 17).

SPLICING

179 The same principles that are used for formed standard section splicing, refer to Paragraph 184, following, may be applied to ribs, diaphragms and intermediate frames, considering the following points:

(a) Rivet requirements for free and attach flanges must be calculated from TENSION column and for webs from SHEAR column in Rivet Tables (see Figure 17).

(b) Splicing should be made, if possible, at an existing stiffener, otherwise it should be backed up by a stiffening section.

(c) Conventional frames of channel or Z-section are relatively deep and thin compared to stringers, and usually fail by twisting or by buckling of the free flange. The splice joint should be reinforced against this type of failure by using a splice plate heavier than the frame, and by splicing the free flange of the frame with a flange of the formed splice plate, as illustrated in Figure 52. Since a frame is likely to be subjected to bending loads, the length of splice plate should be more than twice the width of frame web, and the rivets spread out to cover the splice plate.

(d) Rivet pattern in web should be such that one or two extra rivets be placed in rows close to flanges (see Figure 52).

FORMED AND EXTRUDED STANDARD SECTIONS

GENERAL

180 Typical repairs in this Engineering Order cover damage to free and attach flanges, and splicing of formed and extruded standard sections used in construction as stringers, stiffeners and rib or frame capping. Before commencing any repair, refer to Paragraph 2, preceding, and to applicable aircraft -3 EO for limitations on repairs in restricted areas and to highly stressed members in primary structure. Steps of typical repair procedure in Paragraph 150, preceding, must be followed.

REPAIR TO FLANGES

181 Repair methods for formed or extruded section flanges may be used only if the damage does not penetrate farther than the end of bend or fillet radius. Where the damage has penetrated into the web of a section, the damage must be considered as a cut through the whole section and repair by splicing must be used. Typical repairs to damaged attach flanges may also be used for skin repairs which require cutting out a portion of section flange in order to permit installation of skin or web repair doubler.

182 Damage to free or attach flange beyond negligible limits, regardless of its extent, will require reinforcement in form of an angle; a repair strip alone is not permissible. Repair angle should be made, if possible, of the same material as the original section. The cross-sectional area of the repair angle flange (width of flange multiplied by thickness) adjacent to the damaged flange must be the same or greater but never smaller than that of the flange of original section. Where repair angle flange must not protrude, or when repair angle must be positioned on the inside, heavier gauge reinforcements must be used to produce the required strength.

183 Repair rivets in attach flange must be of the same diameter as existing. Number of rivets required for repair of damage must be calculated from applicable rivet tables, using Figure 17 for formed sections and Figure 18 for extruded sections. The number of rivets given in the tables is for one side of the damage only. The minimum damage dimension for repair rivet calculation in free and attach flanges is the distance across the flange measured from the edge to the bend or fillet radius. For damage penetrating into bend or fillet radius the true dimension must be taken. Distribution of repair rivets is shown in Figure 22, and applicable repair examples.

SPLICING

184 Typical arrangement of the splicing members for various shapes of formed and extruded sections is shown in Figure 23. Splices must be designed to carry both tension and compression loads and Figures 56, 57, 60, 61 and 62 will be used as an example illustrating the following general principles:

(a) To avoid eccentric loading and consequent buckling in compression, splicing members must be placed as symmetrically as possible about the centre-line of the section and attachment made to as many elements as necessary to prevent bending in any direction.

(b) To avoid reducing the strength in tension of the original section, the rivet holes in the attach flange reinforcement must not be larger than the existing, and the rivet holes in the web must be staggered back from the ends. The cross-sectional area at any point, reduced by repair rivet holes must not be greater than that at the manufacturers splice existing in the section being spliced. In general the rivets must be arranged in the splice so that the design tensile load for the section and splicing member can be carried into the splice without failing the section at the outermost rivet holes.

(c) To avoid concentration of load on the end rivet and consequent tendency toward progressive rivet failure, the splicing member must be tapered off at the ends.

185 The preceding principles are especially important in splicing stringers on the lower surface of stressed skin wings, where high tension stresses exist.

186 When splicing an extruded or formed section, each flange and web must be treated as separate element. Splice material should, if possible, be the same as the original. If substitution is necessary, refer to Paragraph 118,

preceding. When the same material is used for the splicing member as for the original section, the net cross-sectional area (i.e., the black area in Figure 23) of the splicing member should be greater than the area of the section element which it splices. The area of a section element (e.g., protruding leg of an angle) is equal to the height multiplied by the thickness.

187 Generally there are three alternatives in the selection of splice members of extruded sections.

(a) Modify available extruded section by machining it to dimensions to suit the repair.

(b) Select a satisfactory existing formed section.

(c) Fabricate a section out of alclad sheet of required thickness.

188 The rivet requirement for each element of a section and pattern for splicing extruded and formed sections are detailed in repair examples. For splicing formed sections of all shapes use only TENSION column in rivet tables in Figure 17. For splicing extruded sections, required rivets must be taken from rivet tables in Figure 18.

NOTE

The number of rivets given in the tables is for one side of the joint only.

189 If a filler is used between the end of the original member, the rivet pattern must be carried through, and the rivets required will be in addition to the amount stated in the tables. The length of the splice members must be sufficient to accommodate the required number of rivets while complying with minimum rivet spacing.

LIMITATIONS

190 The following limitations apply to splicing stringers in primary structure.

(a) Stringers in interspar structure especially on lower surface of the wing, must not be spliced using typical repair without engineering approval from AMCHQ.

(b) Both splice joints of insertion stringers must not be made in the same bay.

(c) No splice joints are allowed in a bay where there is a transverse skin joint.

(d) Adjacent stringers should not be spliced in the same bay, but must be staggered.

(e) Typical splicing is not applicable to section thickness greater than 0.100 for formed sections and 0.125 for extruded sections, unless approved by AMCHQ.

MISCELLANEOUS REPAIRS

GENERAL

191 Miscellaneous repairs shown in Figures 63 to 70 inclusive, cover various types of damage, such as cracked dimples, damage to lightening holes, flight control tabs, trailing edge sections, provision of access panels, honeycomb repair, etc. Some of the repairs are self-contained not requiring rivet tables, others are based on the principles of typical repair procedure.

OIL-CANNING

DEFINITIONS

192 The definitions are:

(a) Bay - A bay is defined as an area of skin surrounded by structural members (e.g., frames, stiffeners, stringers).

(b) Buckle - A buckle is defined as a deformation of the skin out of its original contour which may or may not be permanent.

(c) Cricket - A cricket is defined as a buckle which "pops" in and out as soon as normal pressure is applied and removed.

(d) Oil-can - An oil-can is defined as a permanent buckle which when "popped" inward remains inward, i.e., has two positions of equilibrium (in or out). This buckle may appear as an outward bulge somewhere else and if so, pressure on the new buckle will cause the original buckle to "pop" out again.

NOTE

Because the bay which is oil-canning contains excess metal, it may be moved to either side of its mean position without much effort. Skin bays which can only be moved in and out by considerable force, thus straining the skin, are not considered to be oil-canning.

(e) Skin Panel - A skin panel is defined as an area of skin consisting of a single piece of material.

GENERAL INFORMATION

193 Oil-canning or panting can be said to have taken place when an area of skin has stretched so that it does not follow the correct contour of the surface. It may be caused in various ways:

(a) By insufficient care being taken when riveting the skin, a fault unlikely to be found in a new aircraft.

(b) By rivets working loose due to structural vibration, or by the attachment holes in the skin becoming enlarged or elongated.

(c) By the skin itself stretching due to air and ground loads or more often due to personnel walking on areas of skin not designed for such a purpose.

(d) By the skin itself stretching due to extreme thermal conditions, particularly in relatively stiff structures, etc.

194 Many areas show signs of oil-canning only after long service. The areas most likely to be affected are:

(a) Sections of the fuselage in line with the propeller disc and, areas adjacent to the exhaust pipes of all types of engines.

(b) Areas surrounding the attachment points for the undercarriage.

(c) Areas around hatchways or large cutoucs.

(d) Large or highly flexible skin bays.

195 The load carrying capacity of a panel is divided between the skin and its edge members, the skin carrying the shear loads while the edge members (frames, bulkheads, stringers) react to compressive and tensile end loads. When such end loaded and shear carrying components of the structure are loaded under various static and dynamic flight and ground conditions the body skin is expected to buckle. This is not evidence of failure. On the contrary, the condition shows that the structure is acting as designed. However, the buckles do pose the problem of appearance and tend to arouse a suspicion that the structure has been overloaded or has failed. Oil-canned bays sometimes accompany load effects of a more serious nature which warrant more detailed attention. In these cases, the structure would be permanently strained and the oil-cans would be due to the structure being out of its mean position and not just another case of buckling alone. For this reason, all oil-cans should be carefully inspected.

196 Although oil-canning is objectionable from the appearance standpoint, it does not, in general, impair the strength of the structure. Continual working of the skin, however, may tend to loosen the rivets after a time and for this reason a periodic inspection of attachment rivets is recommended.

INSPECTION

197 It is both impractical and unnecessary to replace all the panels which contain oil-canned bays. The following data is intended as a guide in ascertaining whether a repair should be effected or a panel replaced.

198 Oil-cans are of three types:

(a) Single Bay - The original buckle and any other associated buckle are in one bay.

(b) Double Bay - The original buckle is in one bay and a buckle created by pushing the original buckle inward is an adjacent bay.

(c) Multi Bay - The buckle crickets and reappears across at least three or more bays by crossing two or more stiffeners, frames, or stringers.

199 The skins should be inspected for:

(a) Tilted or loose rivets particularly in the corners of the buckled panels.

(b) Evidence of cracks in the skin. The most likely origin will be at a corner rivet or along the rivet row.

(c) A buckle that crosses a line of rivets. This almost invariably means that either the rivets adjacent to the buckle crossing have failed or that the internal members, to which the skin is riveted have failed.

(d) Oil-cans - Consideration should be given to the method used in supporting the structure, which may cause deflections which would not occur during flight, thus giving rise to oil-cans.

NOTE

Edge members should be inspected for cracks and deformation, particularly local wrinkling which is evidence of failure.

REPAIR

200 It is to be noted that the repairs discussed herein are of a general nature only and in no way take precedence over the approved repair methods and schemes for a particular aircraft type.

(a) Popped, tilted, or loose rivets should be replaced.

(b) Cracked skins should be repaired in accordance with the methods contained in the applicable aircraft -3 EO or this EO.

(c) Oil-cans - Crickets, and single bay oil-cans which are not deeper than 1/50 of the shortest dimension of the bay, are both acceptable except in the vicinity of vibratory sources such as in the plane of the propeller disc or by the exhaust pipes of all types of engines.

(d) Single bay oil-cans within limits but which cause an unpleasant drumming sound when taxiing or in flight, very large single bay oil-cans which are just beyond limits, and crickets and single bay oil-cans near vibratory sources may be repaired by applying sound deadener such as 3M product EC-244 (Item 19, Figure 71) to the inside of the bay.

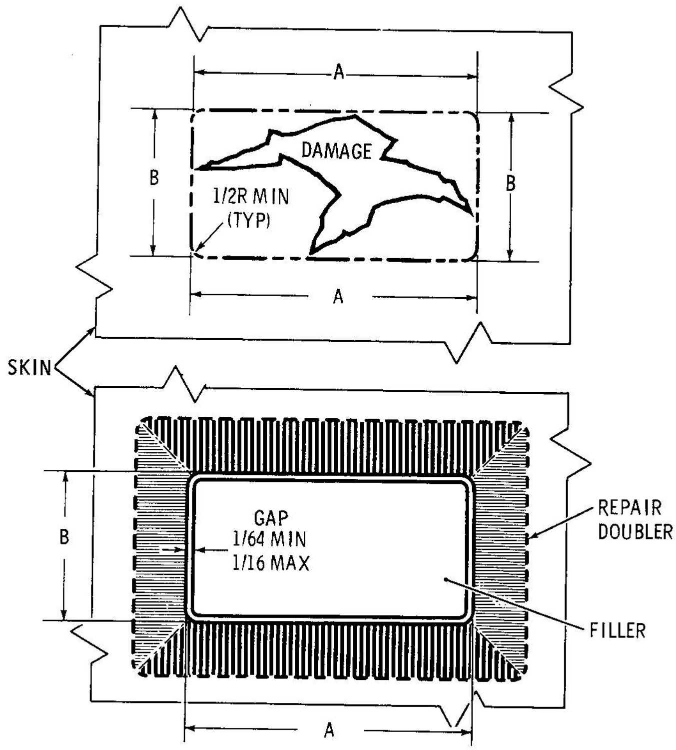
(e) Single bay oil-cans definitely beyond limits and double bay oil-cans should be repaired by fitting stiffeners to the skin in the affected bays. For stiffening the skin, a free floating stiffener is preferred to a fixed stiffener (a stiffener tied into the surrounding frames, bulkheads, or stringers) because a stiffener if fixed would unload the skin and introduce concentrated loads into the members to which it is attached at points, and of a magnitude not considered in the design analysis of the particular structure. The only time that a fixed stiffener should be used is when the repair instructions specifically state that this may be done or when the reserve factors are adequate after a new analysis of the particular area has been carried out with the effect of the stiffener considered.

(f) Stiffeners, in general, when used to rectify oil-cans should be as light as possible and still restrain the buckled skin. The ends, in particular should be cut back at a maximum angle of 30° to the plane of the skin and not merely cropped. This will allow the skin to work to some degree and help to prevent the formation of fatigue cracks in the skin, at the ends of the stiffeners, which are often caused by excessive stiffness next to a flexible area. The stiffeners should be fitted parallel to either the frames or the stringers, never diagonally, the preferred orientation being parallel to the long side of the bay. The ends of the stiffeners should be clean, free from burrs and smooth. Allowance should be made for any curvature of the skin so that the stiffener fits properly. The stiffener should run to about 1/2 inch from either end of the bay. Riveting of the stiffeners to thin skins should be of the highest quality as damage can easily occur and all rivets should be installed wet with zinc chromate primer.

(g) The stiffener section preferably should be either angle, or open channel with its web secured to the skin. Rolled sections are preferred to extruded sections due to the sharp edge on the latter in standard sections. The gauge should be the gauge of the skin. For stiffening purposes, 1/2 inch flanges generally will be sufficient.

(h) Panels containing multi-bay oil-cans and panels containing severe oil-cans, regardless of type, should be either partially replaced in the area of the cans or totally replaced.

201 Damaged edge members should be repaired in accordance with the methods contained in the applicable aircraft -3 EO or this EO.



RECTANGULAR REPAIR

STEPS

1. Trim out damage to rectangular shape as shown.
2. Establish direction of tension and shear stresses.
3. Find the number of rivets required for each side of damage from Rivet Tables.
4. Space required rivets for each side A in area [vertically hatched]
   Space required rivets for each side B in area [horizontally hatched]
5. Observe minimum edge distance and minimum and maximum rivet pitch.
6. The size of repair doubler will be determined by rivet pattern.
7. Secure filler to doubler with smallest structural rivets, or spot-weld.

NOTES

1. If damage of A length requires, for example, 15 rivets, and that of B length 10 rivets, the total number of rivets required for repair will be 50.
2. Opposite rivet patterns should be identical, unless existing rivets are to be picked up.
3. Refer to Typical Repair Procedure in text.

REPAIR EXAMPLE

DAMAGED SKIN: 0.025 Clad 24S-T4

DIMENSIONS OF DAMAGE: 6 inches in shear
3 inches in tension

RIVET CHOSEN: MS20426AD4 (Rivet holes dimpled)

REPAIR DOUBLER: 0.028 Clad 24S-T4

RIVETS REQUIRED FROM RIVET TABLES:
In shear: 6 inches x 2.7 rivets per inch = 17 rivets (+)
In tension: 3 inches x 4.1 rivets per inch = 13 rivets (⌖)

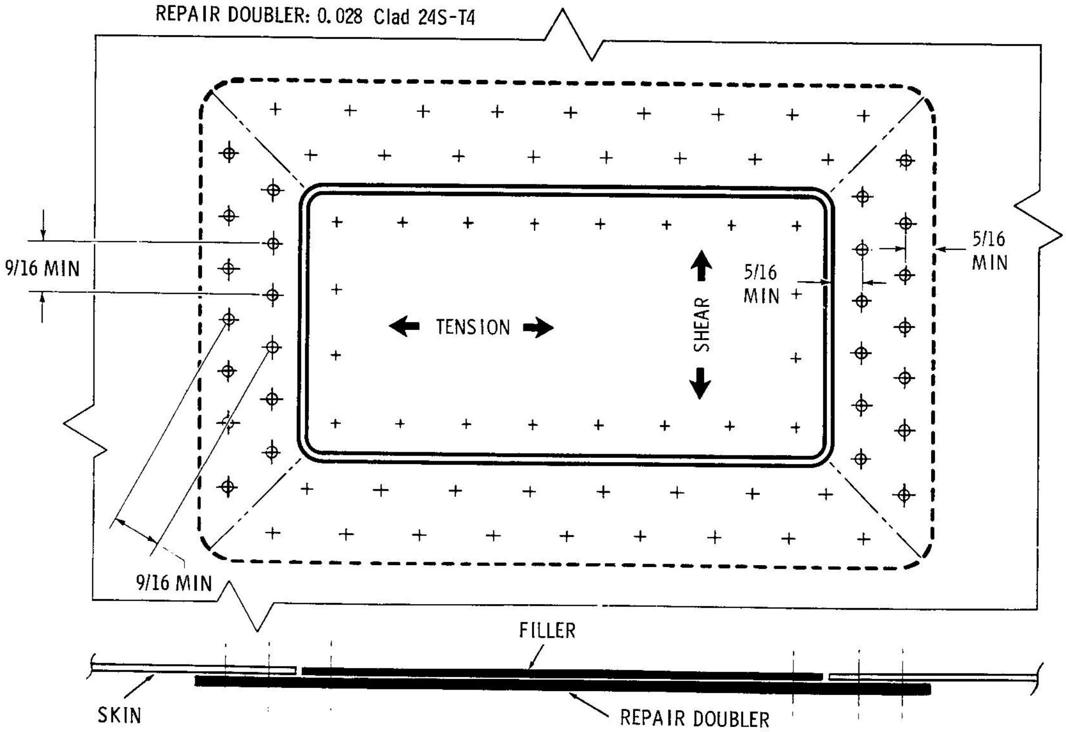


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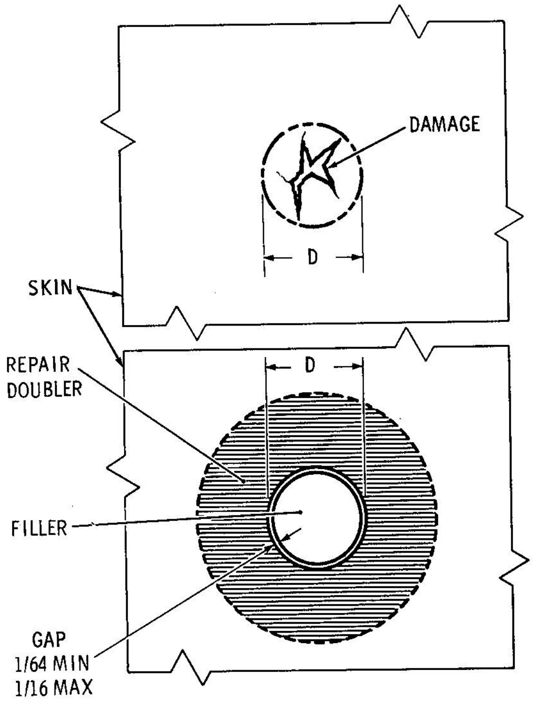
Figure 21 (Sheet 1 of 6) Rivet Distribution Pattern - Rectangular Repair



CIRCULAR REPAIR

STEPS

1 Trim out damage to circular shape as shown.
2 Calculate the length of damage by multiplying diameter of the hole by 3.
3 Find the number of rivets required for the length of damage using TENSION or SHEAR column in Rivet Tables. (See Notes.)
4 Space required rivets evenly around the hole in shaded area.
5 Observe minimum edge distance and minimum and maximum rivet pitch.
6 The size of repair doubler will be determined by rivet pattern.
7 Secure filler to doubler with smallest structural rivets, or spot-weld.

NOTES

1 For circular repairs in primary and secondary structures use TENSION column and in tertiary structures use SHEAR column in Rivet Tables.
2 Refer to Typical Repair Procedure in text.

REPAIR EXAMPLE

(SECONDARY SIRUCTURE)

DAMAGED SKIN: 0.032 Clad 75S-T6

LENGTH OF DAMAGE: 2 inch diameter x 3 = 6 inches

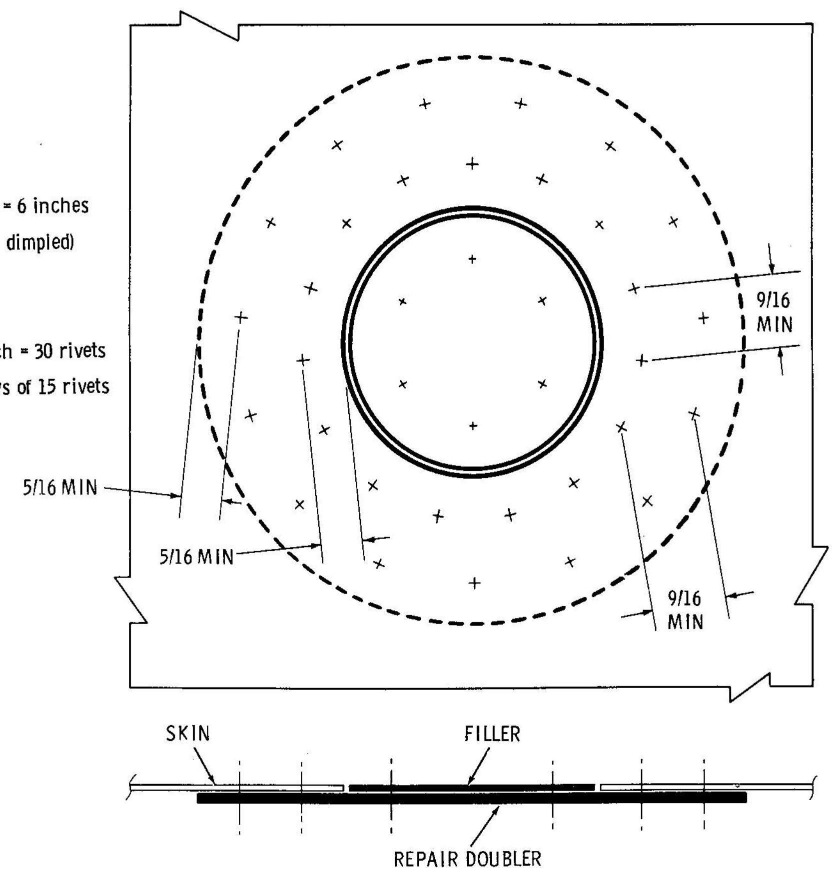
RIVET CHOSEN: MS20426AD4 (Rivet holes dimpled)

REPAIR DOUBLER: 0.036 Clad 75S-T6

RIVETS REQUIRED FROM RIVET TABLES:

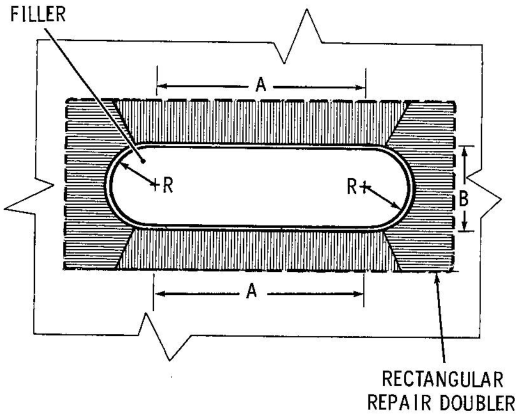
In tension: 6 inches x 5 rivets per inch = 30 rivets

RIVET DISTRIBUTION: Two staggered rows of 15 rivets in each are used.



13-24-61

Figure 21 (Sheet 2 of 6) Rivet Distribution Pattern - Circular Repair



STEPS

1 Trim out damage to oval shape as shown.

2 Establish direction of tension and shear stresses.

3 Find the number of rivets required for each side of damage from Rivet Tables. (See Notes.)

4 Space required rivets for each side A in area [vertical hatch]

Space required rivets for each side B (3R) in area [horizontal hatch]

5 Observe minimum edge distance and minimum and maximum rivet pitch.

6 The size of repair doubler will be determined by rivet pattern.

7 Secure filler to doubler with smallest structural rivets, or spot-weld.

NOTES

1 The length of damage B must be calculated by multiplying radius (R) by 3.
B = 3R

2 Refer to Typical Repair Procedure in text.

REPAIR EXAMPLE

DAMAGED SKIN: 0.040 Clad 75S-T6
DIMENSIONS OF DAMAGE:
In Shear: 2 inches
In Tension: 0.75R x 3 = 2.25 inches

RIVET CHOSEN: MS20470AD4 (Protruding-head)
REPAIR DOUBLER: 0.045 Clad 75S-T6
RIVETS REQUIRED FROM RIVET TABLES:
In Shear: 2 inches x 4.5 rivets per inch = 9 rivets
In Tension: 2.25 inches x 7.5 rivets per inch = 17 rivets

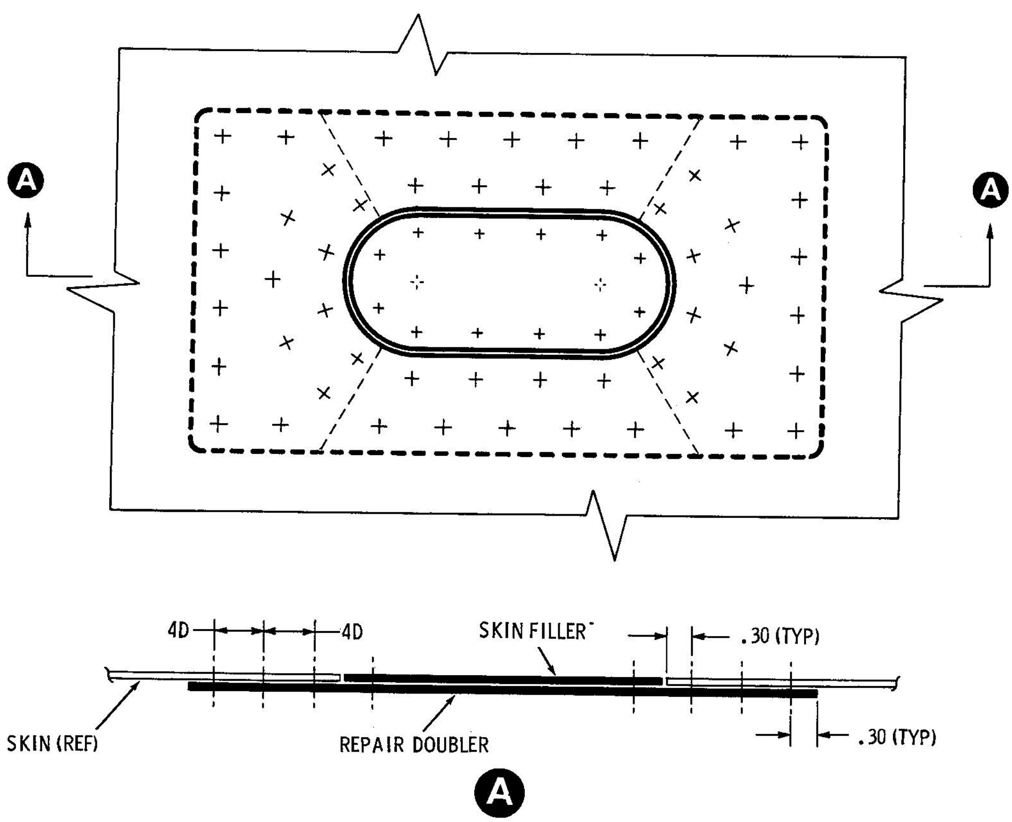
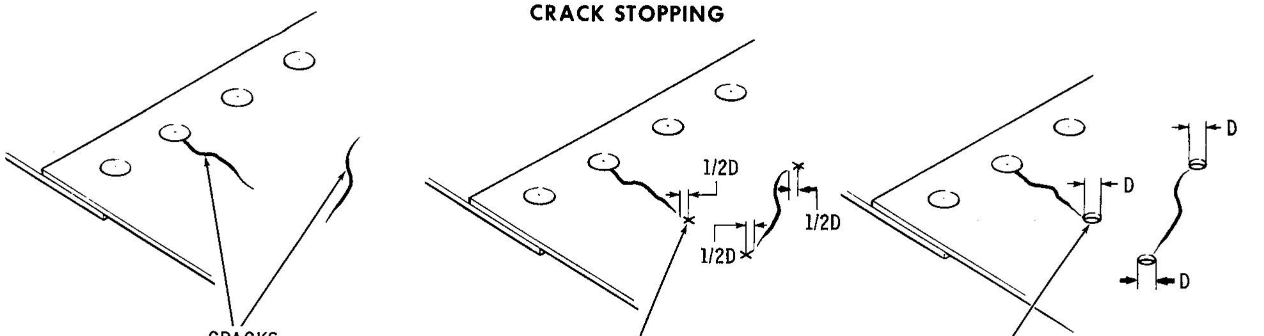


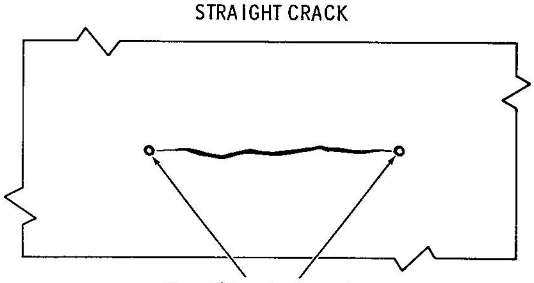
Figure 21 (Sheet 3 of 6) Rivet Distribution Pattern - Oval Repair

CRACK STOPPING

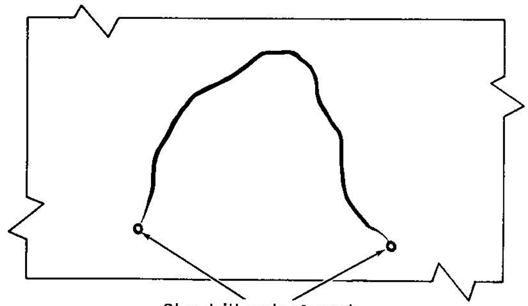


CRACK REPAIR

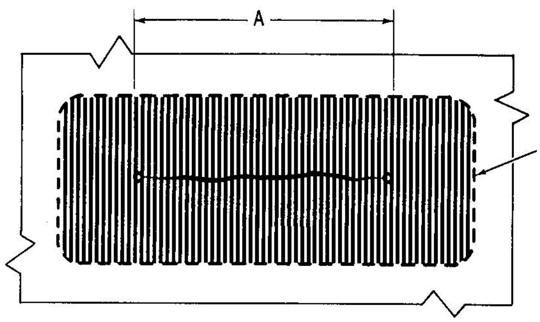
STRAIGHT CRACK



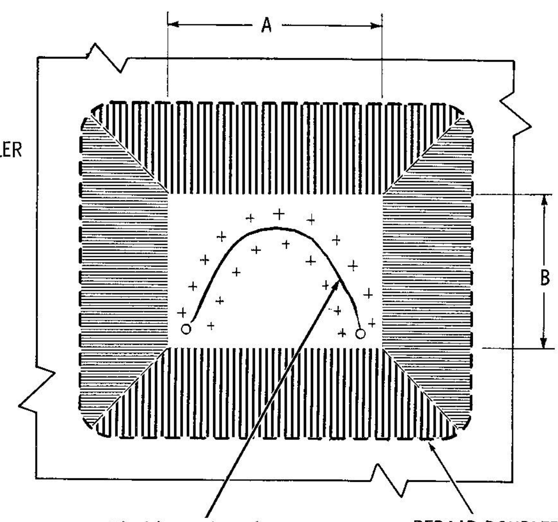
IRREGULAR CRACK



THIS DAMAGE HAS ONLY ONE DIMENSION - A



THIS DAMAGE HAS TWO DIMENSIONS - A AND B



NOTES

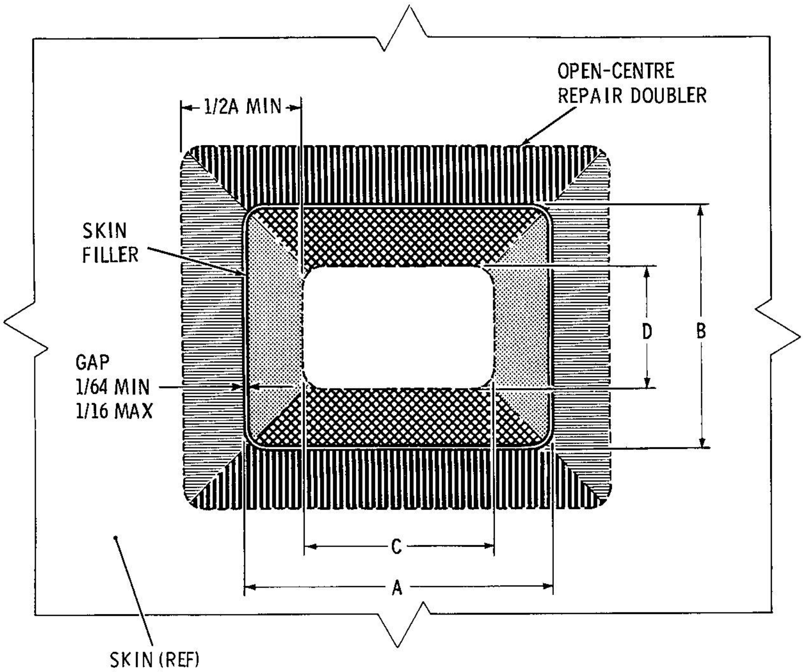
1. Depending on the shape of crack, use circular, rectangular or oval repair. See Sheet 1, 2 or 3 for applicable information.
2. Hair cracks longer than 2 inches, or cracks with a tendency to open, must be repaired by cutting out damage to a regular shape.
3. Calculate the number of rivets required for repair from Rivet Tables. Refer to Typical Repair Procedure in text and see appropriate illustrations.
4. Observe minimum edge distance, and minimum and maximum rivet pitch.

13-24-63

Figure 21 (Sheet 4 of 6) Rivet Distribution Pattern - Crack Repair

DAMAGE IN CLOSED SKIN

(FLUSH REPAIR WITH OPEN-CENTRE DOUBLER)



STEPS

1 Trim out damage to regular shape as indicated by A and B dimensions.

2 Establish direction of tension and shear stresses.

3 Find the number of rivets required for each side of damage from Rivet Tables.

4 Space required rivets as follows:
(a) Damage in Skin:
For each side A in area
For each side B in area
(b) Opening in Doubler:
For each side C in area
For each side D in area

5 Observe minimum edge distance and minimum and maximum rivet pitch.

6 The size of repair doubler will be determined by rivet pattern.

NOTES

1 Rivet requirements from Rivet Tables must also be taken for opening in the doubler.

2 Refer to Typical Repair Procedure in text.

REPAIR EXAMPLE

DAMAGED SKIN: 0.025 Clad 24S-T4
DIMENSIONS OF DAMAGE: 5-1/2 by 4-1/2 inches in Shear

RIVET CHOSEN: MS20426AD4 for attachment of doubler to skin. (Dimpled holes)
MS20601AD4 for attachment of filler to doubler. (Dimpled holes)

REPAIR DOUBLER: 0.028 Clad 24S-T4 (With open centre to permit the use of solid rivets.)

RIVETS REQUIRED FROM RIVET TABLES:
For attachment of doubler to skin:
5.5 inches x 2.7 rivets per inch = 15 rivets
4.5 inches x 2.7 rivets per inch = 13 rivets
For attachment of filler to doubler:
2.8 inches x 4.9 rivets per inch = 14 rivets
2.0 inches x 4.9 rivets per inch = 10 rivets

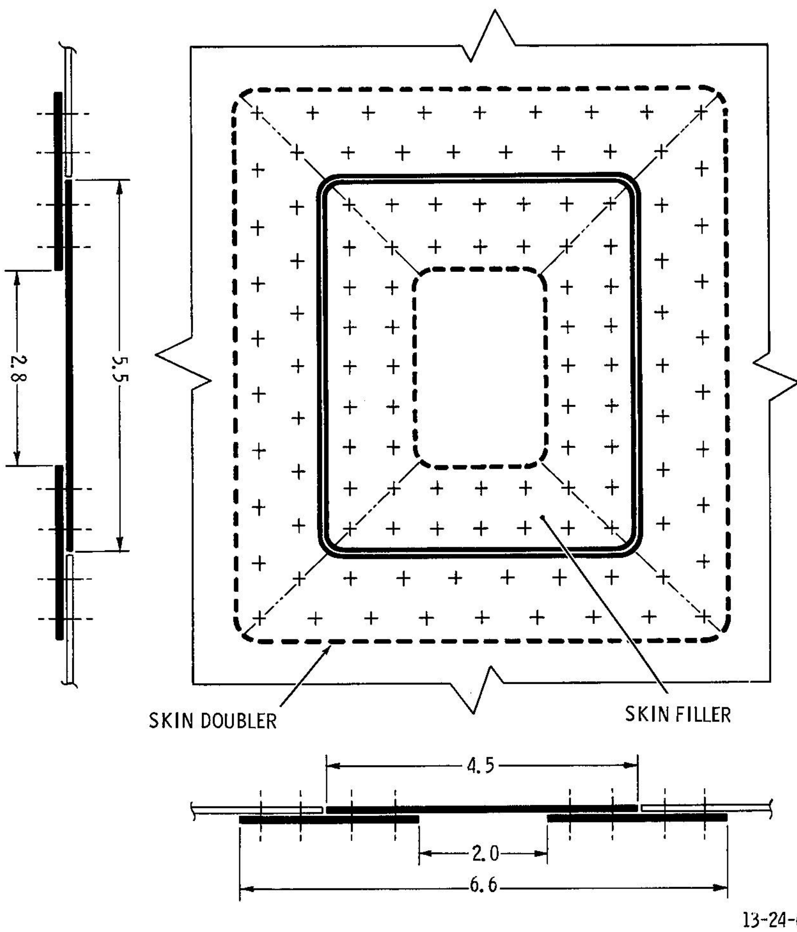
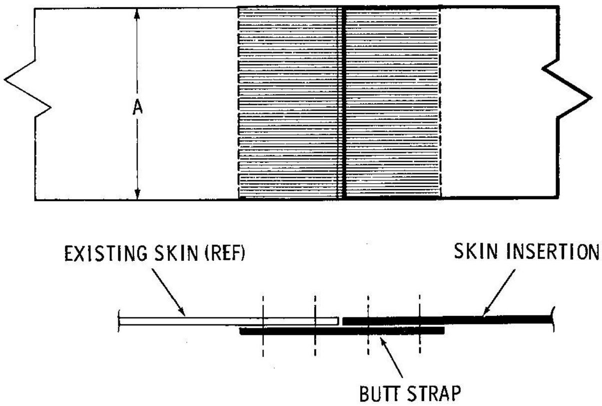
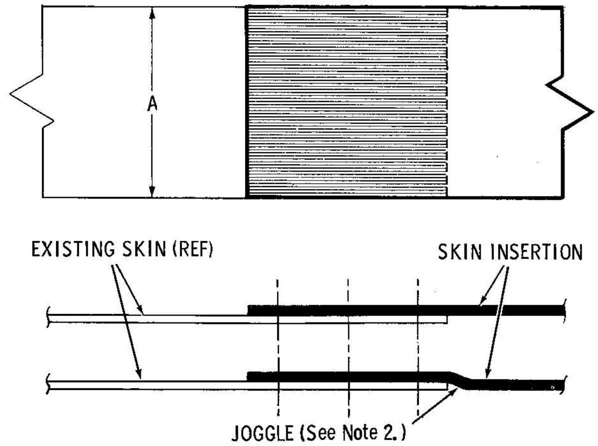


Figure 21 (Sheet 5 of 6) Rivet Distribution Pattern - Blind Repair

BUTT JOINT



OVERLAP JOINT



STEPS

1 Cut skin midway between existing rivets.

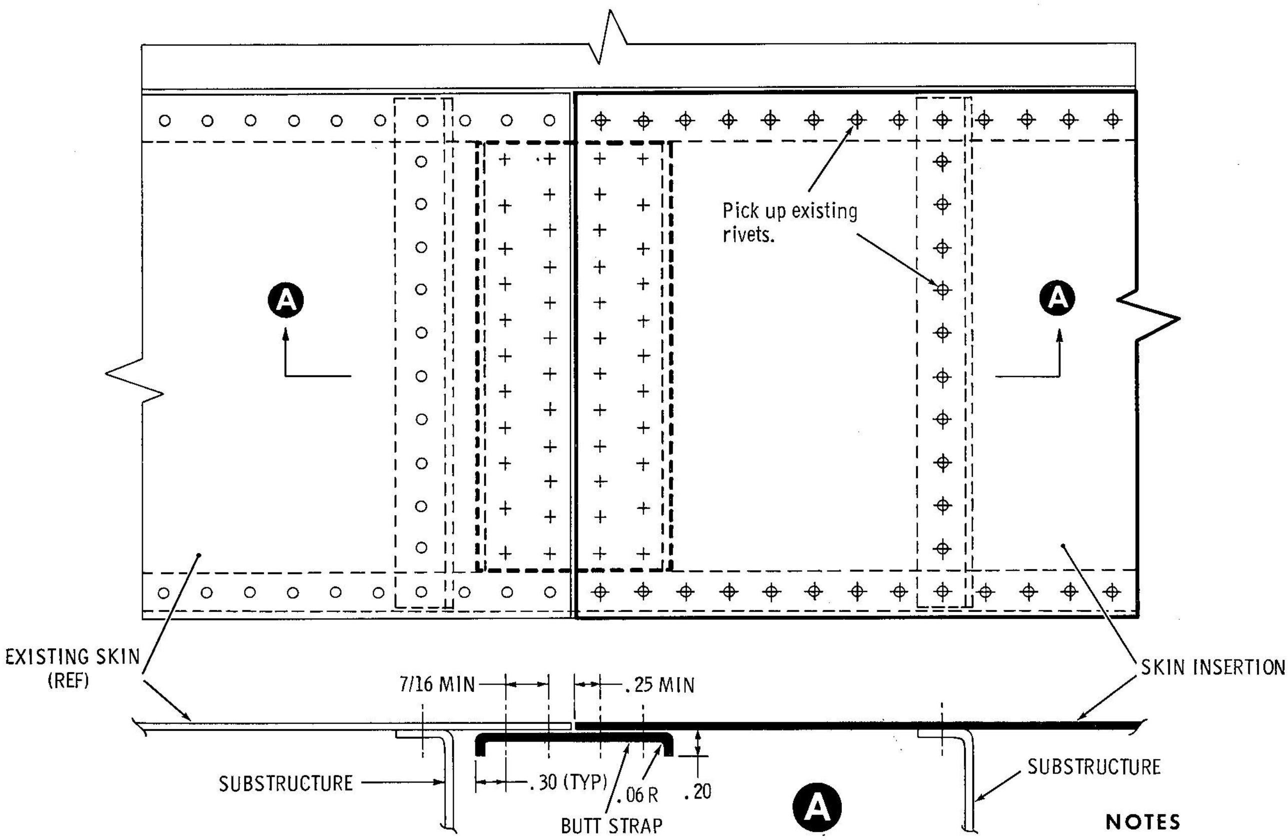
2 Establish whether splice is in tension or shear.

3 Find the number of rivets required for the length of joint A from Rivet Tables.

4 For butt joint, space required rivets on each side of the joint. For overlap joint, space required rivets within the overlap area.

5 Observe minimum edge distance and minimum and maximum rivet pitch.

6 The width of butt strap will be determined by rivet pattern.



REPAIR EXAMPLE

SKIN TO BE SPLICED: 0.018 Clad 24S-T3
LENGTH OF SPLICE: 6 inches in Shear
RIVET CHOSEN: MS20426AD3 (Holes dimpled)
BUTT STRAP: 0.028 Clad 24S-T3

RIVETS REQUIRED FROM RIVET TABLES:
6 inch splice x 3.6 rivets per inch = 22 rivets
RIVET DISTRIBUTION: 23 rivets in 2 staggered rows are used on each side of the joint.

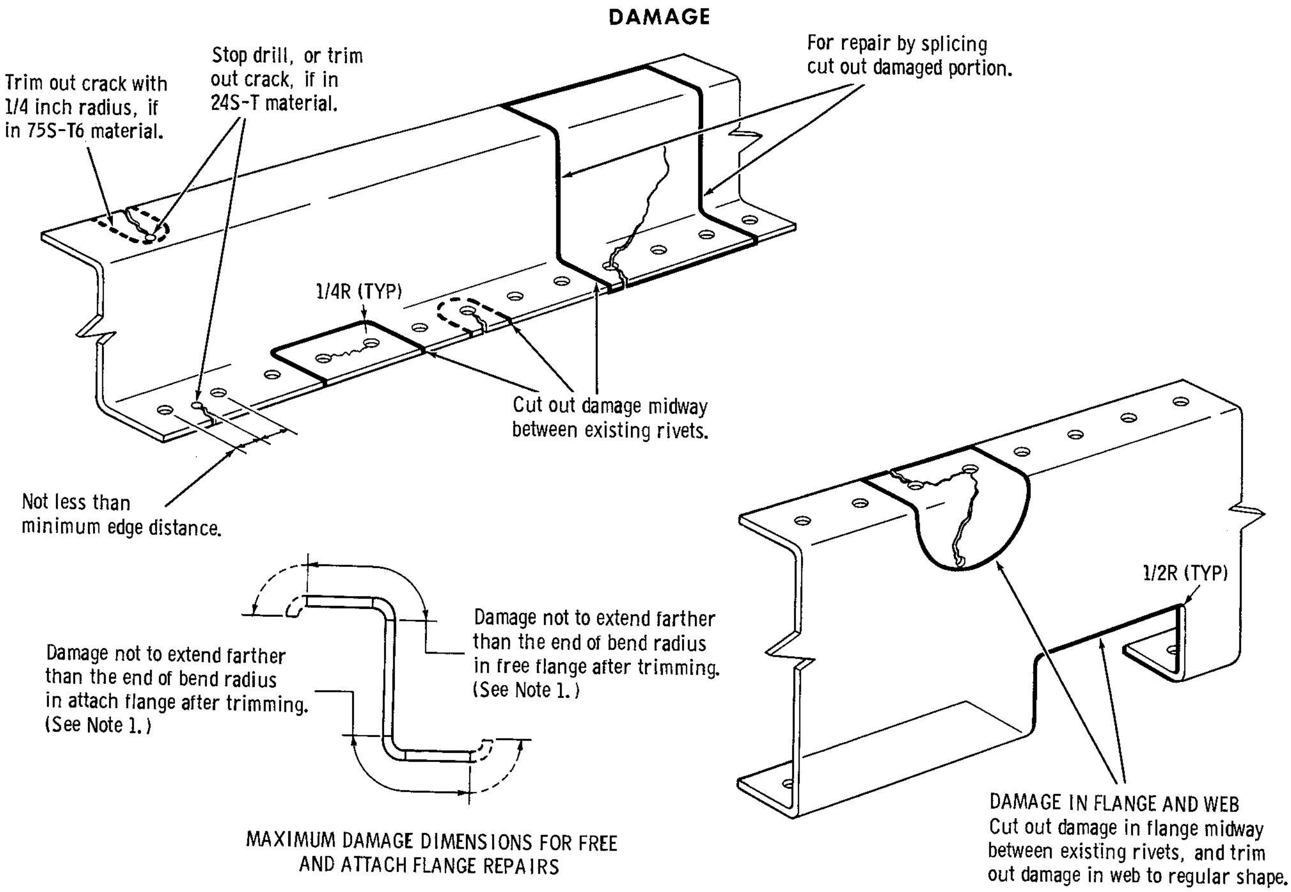
NOTES

1 Refer to Typical Repair Procedure in text.

2 Joggle must not be used where joint is under tension.

13-24-65

Figure 21 (Sheet 6 of 6) Rivet Distribution Pattern - Skin Splicing



NOTES

1 Damage in stringers and stiffeners extending beyond the end of bend radius into web will require repair by splicing. Damage in ribs, diaphragms, frames and spars extending beyond the end of bend radius into web will require a flange and web repair.

2 Refer to text for methods of crack stop drilling and trimming out damage.

RIVET DISTRIBUTION (See Sheet 2.)

1 Trim out damage to regular shape, or stop drill cracks as shown.

2 Measure dimension of damage in each member of the part for repair rivet requirements.

3 Find the number of repair rivets required separately for each damage dimension from applicable Rivet Table. (See Notes, Sheet 2.)

4 Space required rivets for each damage dimension on each side of the break in corresponding area:

For L_1 in

For L_2 in

For L_3 in

5 Observe minimum edge distance and minimum and maximum rivet pitch.

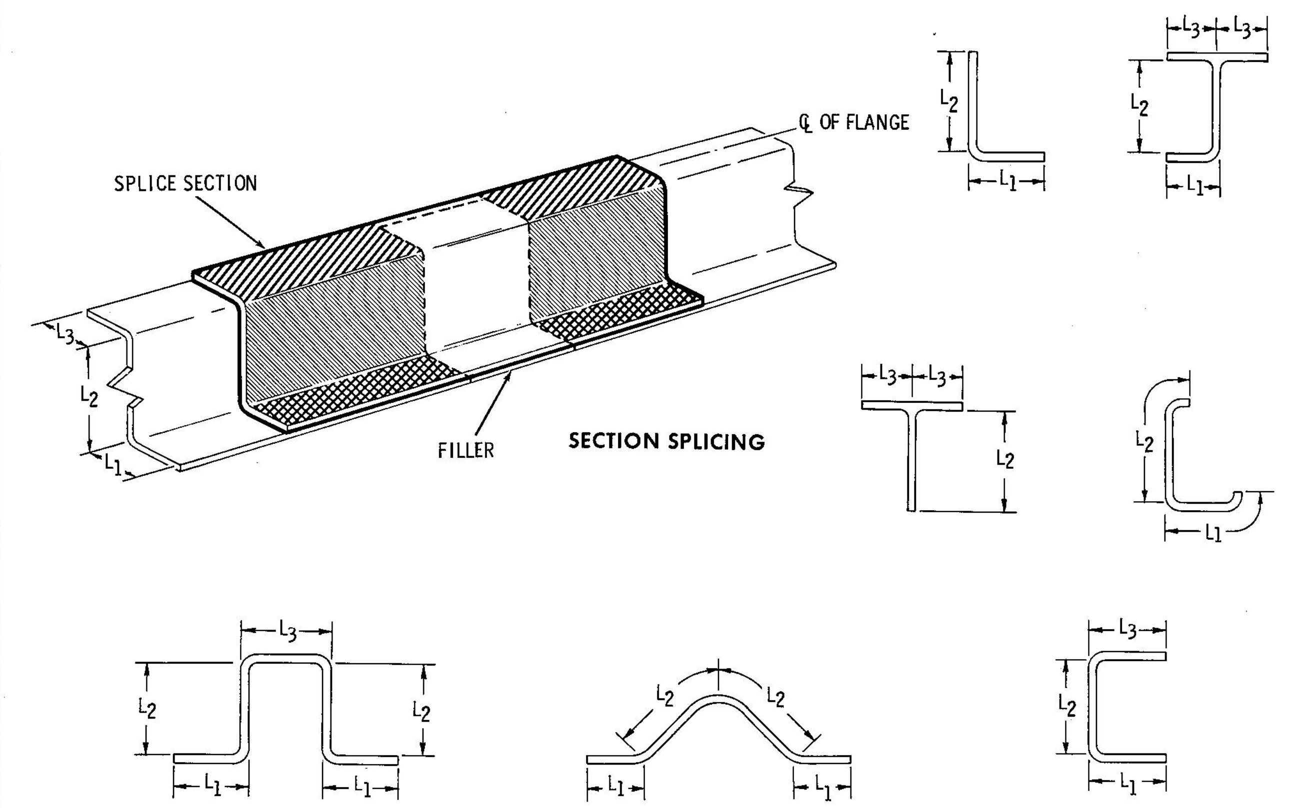
6 The size of repair member will be determined by the number of repair rivets required and rivet pattern.

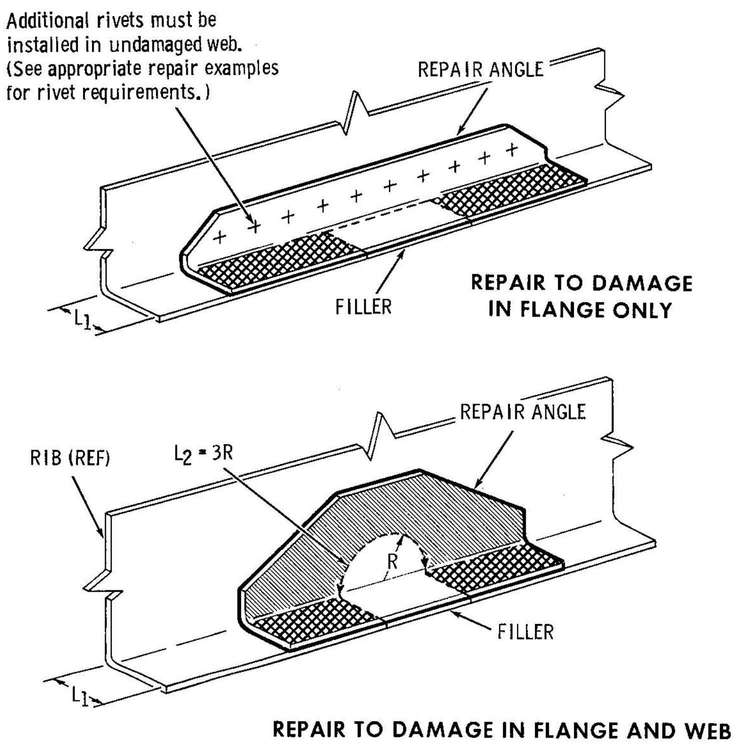
7 The rivet pattern should be similar on each side of the break, unless existing rivets must be picked up.

8 When a flange has one row of rivets, that row should be approximately on the centre-line of the flange, required edge distance being maintained.

13-24-112

Figure 22 (Sheet 1 of 2) Rivet Distribution Pattern - Formed and Extruded Section Repair





NOTES

1 Calculation of repair rivets must be done separately for each damaged member of the section by multiplying maximum allowable dimension of damage, for each type of repair, by the number of rivets required per inch of damage, and bringing requirement to the next whole number. If, for example, 4 rivets are required for L_1 flange, install 4 rivets on each side of the break.

2 For structural parts formed from metal sheet, use the same Rivet Tables as for skin and webs. For extruded parts, separate Rivet Tables have been included.

Use TENSION and SHEAR columns in Rivet Tables as follows:

(a) TENSION - For all types of repair to stringers and stiffeners, and for free and attach flanges of frames, ribs, spars, and diaphragms.

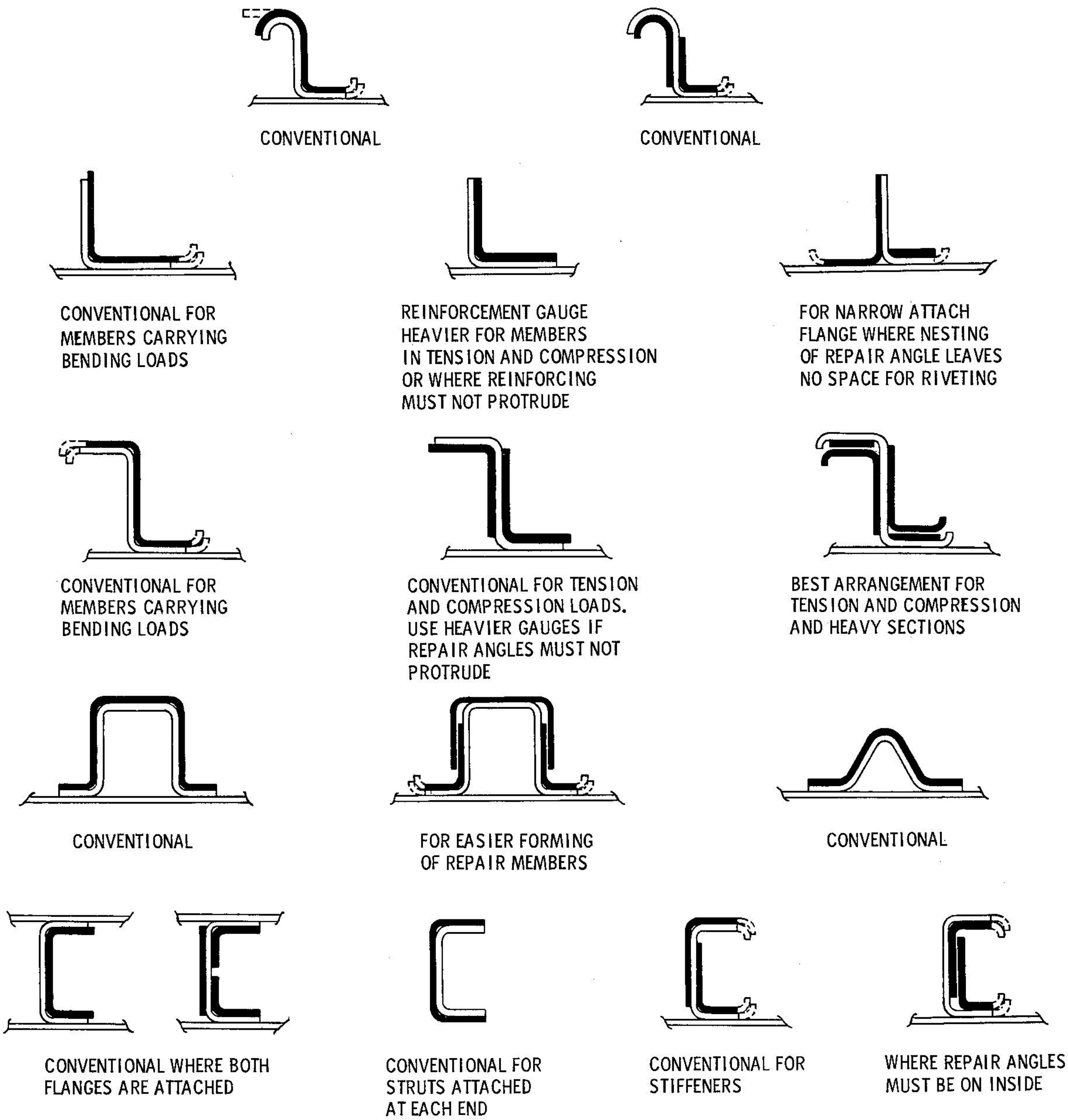
(b) SHEAR - For repair to webs in ribs, spars, frames, and diaphragms, unless otherwise noted.

3 See appropriate examples of partial repair and splicing of formed and extruded parts.

4 Maximum dimension of damage for each type of repair must not be exceeded.

13-24-113

Figure 22 (Sheet 2 of 2) Rivet Distribution Pattern - Formed and Extruded Section Repair



NOTES

1. In splicing members subjected to bending loads (stiffeners), full width of flanges is important. Use external reinforcements where possible. Additional cross-sectional area is required when width is reduced.
2. In splicing tension and compression members (stringers), centre of mass of reinforcing members should be as near the original centroid as possible. Additional cross-sectional area is required to compensate for bending moments introduced when centroids do not coincide.
3. Cross-sectional area of flange must be equal to, or greater than the original, if of the same material. (See Table of Material Substitution Factors.)
4. If one flange is reinforced by a flat strip, the cross-sectional area must be 10% greater than that of the original flange.
5. For repair rivet requirements, refer to text: Typical Repair Procedure and Rivet Tables.
6. Sections with lipped flanges are shown in dotted lines.

13-24-101

Figure 23 (Sheet 1 of 2) Formed and Extruded Section Splice - Arrangement of Repair Members

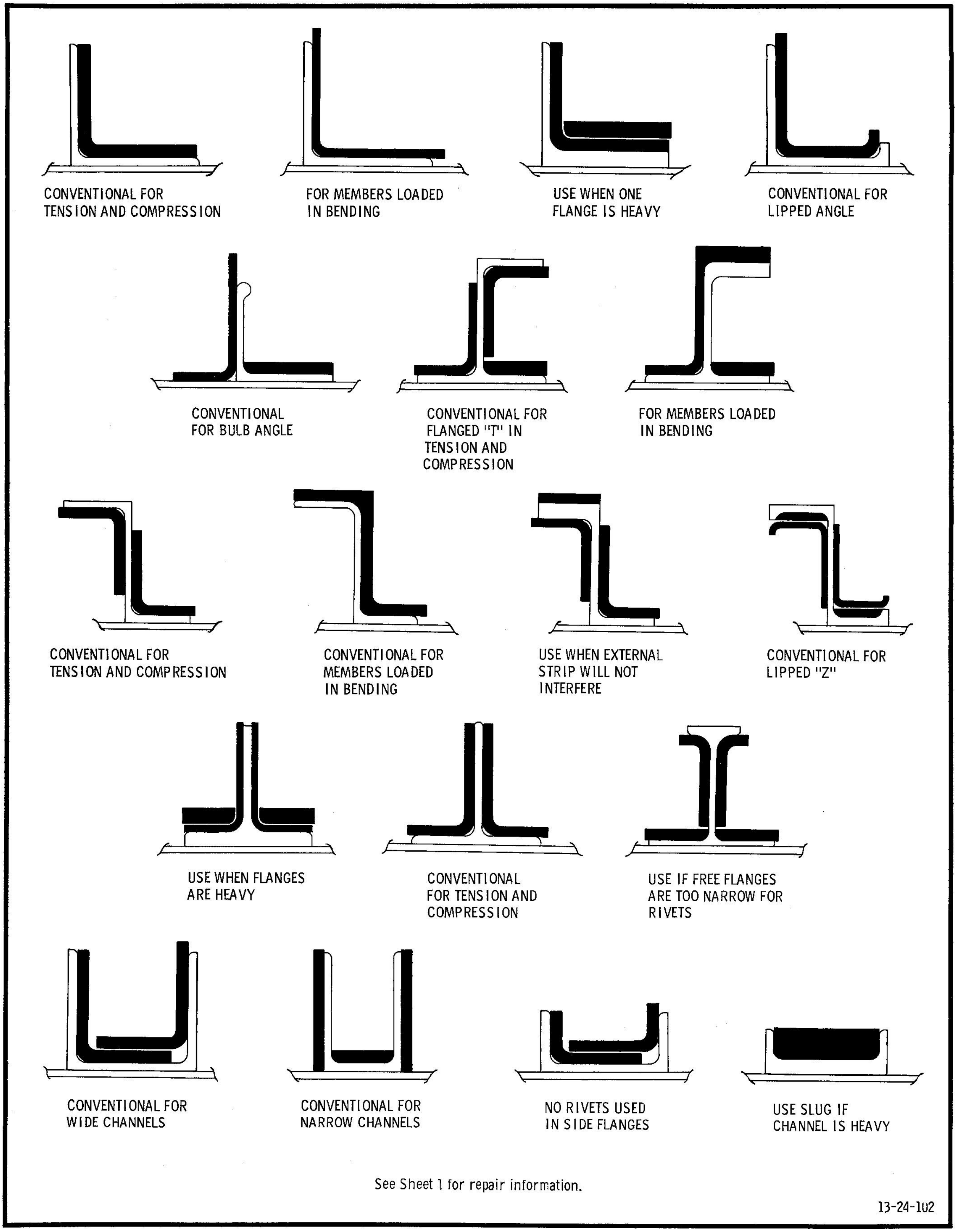
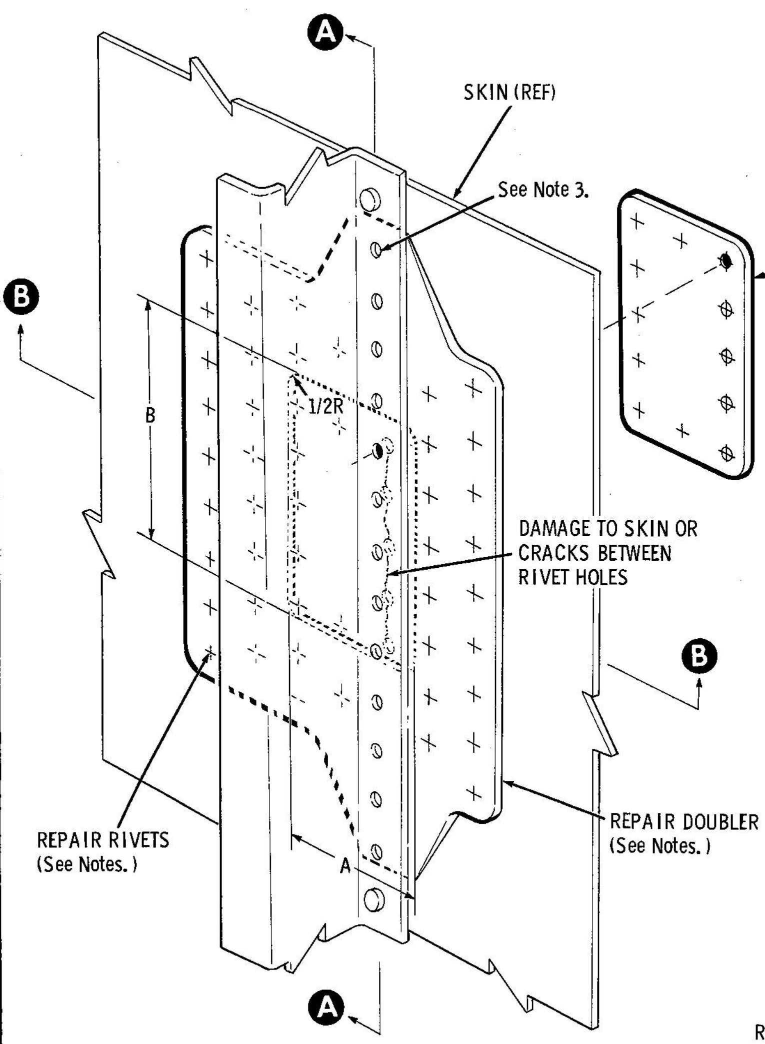
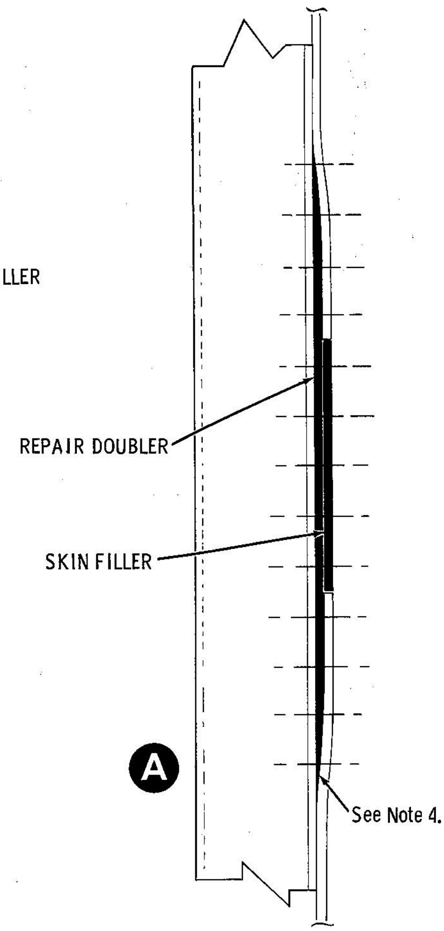
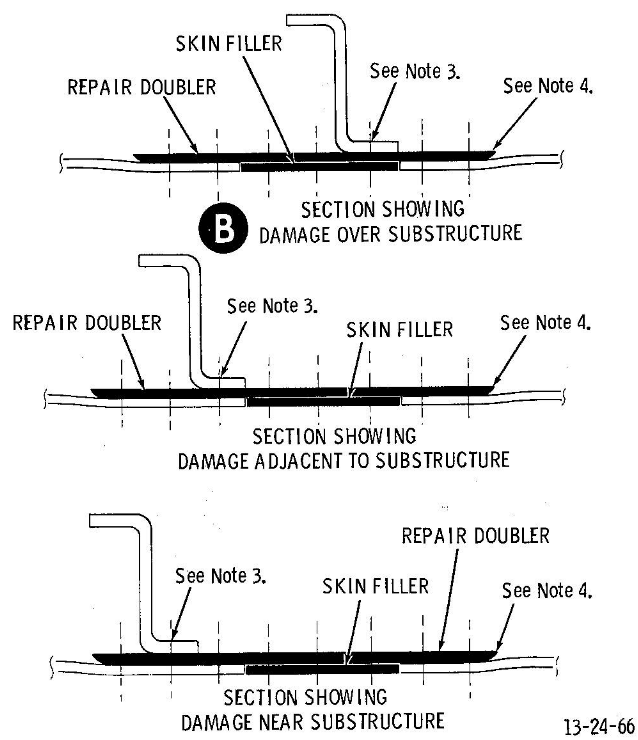


Figure 23 (Sheet 2 of 2) Formed and Extruded Section Splice - Arrangement of Repair Members



DAMAGE OVER SUBSTRUCTURE





NOTES

1 These repair methods are applicable to light gauge skin in which the repair doubler, by removing suitable number of existing rivets, may be inserted between the skin and substructure.

2 For selection of repair material, number of rivets required for damage dimensions A and B, and method of rivet distribution, refer to Typical Repair Procedure in text and see appropriate illustrations.

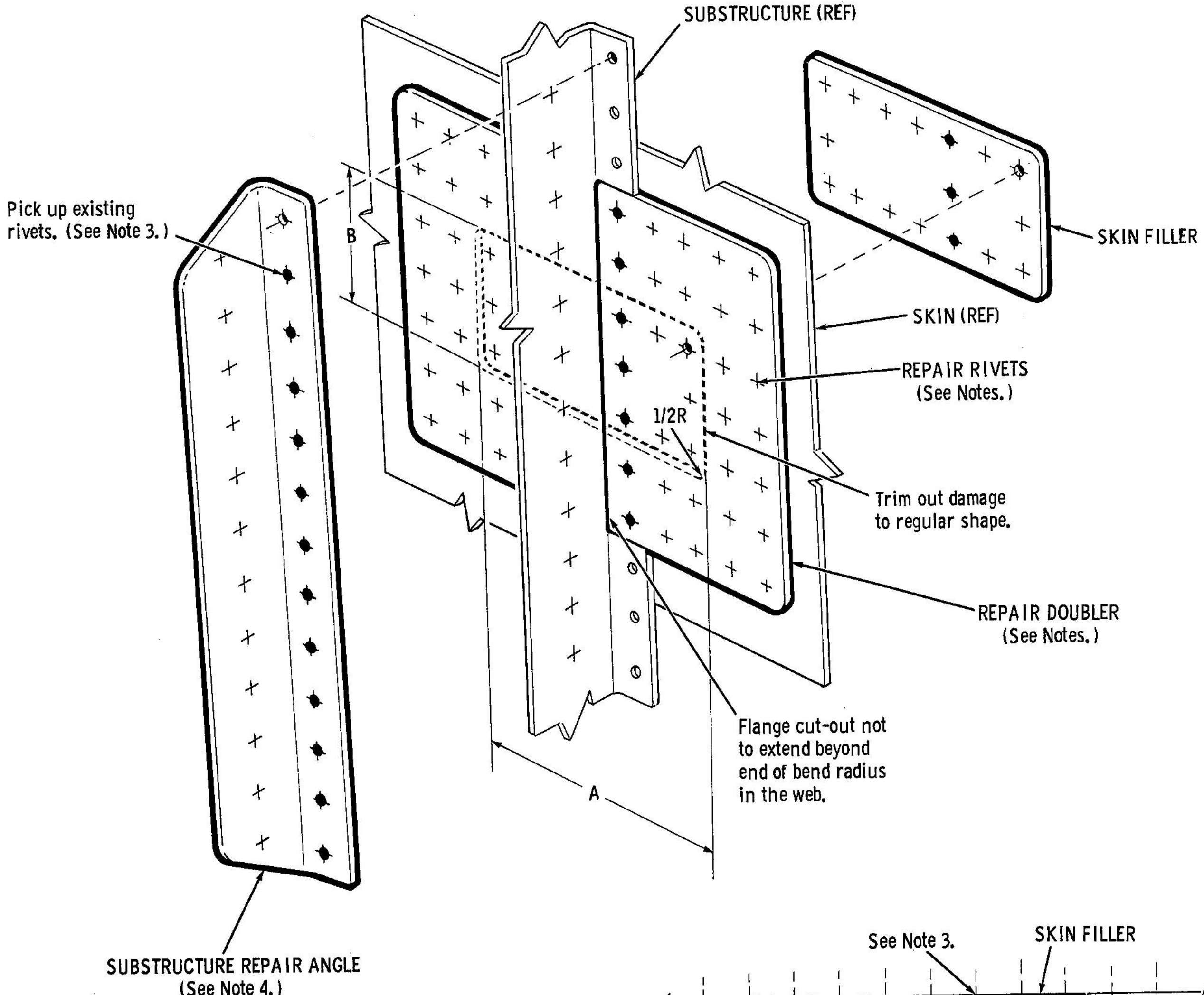
3 Pick up existing rivets in substructure but do not include them in rivet requirements for repair of damage.

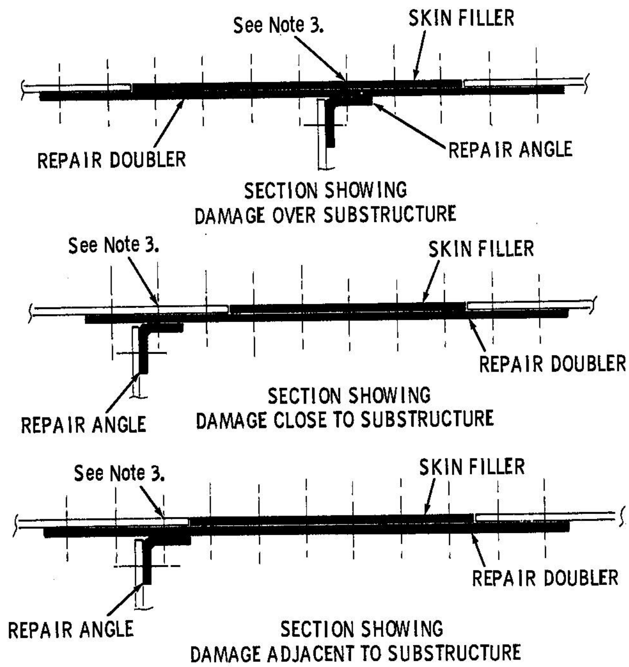
4 Taper and chamfer edges of doubler as shown, or install tapered packings.

LIMITATION

These repairs are limited to doubler thickness not exceeding 0.036 inch. Where repair doubler of heavier gauge is required, see alternative skin repairs. Not applicable to bonded structure.

Figure 24 Skin Repair Methods - Repair Doubler Inserted Between Skin and Substructure





NOTES

1 These repair methods are applicable to skin, or skin and substructure flange damage, in which the substructure flange is cut out to permit installation of skin repair doubler.

2 For selection of repair material, number of rivets required for damage dimensions A and B, and method of rivet distribution, refer to Typical Repair Procedure in text and see appropriate illustrations.

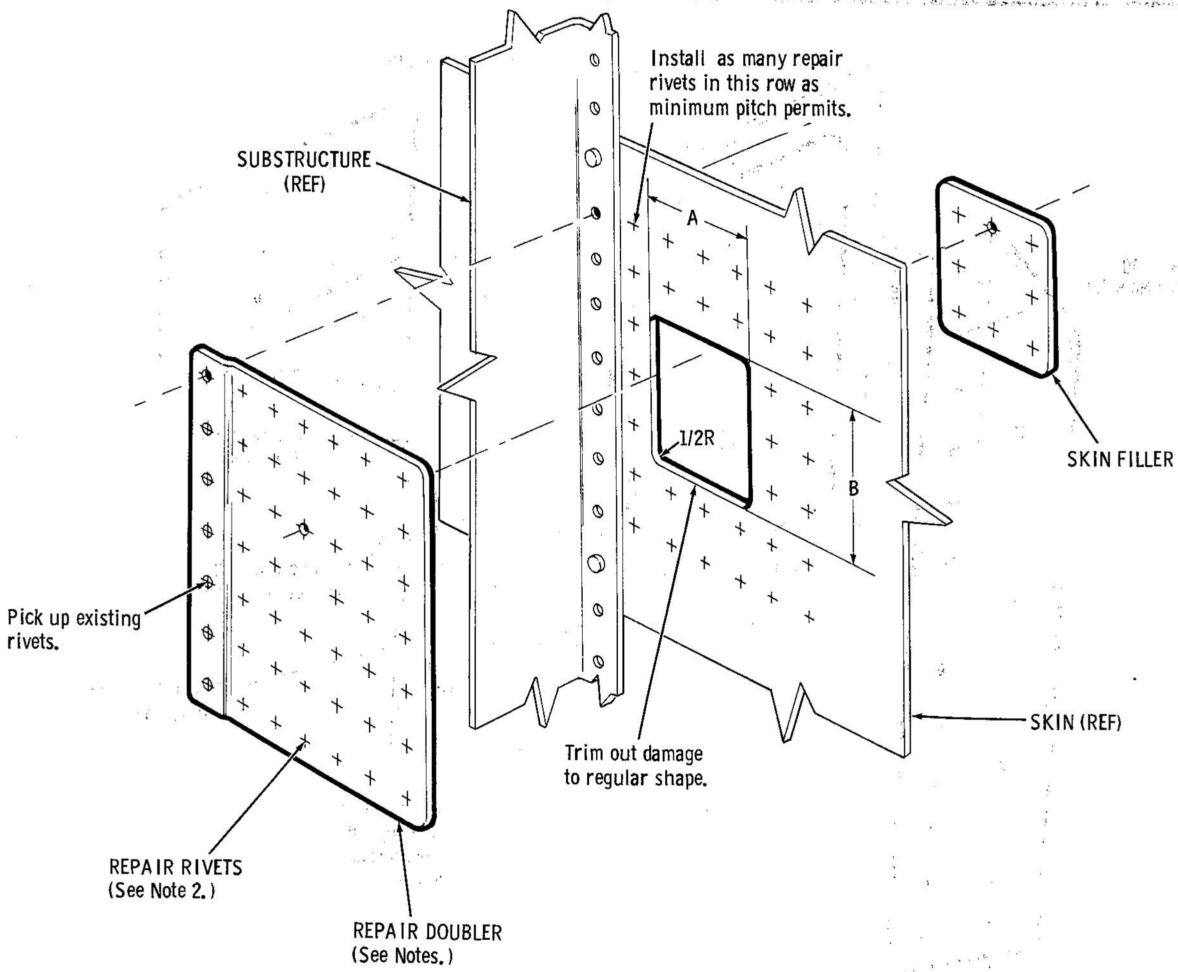
3 Pick up existing rivets in substructure but do not include them in rivet requirements for repair of skin damage.

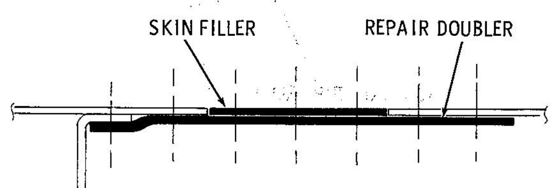
4 Repair substructure in accordance with applicable repair illustration for attach flanges.

LIMITATION

These repairs must not be used in heavily stressed primary structure or in restricted areas. Refer to text for detailed limitation of typical repairs.

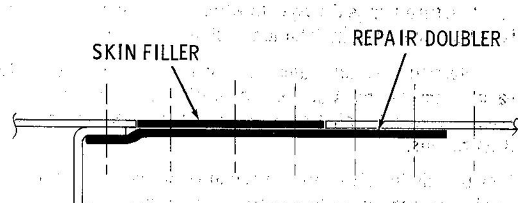
Figure 25 Skin Repair Methods - Substructure Flange Cut-out for Insertion of Repair Doubler





REPAIR A

SECTION SHOWING
DAMAGE CLOSE TO SUBSTRUCTURE



REPAIR B

SECTION SHOWING
DAMAGE ADJACENT TO SUBSTRUCTURE

NOTES

1 These repair methods are applicable to skin damage close or adjacent to substructure in which repair doubler must be joggled over substructure flange. See Limitation.

2 For selection of repair material, number of rivets required for damage dimensions A and B, and method of rivet distribution, refer to Typical Repair Procedure in text and see appropriate illustrations.

3 For forming joggle in repair doubler, refer to EO 05-1-3/20.

LIMITATION

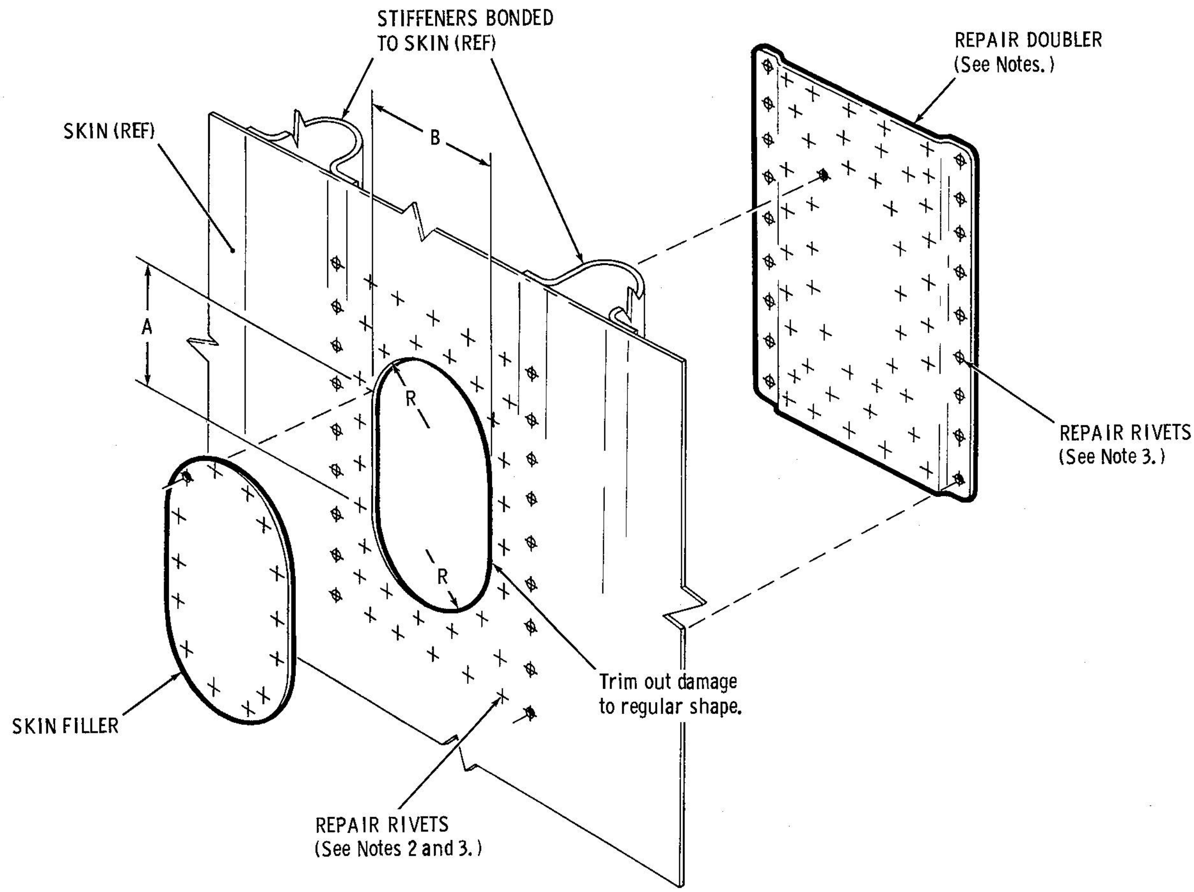
Because of insufficient area on one side of the damage for spacing required number of repair rivets, substructure will be additionally loaded by the skin repair. Therefore these repairs are limited to substructure flange thickness not exceeding 0.050 inch, and may be used only as follows:

Repair A - In tertiary and secondary structure. Skin loaded in shear, or where tension stresses are acting only along the substructure.

Repair B - In tertiary structure only.

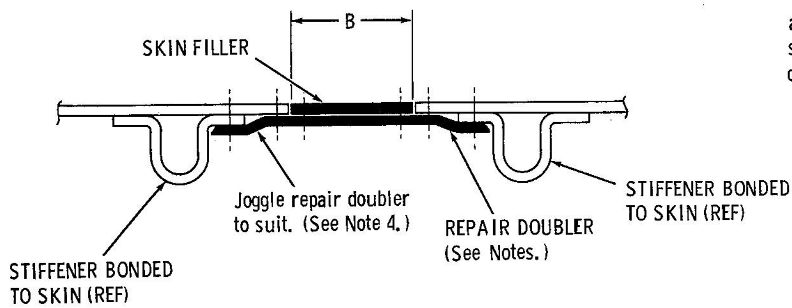
13-24-68

Figure 26 (Sheet 1 of 2) Skin Repair Methods - Repair Doubler Joggled over Substructure Flange



LIMITATION

This repair is limited to such damage size, which will allow two rows of repair rivets to be installed on each side of damage; one row through stiffener flange and one adjacent row through skin and doubler.



NOTES

1 This repair method is applicable to skin damage, between stiffeners bonded to skin, in which a repair doubler is joggled over stiffener flanges. See Limitation.

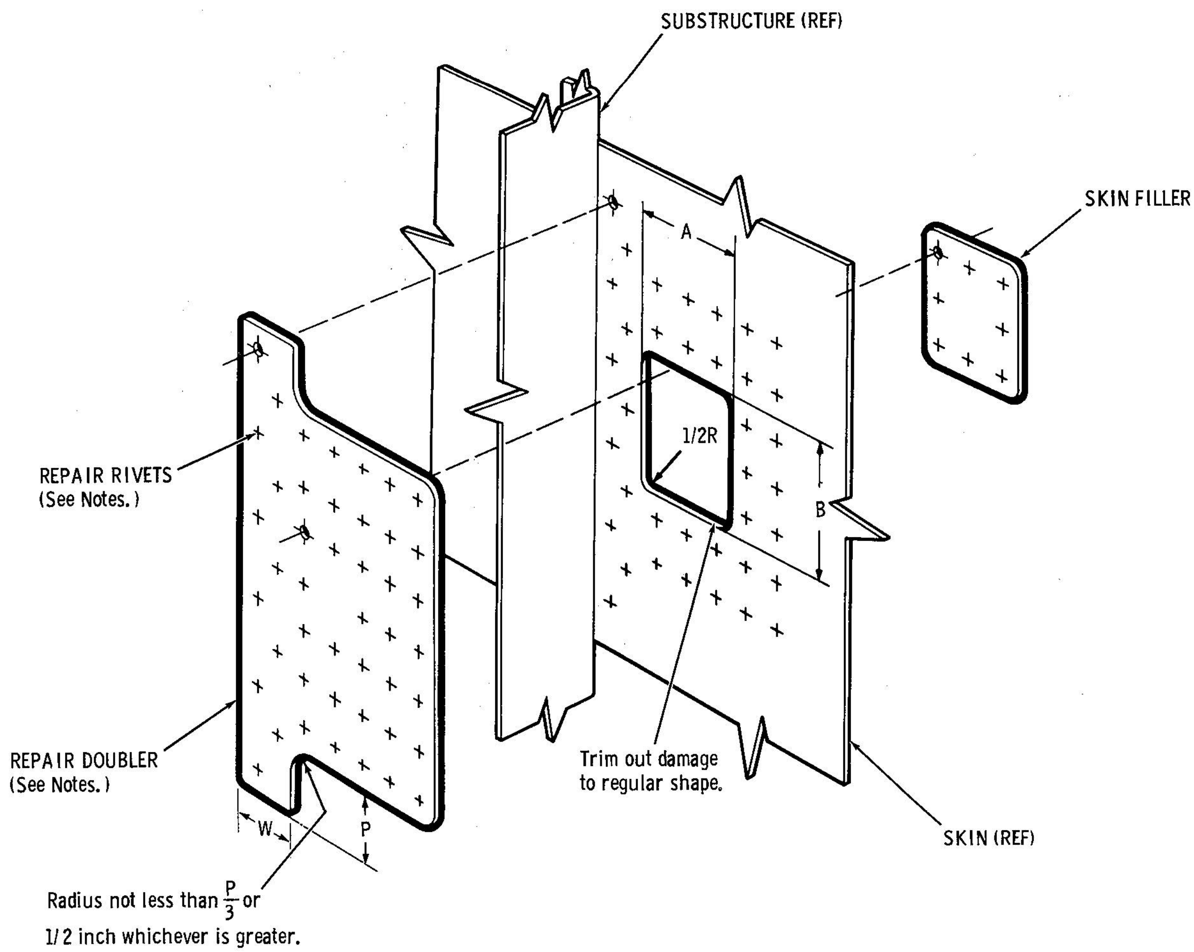
2 For selection of repair material, number of rivets required for damage dimensions A and B, and method of rivet distribution, refer to Typical Repair Procedure in text and see appropriate illustrations.

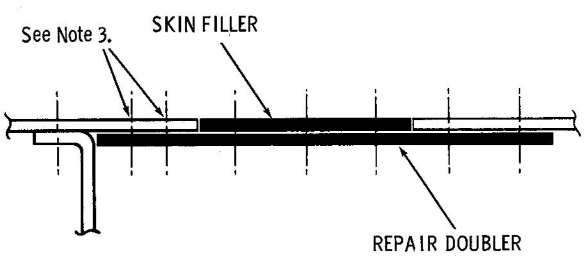
3 To avoid dimpling of bonded parts, protruding-head rivets should be installed through stiffener flanges bonded to skin. Where aerodynamic effect is critical, rivet holes for countersunk-head rivets may be dimpled in bonded areas only if approved by the CTSO or his delegated representative.

4 For forming joggle in repair doubler, refer to EO 05-1-3/20.

13-24-69

Figure 26 (Sheet 2 of 2) Skin Repair Methods - Repair Doubler Joggled over Substructure Flange





LIMITATION

This type of a repair doubler and rivet distribution pattern may be used only where substructure restricts doubler width on one side of the repair.

Length of projecting portion of repair doubler (P) must not exceed the width (W).

NOTES

1 This repair method is applicable to skin damage close to substructure, in which one side of the damage requires larger portion of repair doubler to accommodate required number of repair rivets.

2 For selection of repair material, number of rivets required for damage dimensions A and B, and method of rivet distribution, refer to Typical Repair Procedure in text and see appropriate illustrations.

3 If required number of repair rivets for damage dimension B (narrower side) cannot be spaced in one row, use staggered pattern.

13-24-70

Figure 27 Skin Repair Methods - Irregular Shape Repair Doubler

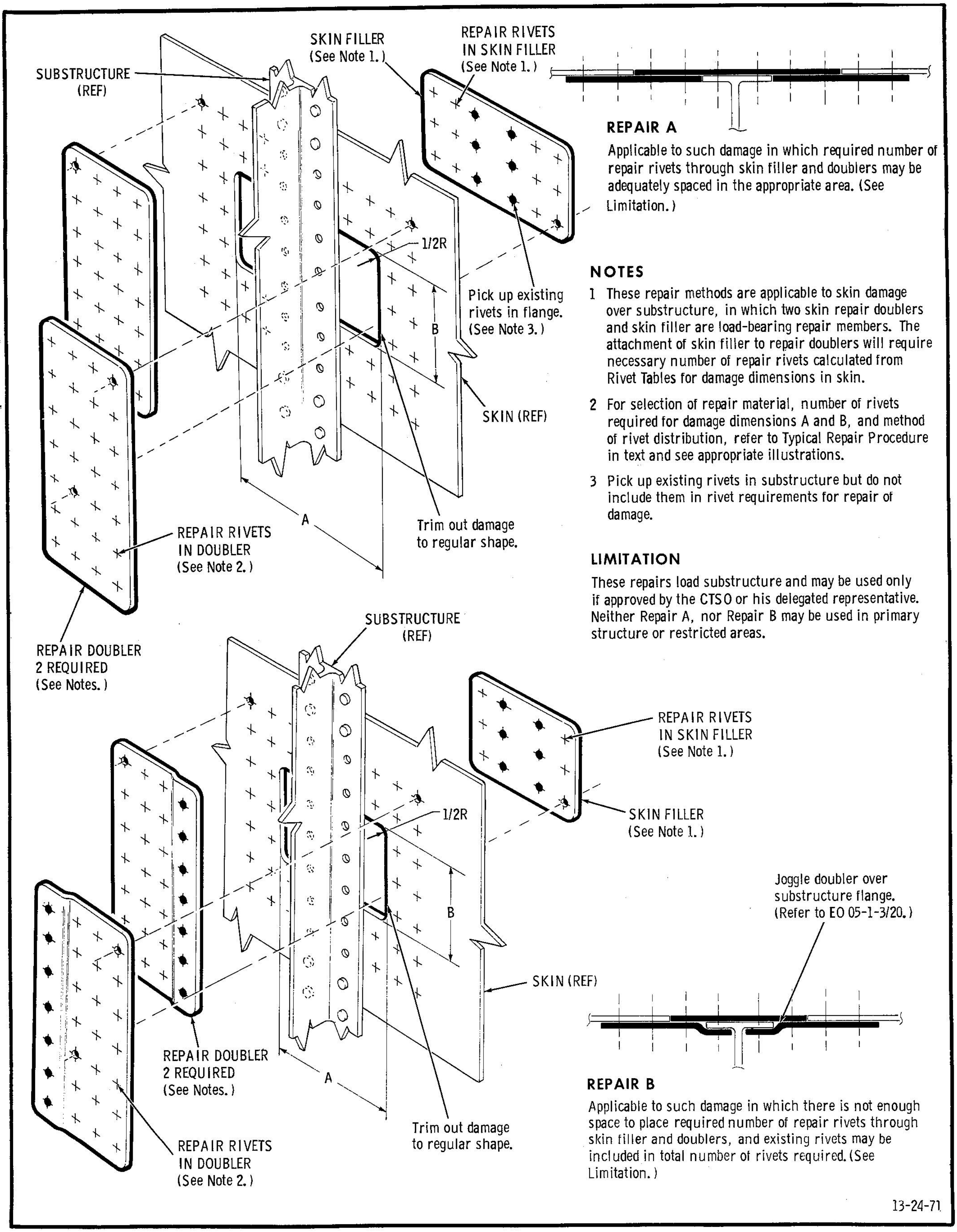
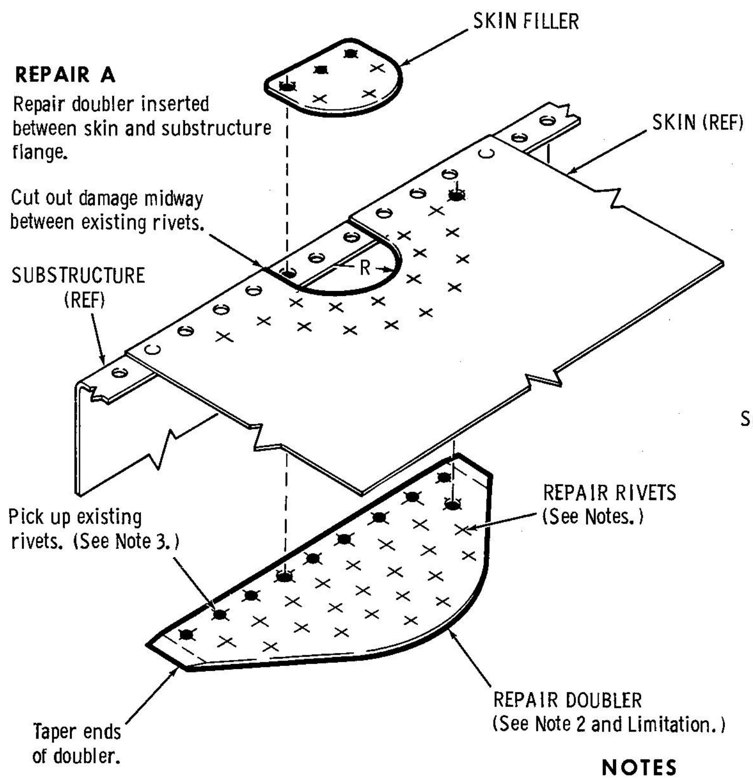
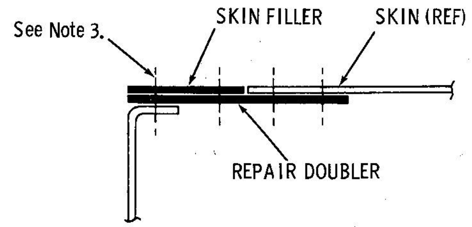


Figure 28 Skin Repair Methods - Two Repair Doublers and Skin Filler Carrying Loads

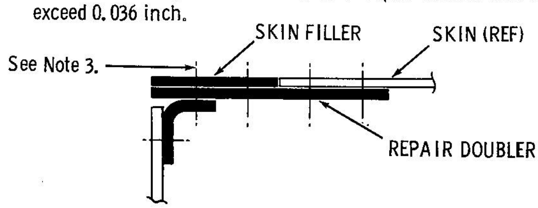
REPAIR A
Repair doubler inserted between skin and substructure flange.





LIMITATION

Repair A is limited to damage where original skin joint has only one row of rivets, and the thickness of repair doubler does not exceed 0.036 inch.



REPAIR A ALTERNATIVE

Alternative method where repair doubler thickness exceeds limits given in Repair A.
Cut out substructure flange to permit installation of repair doubler as shown. For repair methods to substructure, refer to appropriate illustration.

NOTES

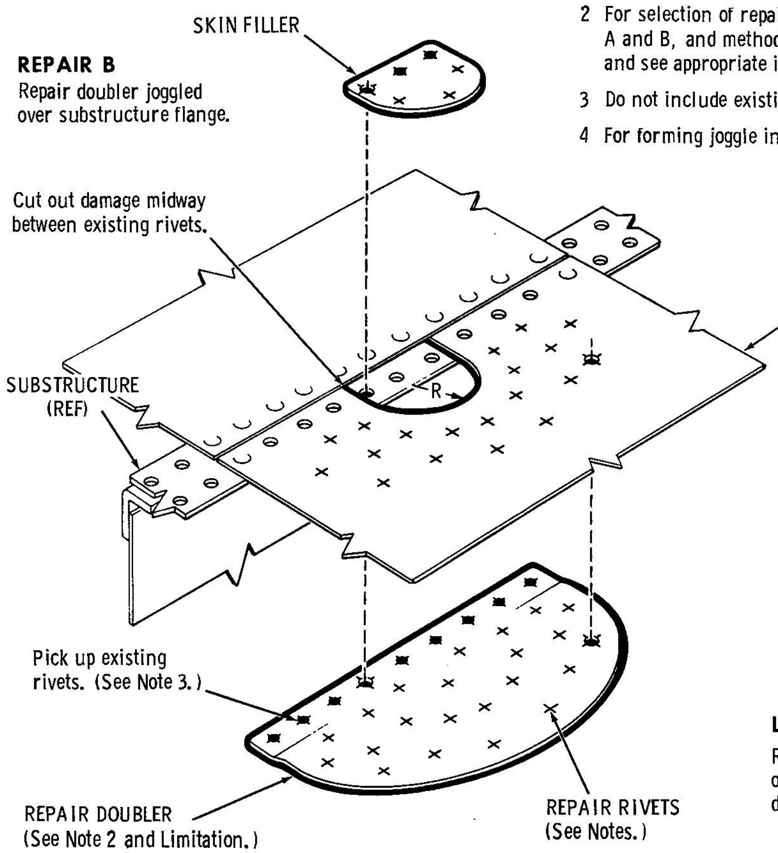
1 These repair methods are applicable to damage at skin end where original skin joint has only one row of attaching rivets.

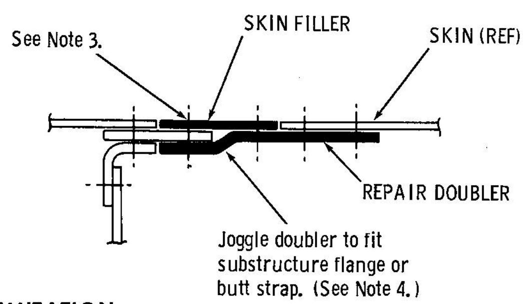
2 For selection of repair material, number of rivets required for damage dimensions A and B, and method of rivet distribution, refer to Typical Repair Procedure in text and see appropriate illustrations.

3 Do not include existing rivets in number of rivets required for repair.

4 For forming joggle in repair doubler, refer to EO 05-1-3/20.

REPAIR B
Repair doubler joggled over substructure flange.





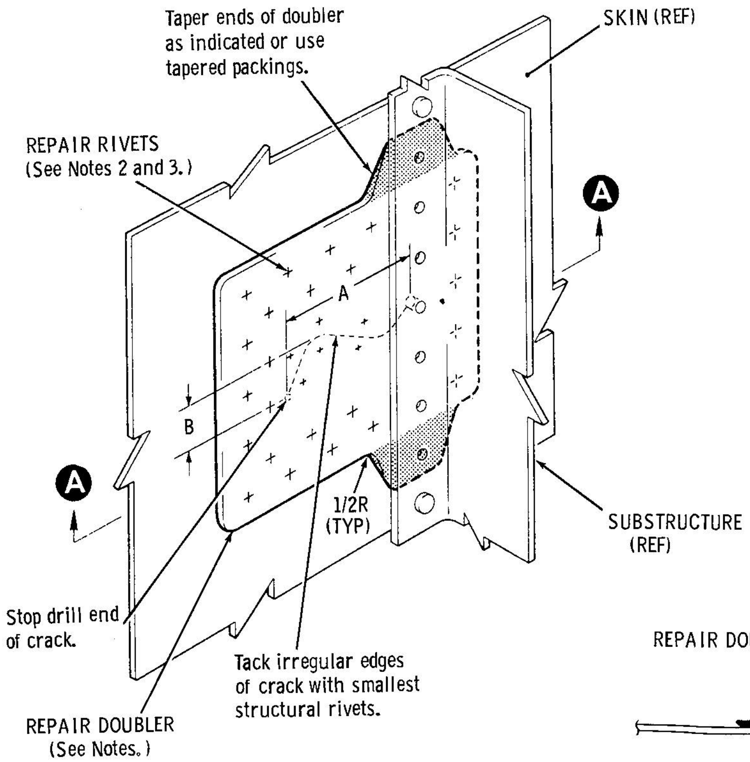
LIMITATION

Repair B is limited to damage where original skin joint has only one row of rivets, and the thickness of substructure flange for doubler joggling not to exceed 0.050 inch.

13-24-72

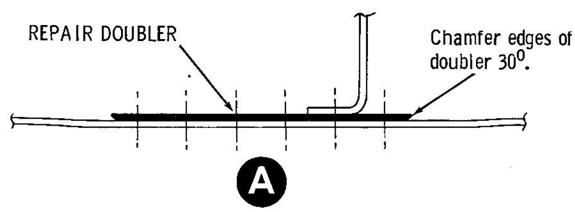
Figure 29 Skin Repair Methods - At End of Skin

REPAIR A



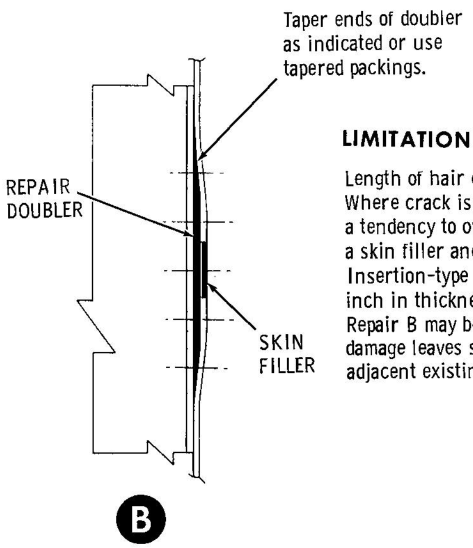
NOTES

1. These repair methods are applicable to skin cracks radiating from rivet holes, in which repair doubler is inserted between skin and substructure. For damage requiring a heavier gauge doubler, see repair method necessitating cutting out substructure flange.
2. For selection of repair material, number of rivets required for damage dimensions A and B, and method of rivet distribution, refer to Typical Repair Procedure in text and see appropriate illustrations.
3. Pick up existing rivets in substructure but do not include them in rivet requirements for repair of damage.



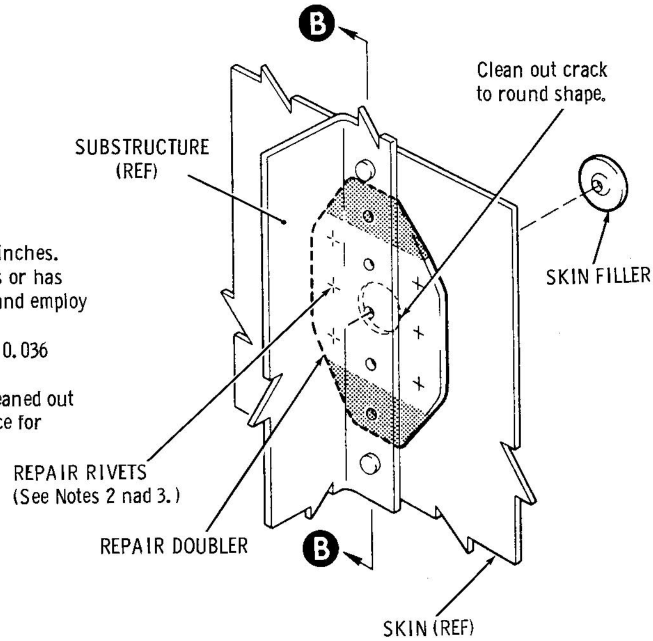
REPAIR B

Minimum rivet requirement shown.



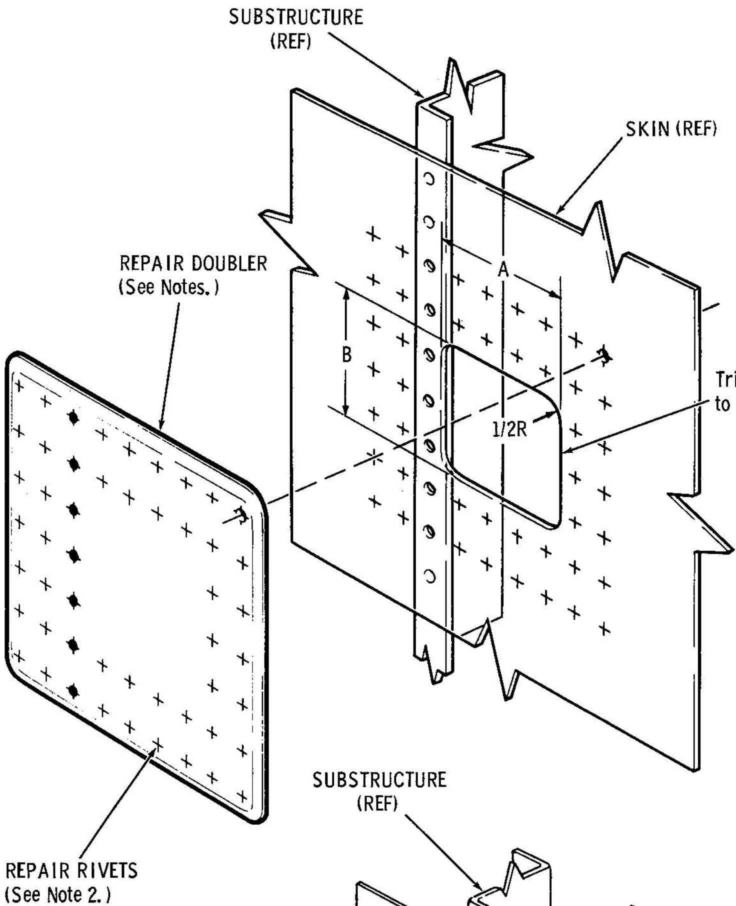
LIMITATION

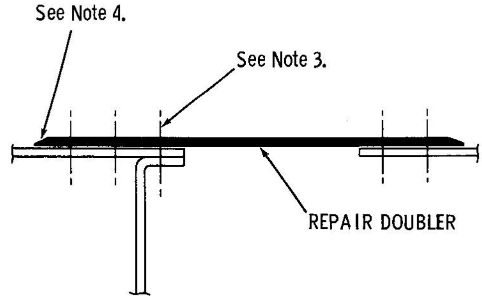
Length of hair crack not to exceed 2 inches. Where crack is longer than 2 inches or has a tendency to open, cut out damage and employ a skin filler and doubler.
Insertion-type doubler not to exceed 0.036 inch in thickness.
Repair B may be used only where cleaned out damage leaves sufficient edge distance for adjacent existing rivets.



13-24-75

Figure 30 Skin Repair Methods - Crack Radiating from Rivet Hole





NOTES

1 These repair methods using external repair doublers and solid rivets are structurally adequate. If desired, they may be reworked to flush repairs for aerodynamic efficiency only.

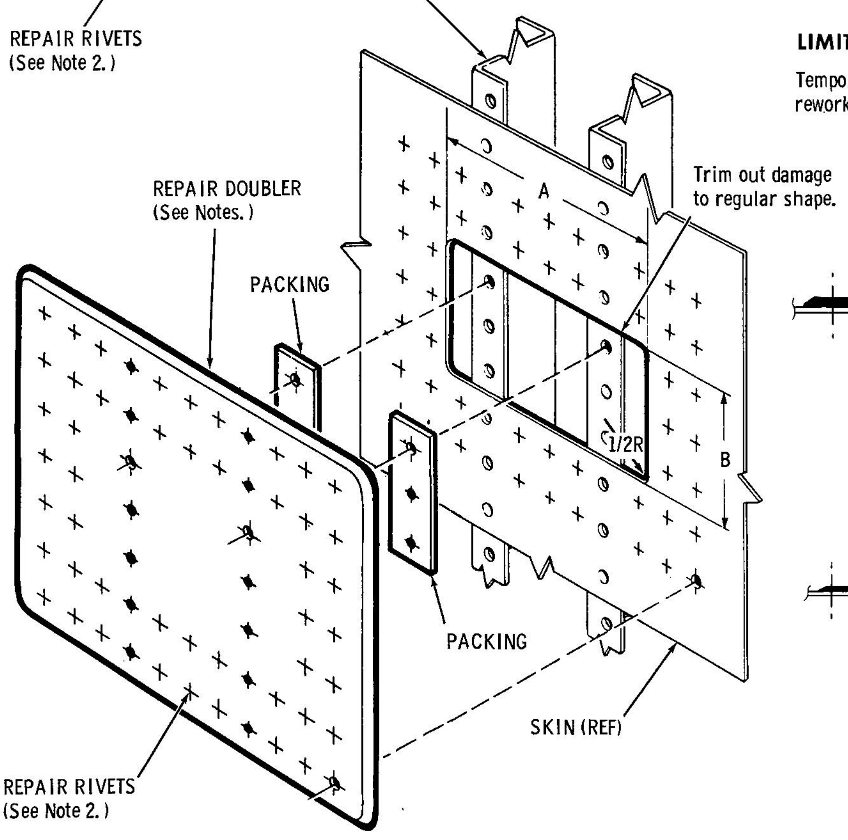
2 For selection of repair material, number of rivets required for damage dimensions A and B, and method of rivet distribution, refer to Typical Repair Procedure in text and see appropriate illustrations.

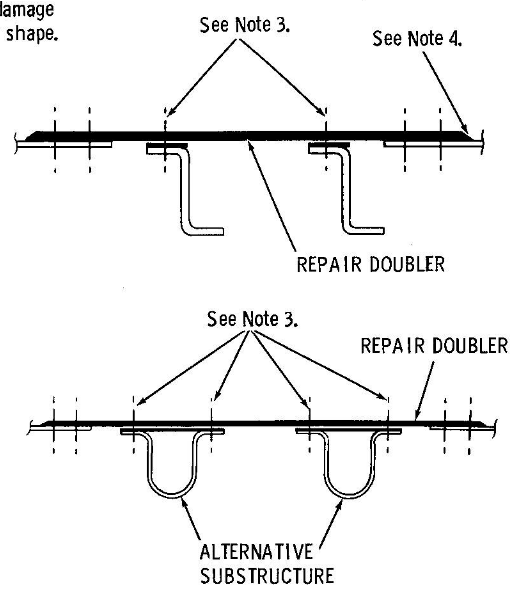
3 Pick up existing rivets in substructure but do not include them in rivet requirements for repair of damage. Use drilled rivet heads to fill countersunk or dimpled holes (refer to text).

4 Chamfer all edges of repair doubler 30°.

LIMITATION

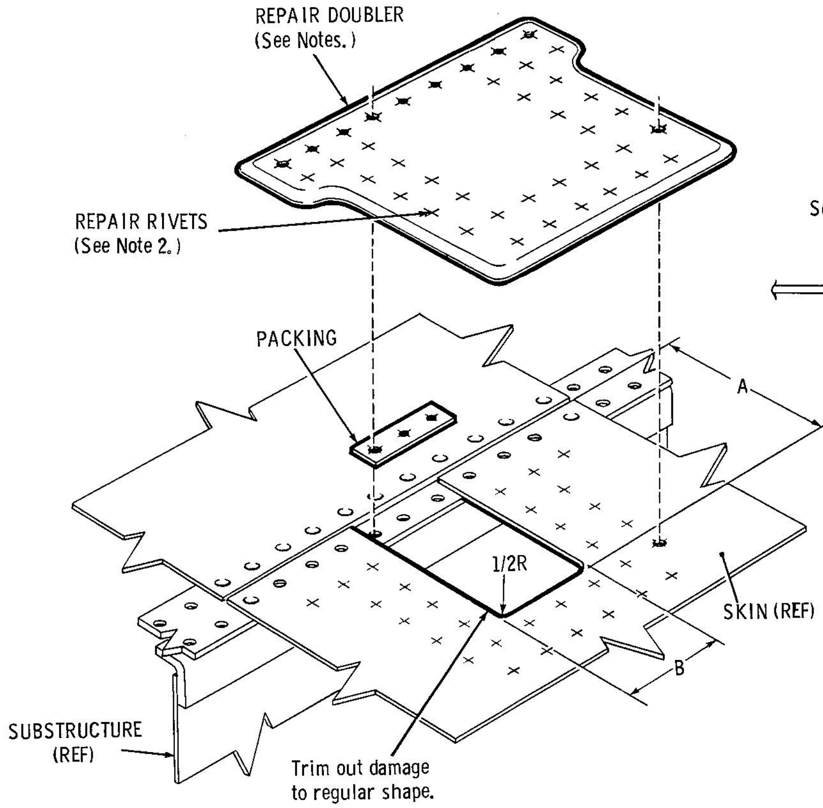
Temporary repairs on lift producing surfaces must be reworked to flush repairs.

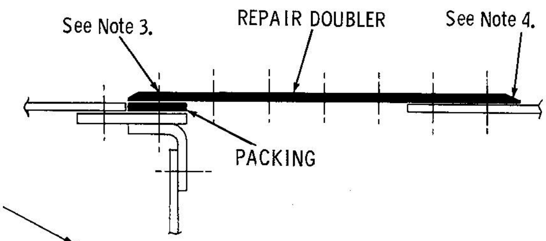


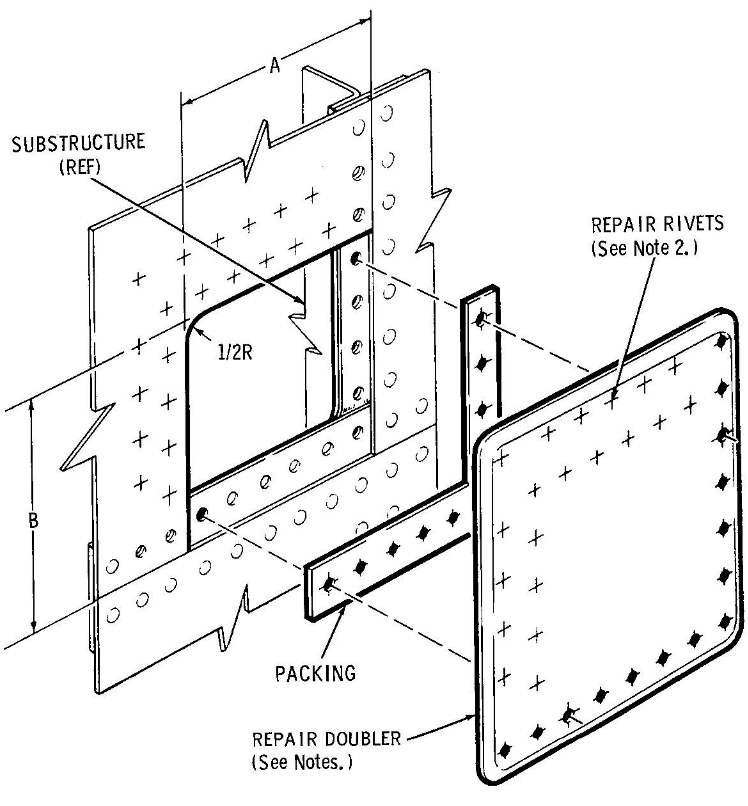


13-24-73

Figure 31 (Sheet 1 of 2) Skin Repair Methods - With External Repair Doubler







NOTES

1 These repair methods using external repair doublers and solid rivets are structurally adequate. If desired, they may be reworked to flush repairs for aerodynamic efficiency only.

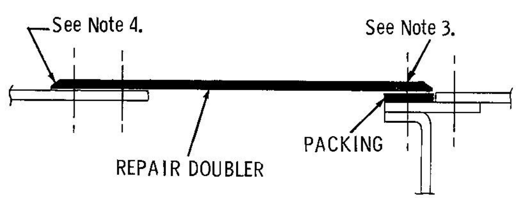
2 For selection of repair material, number of rivets required for damage dimensions A and B, and method of rivet distribution, refer to Typical Repair Procedure in text and see appropriate illustrations.

3 Pick up existing rivets in substructure but do not include them in rivet requirements for repair of damage. Use drilled rivet heads to fill countersunk or dimpled holes (refer to text).

4 Chamfer all edges of repair doubler 30°.

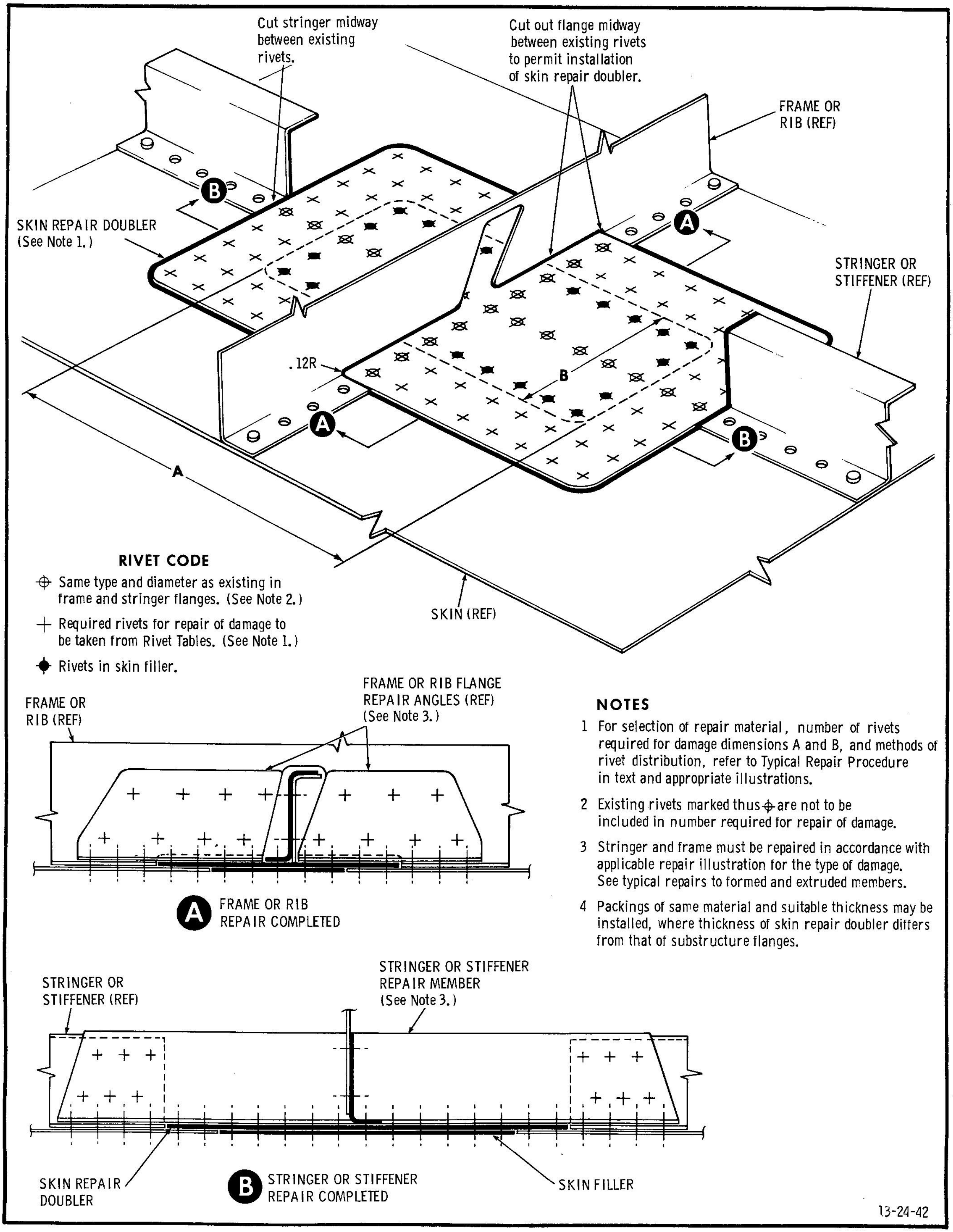
LIMITATION

These repairs are limited to damage at skin end where original skin joint has only one row of fasteners. Temporary repairs on lift producing surfaces must be reworked to flush repairs.



13-24-74

Figure 31 (Sheet 2 of 2) Skin Repair Methods - With External Repair Doubler



NOTES

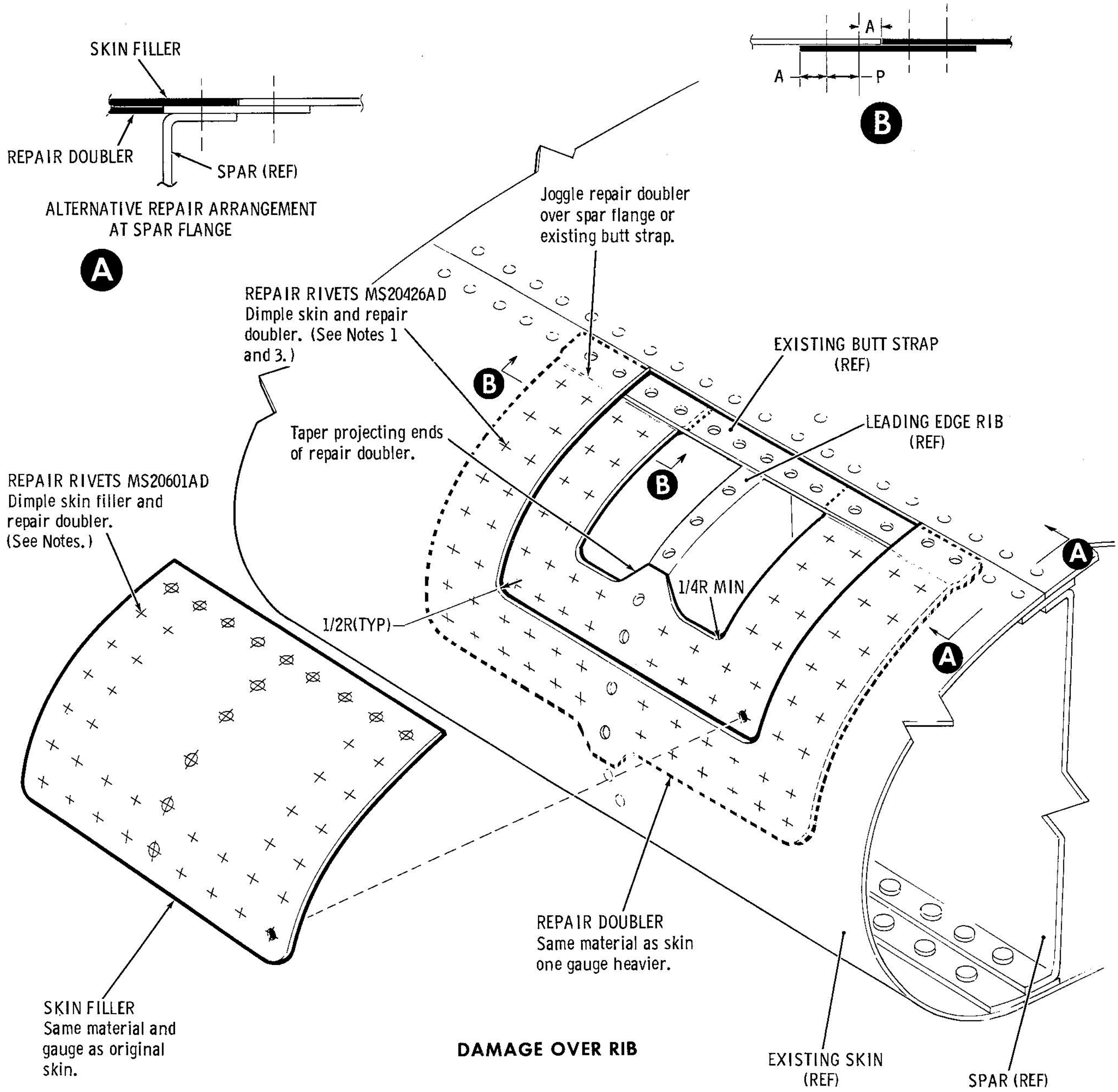
1 For selection of repair material, number of rivets required for damage dimensions A and B, and methods of rivet distribution, refer to Typical Repair Procedure in text and appropriate illustrations.

2 Existing rivets marked thus ⌖ are not to be included in number required for repair of damage.

3 Stringer and frame must be repaired in accordance with applicable repair illustration for the type of damage. See typical repairs to formed and extruded members.

4 Packings of same material and suitable thickness may be installed, where thickness of skin repair doubler differs from that of substructure flanges.

Figure 32 Skin Repair Methods - Damage at Intersection of Substructure

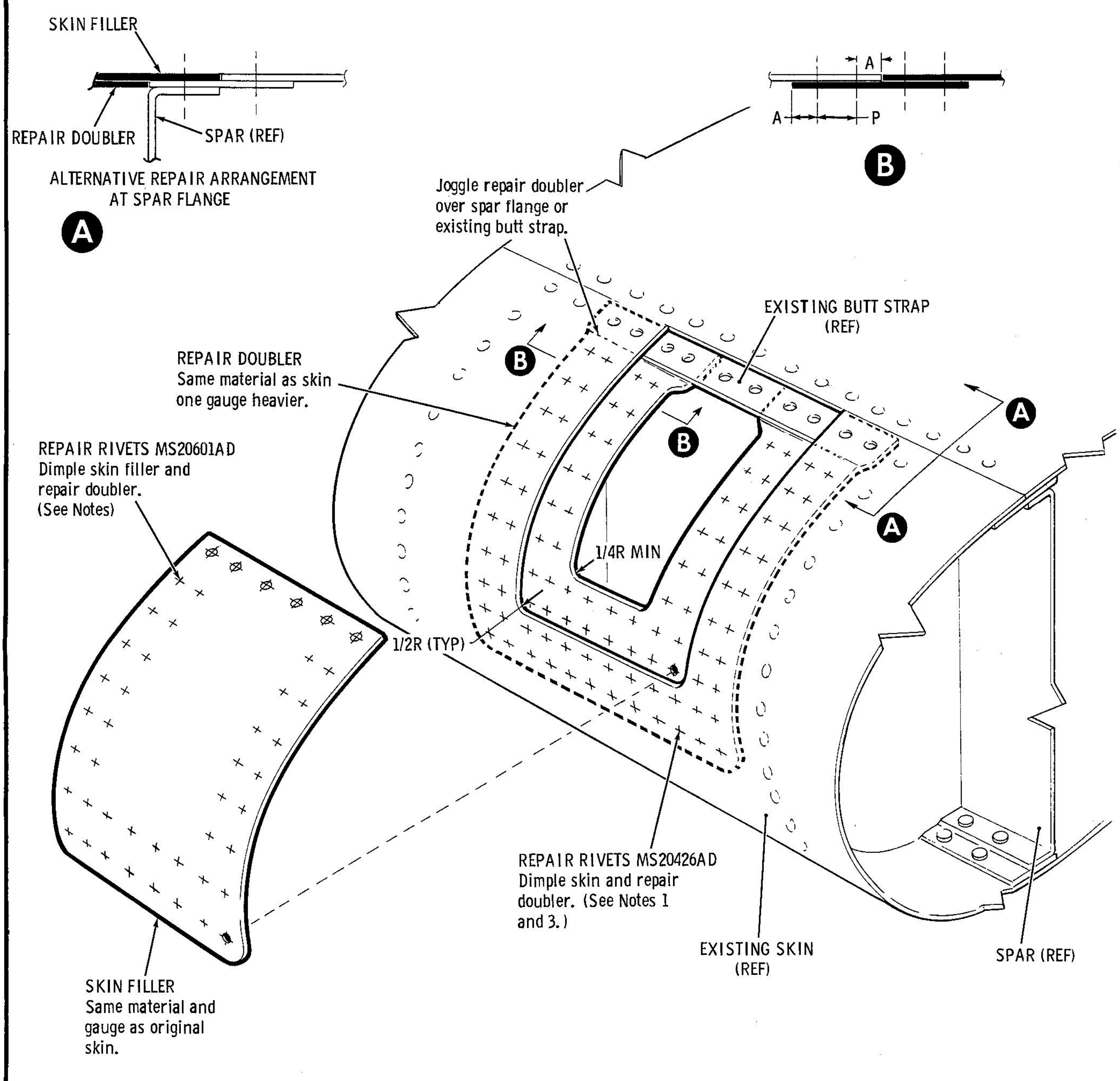


NOTES

1. For selection of repair material, number of rivets required for damage dimensions, and method of rivet distribution, refer to Typical Repair Procedure in text and appropriate illustrations.
2. Where possible, solid shank rivets should also be used to attach skin filler to doubler, rib and spar flange, especially in the case of damage being in the upper part of the leading edge skin.
3. Minimum edge distance (A) and minimum and maximum rivet pitch (P) must be maintained. Refer to text.

13-24-90

Figure 33 (Sheet 1 of 2) Skin Repair Methods - Leading Edge



DAMAGE BETWEEN RIBS

NOTES

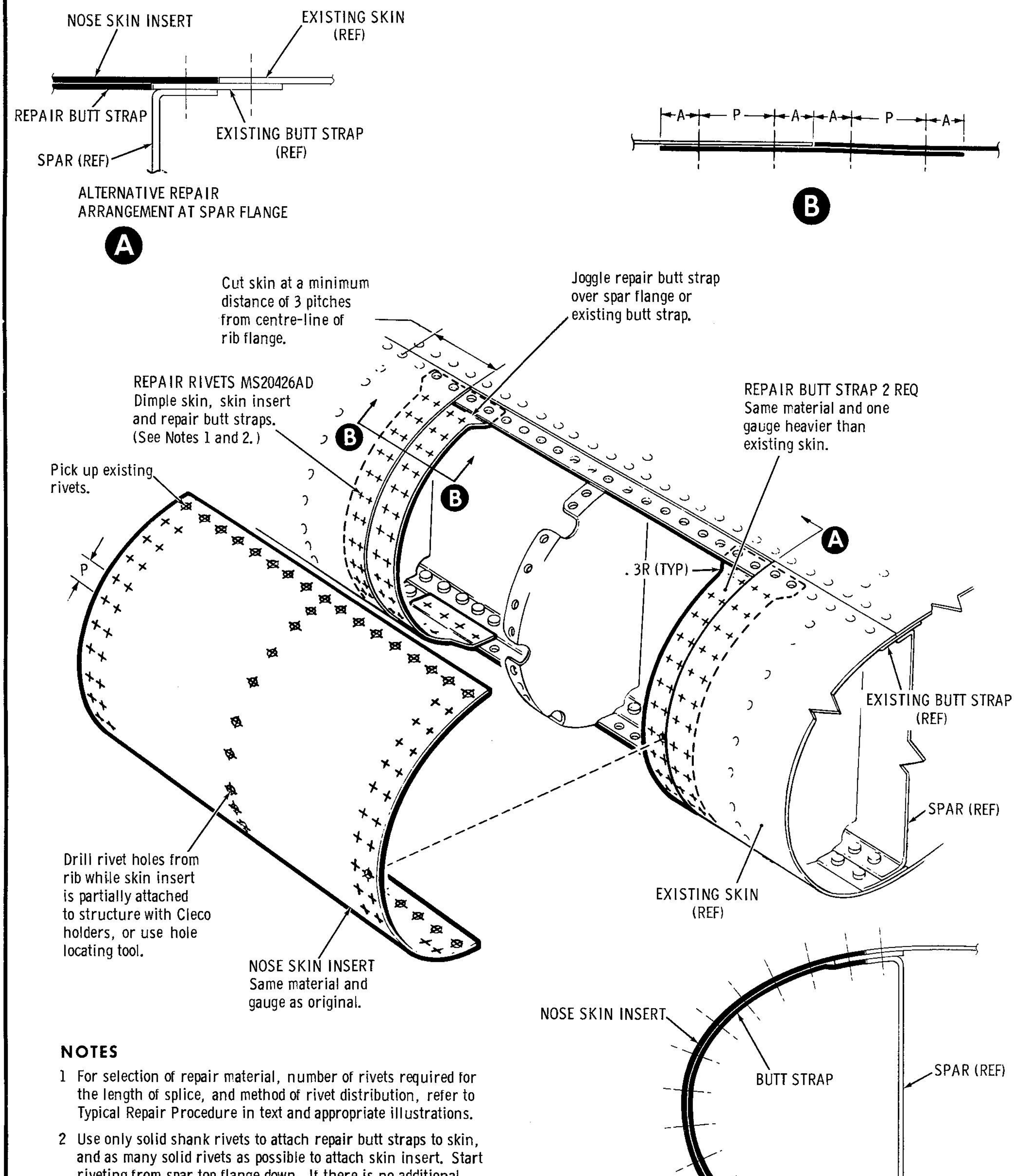
1 For selection of repair material, number of rivets required for damage dimensions, and method of rivet distribution, refer to Typical Repair Procedure in text and appropriate illustrations.

2 Where possible, solid shank rivets should also be used to attach skin filler to doubler and spar flange, especially in the case of damage being in the upper part of the leading edge skin.

3 Minimum edge distance (A) and minimum and maximum rivet pitch (P) must be maintained. Refer to text.

13-24-86

Figure 33 (Sheet 2 of 2) Skin Repair Methods - Leading Edge



NOTES

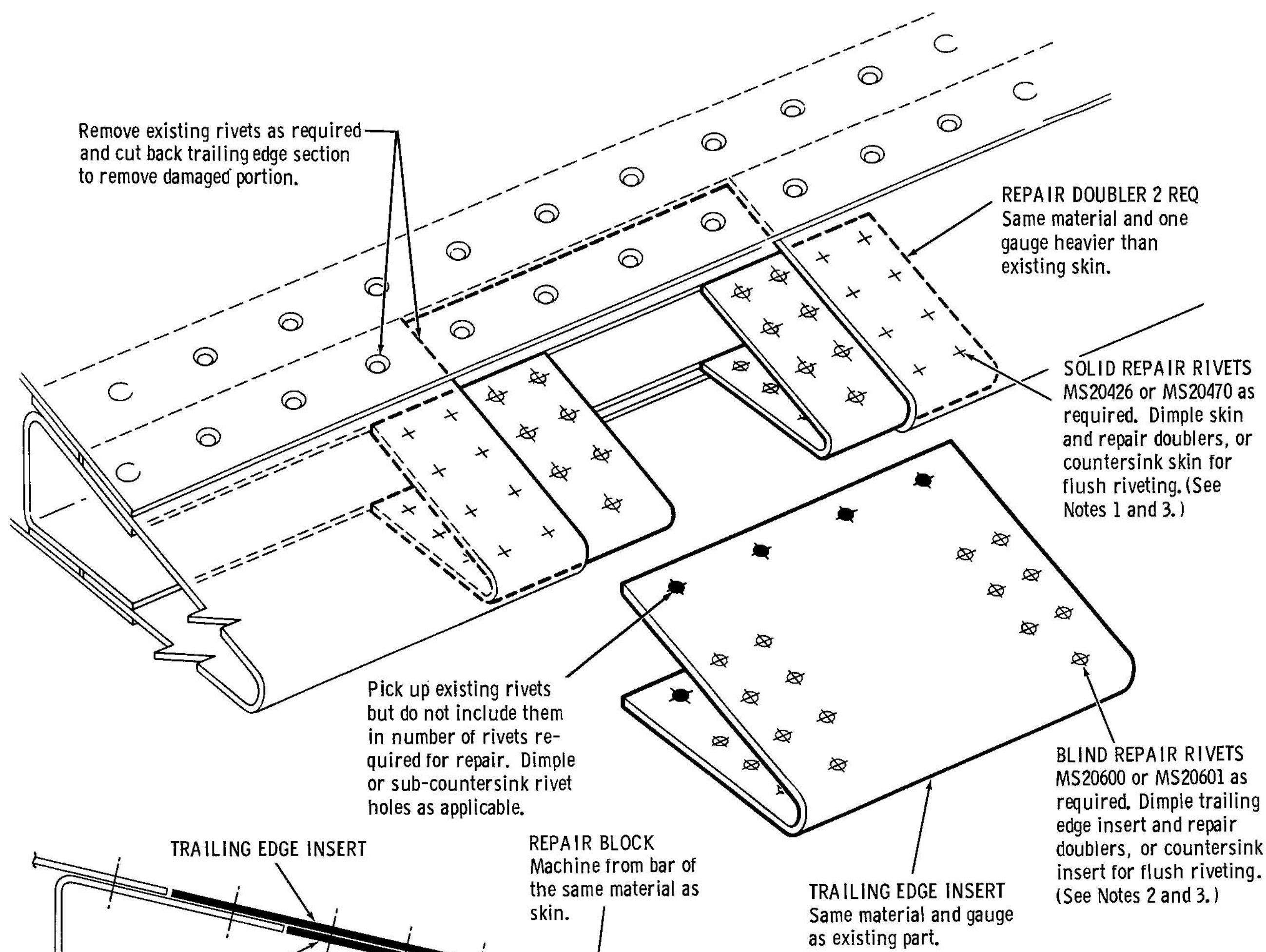
1 For selection of repair material, number of rivets required for the length of splice, and method of rivet distribution, refer to Typical Repair Procedure in text and appropriate illustrations.

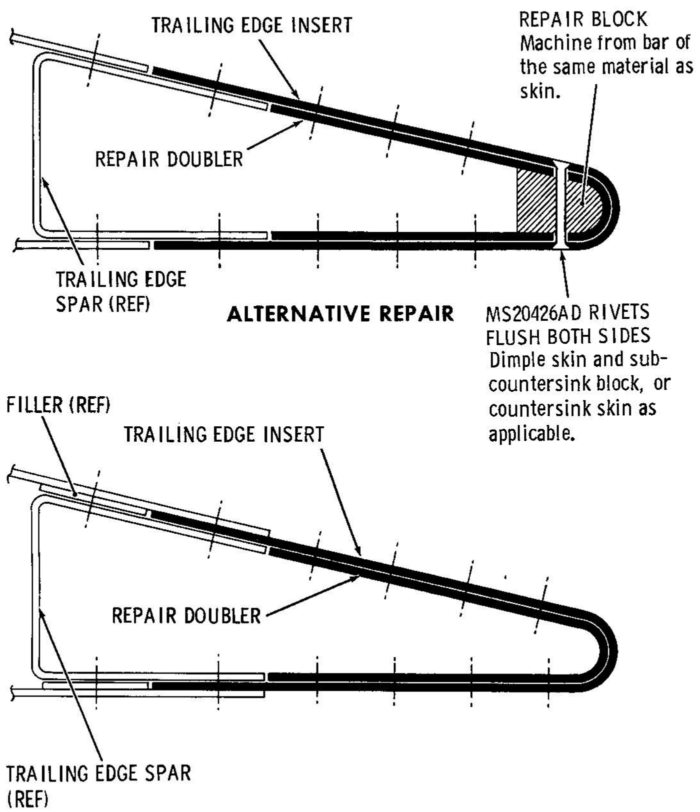
2 Use only solid shank rivets to attach repair butt straps to skin, and as many solid rivets as possible to attach skin insert. Start riveting from spar top flange down. If there is no additional access for bucking rivets, close the repair at spar bottom flange with blind rivets.

3 Minimum edge distance (A) and minimum and maximum rivet pitch (P) must be maintained. Refer to text.

13-24-85

Figure 34 Skin Repair Methods - Leading Edge Butt Splice





NOTES

1 Use solid repair rivets of the same type and material as existing in attachment of trailing edge. To facilitate installation, top and bottom rivet pattern on aft portion of trailing edge should be staggered.

2 Use Cherry blind rivets or equivalent, of the same material as existing rivets, to attach trailing edge insert. Where insufficient space does not permit the use of self-plugging rivets, hollow pull-through type may be used, providing the rivet stem holes are plugged after installation.

3 For selection of repair material, number of rivets required for the length of splice, and methods of rivet distribution, refer to Typical Repair Procedure in text and appropriate illustrations.

4 Minimum edge distance and minimum and maximum rivet spacing must be maintained. Refer to text.

5 Where installation of rivets in aft portion of trailing edge is not possible, because of insufficient space, machine required length of trailing edge block and install solid rivets, flush on both sides. See section of alternative repair.

13-24-91

Figure 35 Skin Repair Methods - Trailing Edge

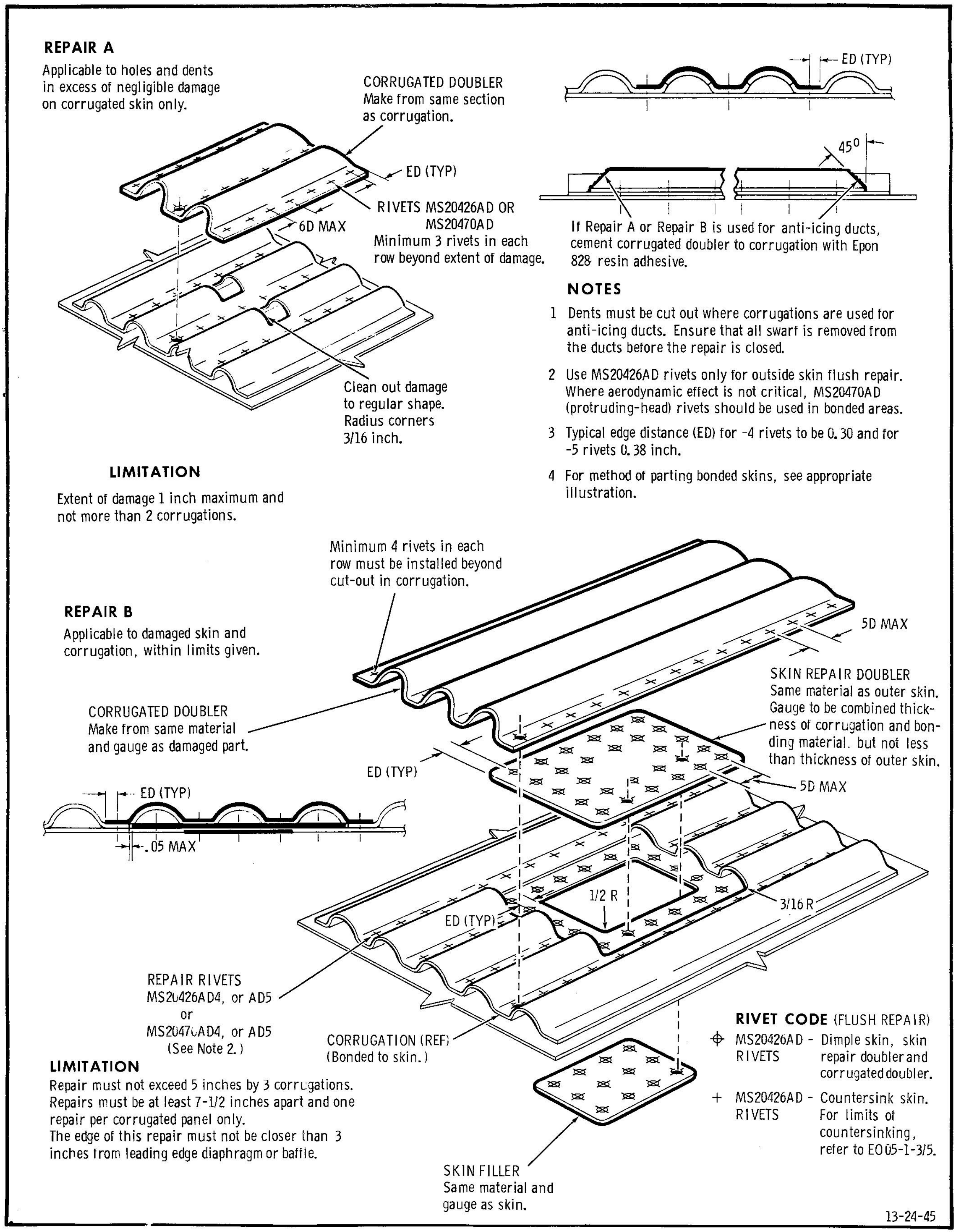


Figure 36 (Sheet 1 of 2) Skin Repair Methods - Reinforced with Bonded Corrugations

LIMITATION

Maximum size of damage:
2 corrugations x 10 inches, or
4 corrugations x 6 inches.
Only one such repair per skin panel.
This repair must not be used for anti-icing duct and pressure bulkheads.

NOTES

1 Wherever possible, damage to skin reinforced with corrugations should be repaired using corrugated doubler as shown in Sheet 1.

2 Where combined thickness of skin, corrugation and bonding film is within limits for countersinking holes, use MS20426AD rivets. If this thickness is below the limits, use MS20470AD rivets. (Refer to EO 05-1-3/5.) Dimpling of rivet holes in bonded areas may be done only if approved by engineering authority.

3 For selection of repair material and other pertinent data, refer to text: Skin Repairs, Typical Repair Procedure.

4 See Note 3 in Sheet 1, for typical edge distance.

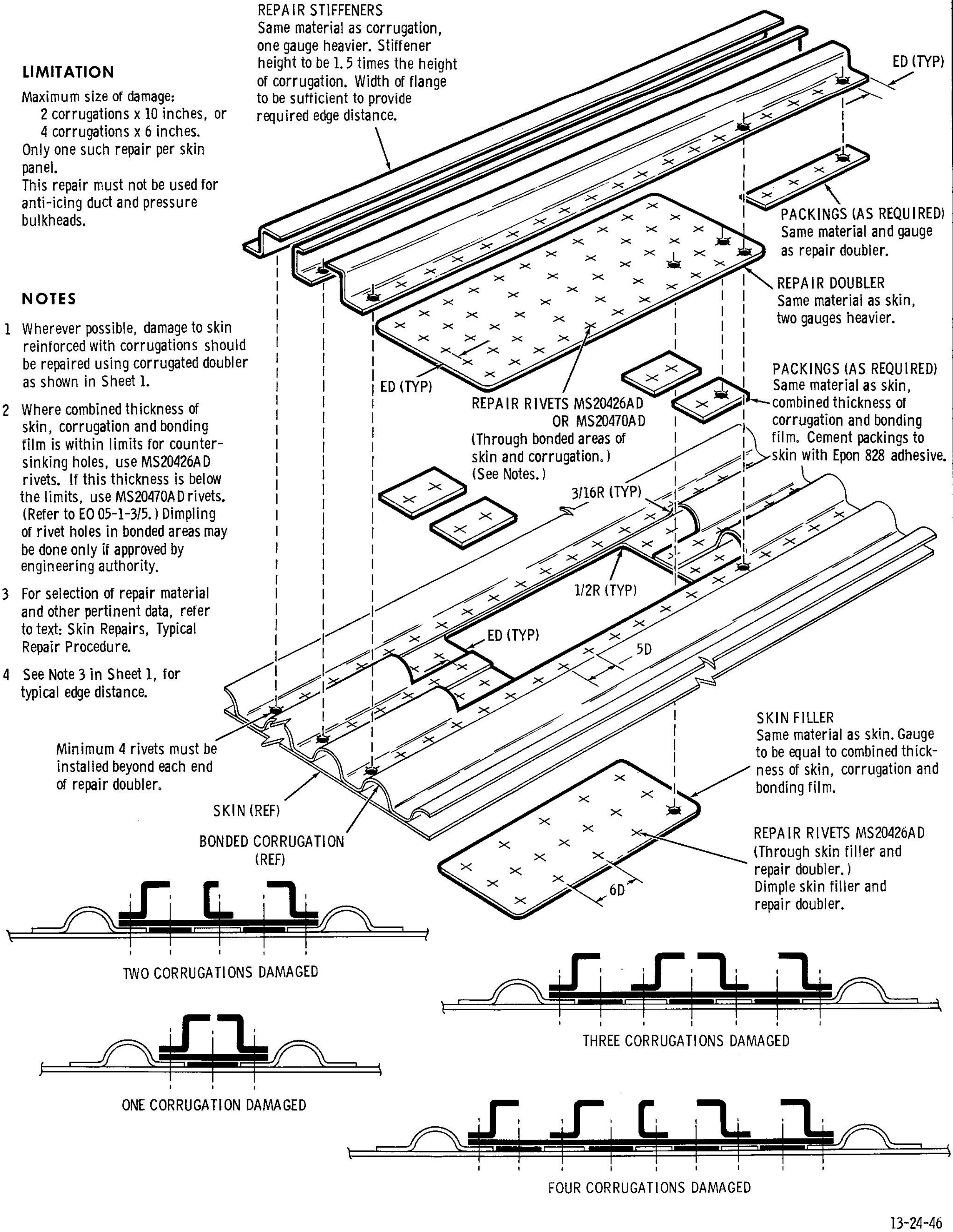
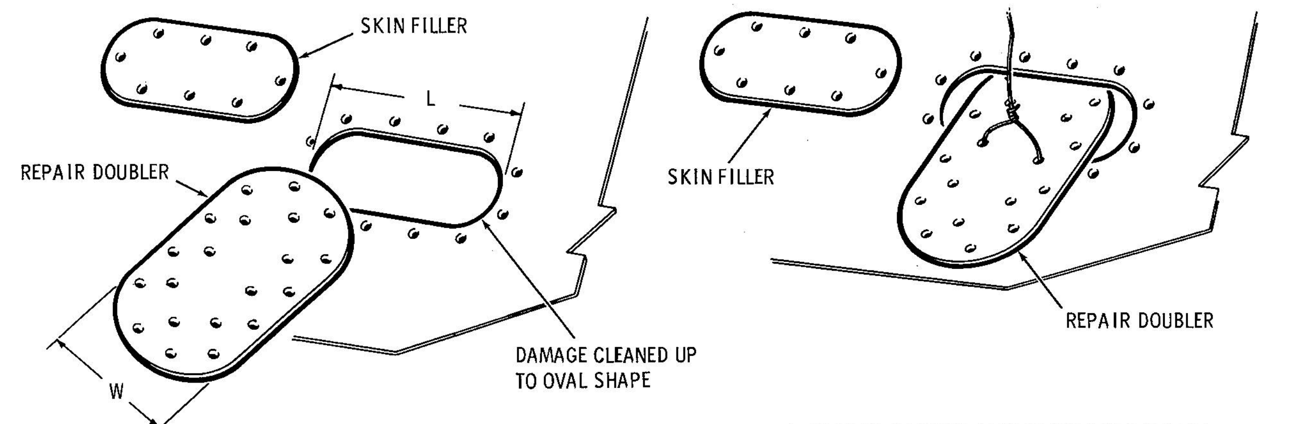


Figure 36 (Sheet 2 of 2) Skin Repair Methods - Reinforced with Bonded Corrugations

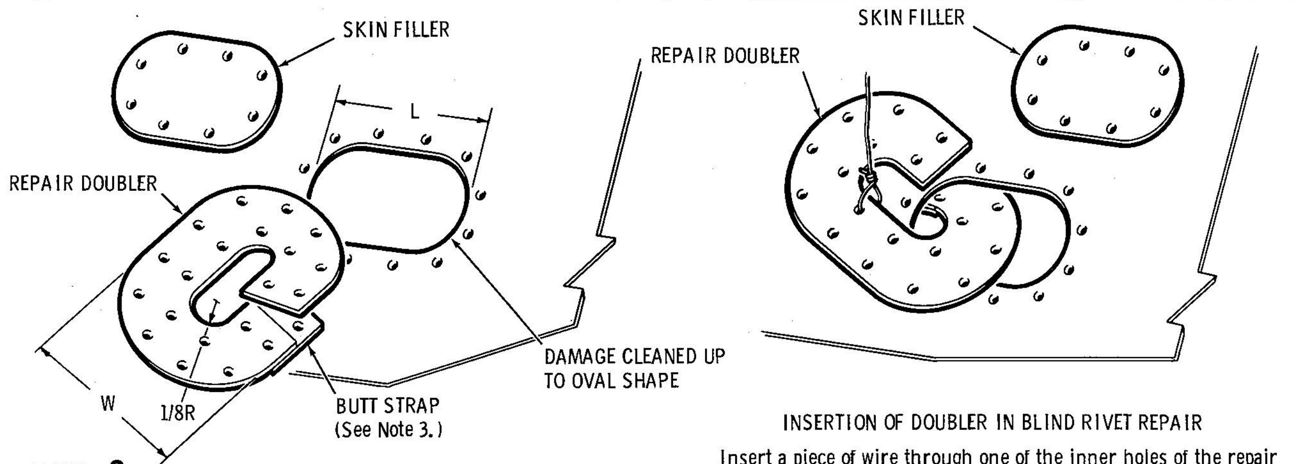


NOTE 1

When the width (W) of the doubler is slightly smaller than the length (L) of cleaned-up damage, use this type of doubler.

INSERTION OF DOUBLER IN BLIND RIVET REPAIR

Insert a piece of wire through two inner holes of the repair doubler and manipulate the doubler into position beneath the skin. Line up holes, insert Cleco holders and rivet doubler to the skin.

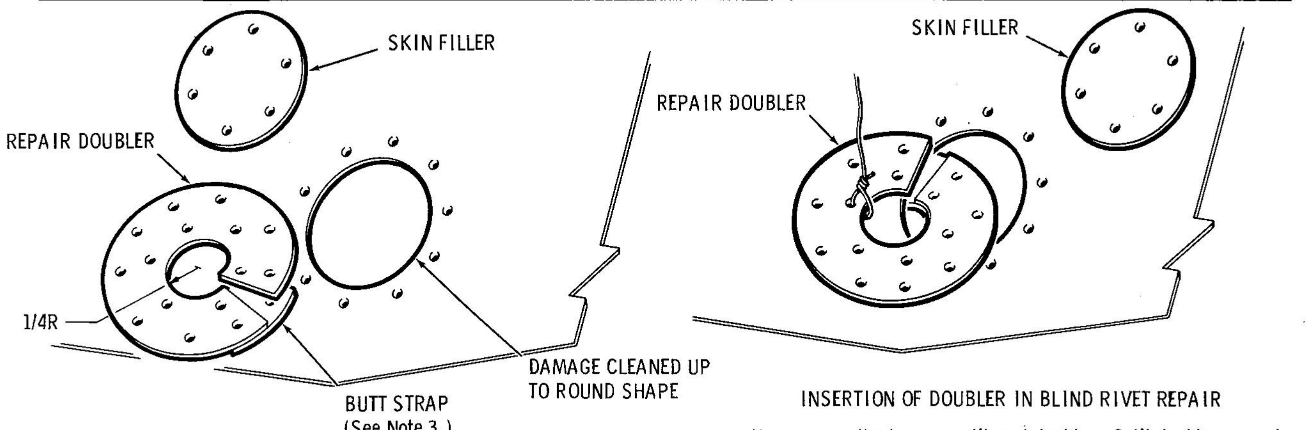


NOTE 2

When the width (W) of the doubler is greater than the length (L) of cleaned-up damage, use this type of doubler.

INSERTION OF DOUBLER IN BLIND RIVET REPAIR

Insert a piece of wire through one of the inner holes of the repair doubler, open the split sufficiently to manipulate the doubler into position beneath the skin. Line up holes, insert Cleco holders and rivet doubler to the skin.



NOTE 3

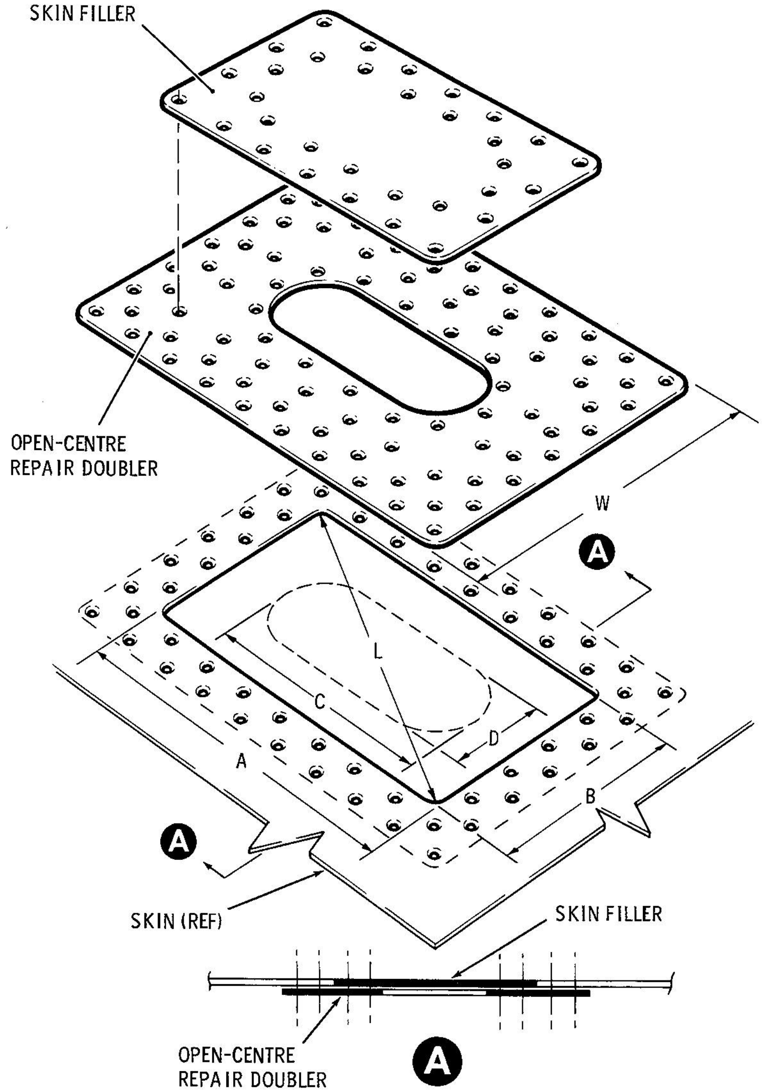
For easier insertion, cement half of butt strap to doubler with Epon 828 resin adhesive before installation.

INSERTION OF DOUBLER IN BLIND RIVET REPAIR

Use the same method as for split oval doubler. Split doublers may be inserted only if the width of the ring is slightly smaller than the diameter of cleaned up hole.

13-24-77

Figure 37 Closed Skin - Insertion of Repair Doubler in Blind Repair



NOTES

1. Use this type of repair doubler with open centre for flush, partially blind repair in secondary and tertiary structures only.
2. The aperture in repair doubler must be just large enough to permit insertion of rivet bucking bars.
3. First prepare paper template establishing rivet pattern and dimensions of repair doubler and skin filler. Test in place and transfer the marking to repair members.
4. Rivet repair doubler to skin with solid flush rivets through the opening in doubler.
5. Rivet skin filler to repair doubler with blind flush rivets.
6. In this repair, rivet pattern through skin filler and repair doubler must be adequate to compensate for the reduced strength of the open centre doubler.
7. Required number of rivets to secure filler to doubler will depend on dimensions of opening in the doubler. (See Note 10.)
8. Dimensions of repair doubler and skin filler will be governed by rivet pattern.
9. When the width (W) of repair doubler is greater than diagonal (L) of cleaned-up damage, use alternative split doublers as shown below.
10. For selection of repair material, required number of repair rivets for damage dimensions A and B in skin and opening dimensions C and D in doubler, and for methods of rivet distribution, refer to Typical Repair Procedure in text and see appropriate illustrations.

ALTERNATIVE DOUBLERS

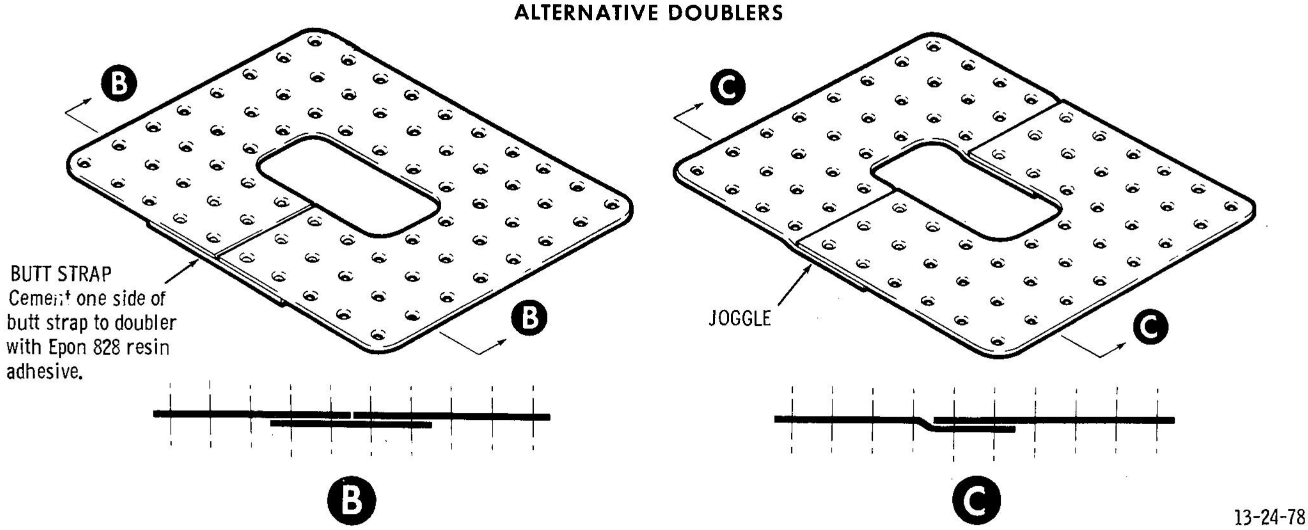


Figure 38 Closed Skin - Partial Blind Repair Methods

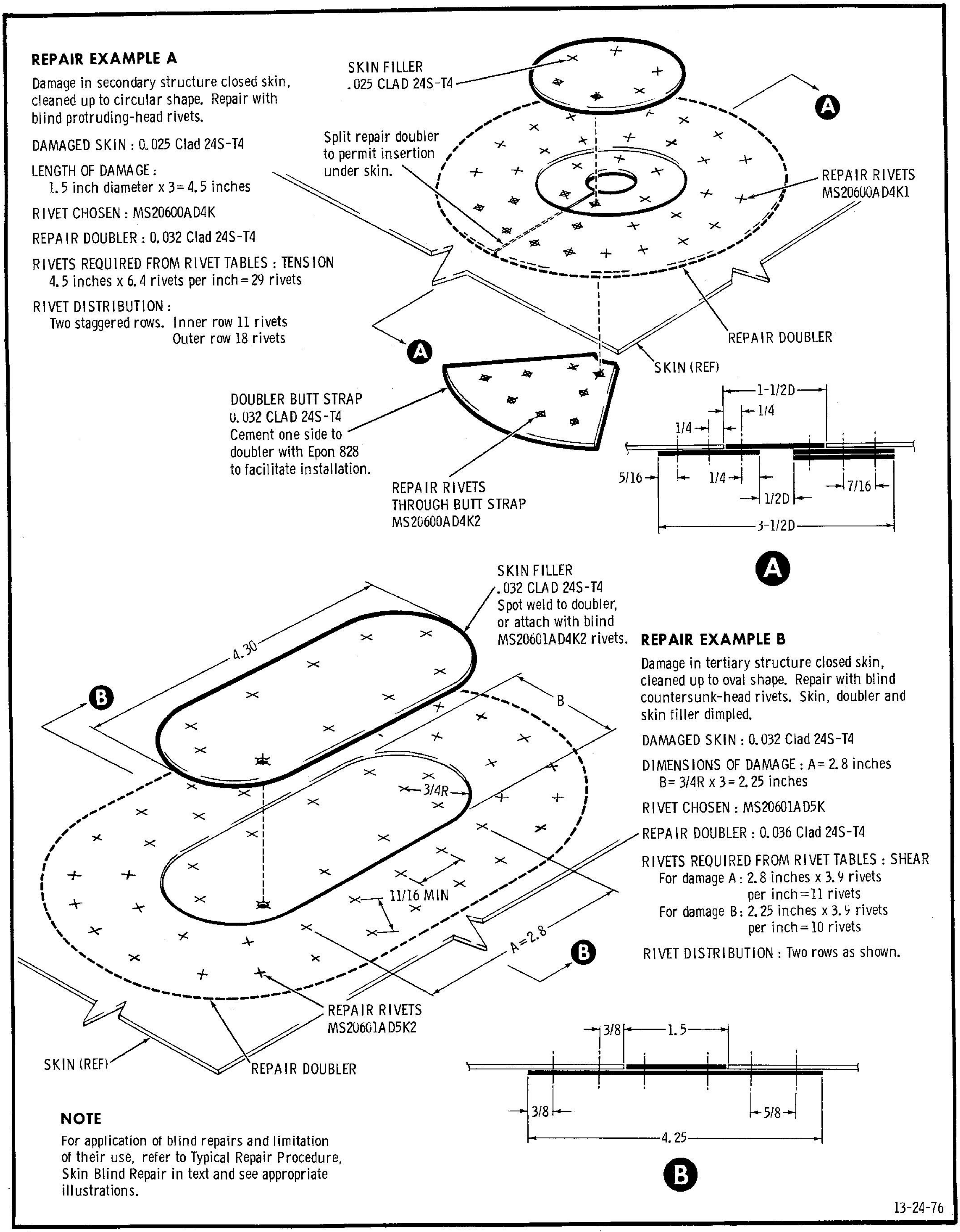
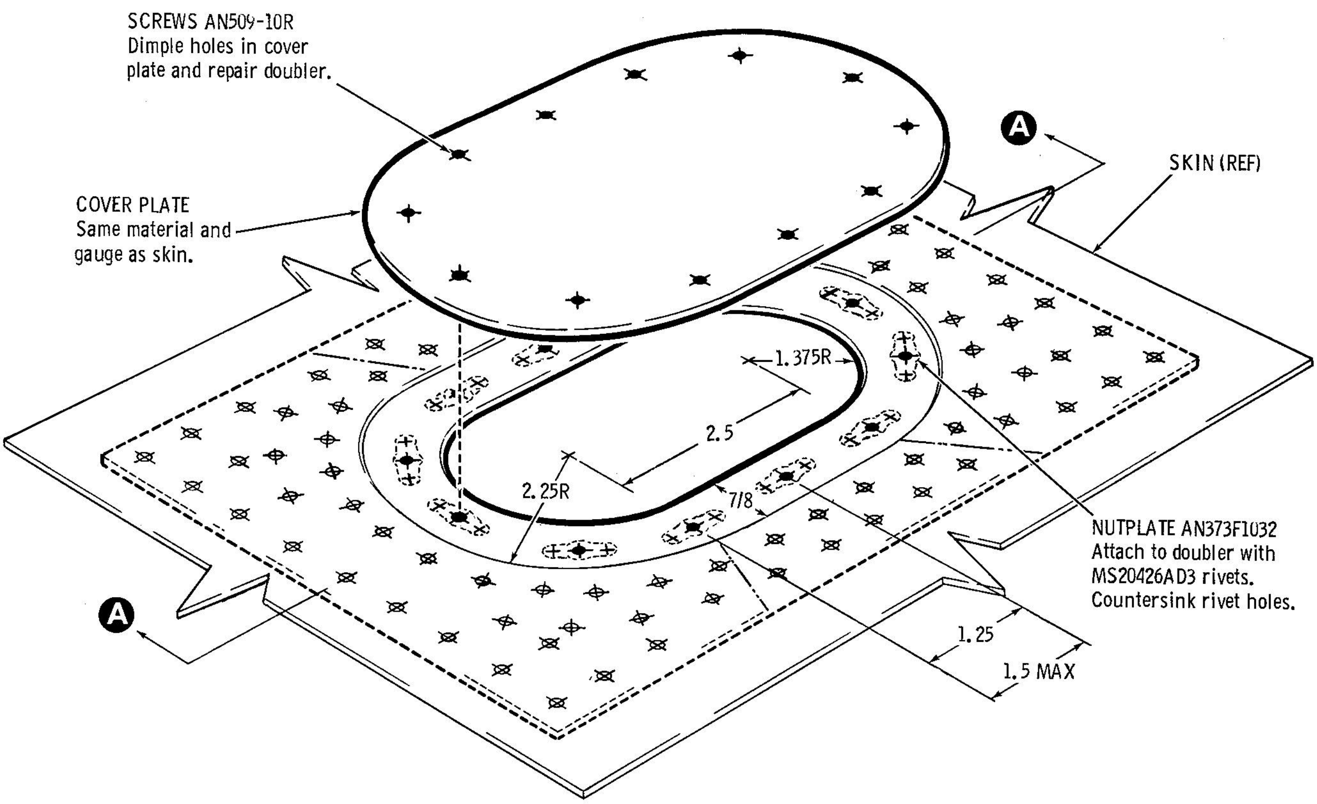
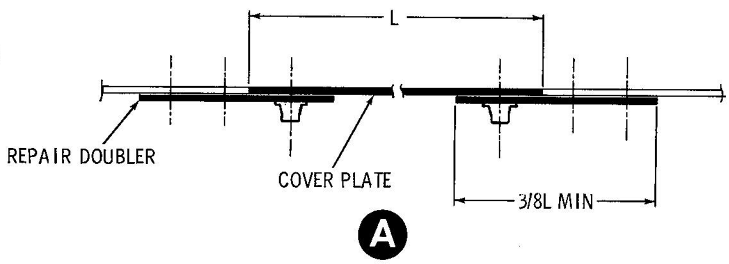


Figure 39 Closed Skin - Blind Repair Methods



ACCESS PANEL INSTALLATION - EXAMPLE



SECONDARY STRUCTURE - LOAD IN SHEAR AND TENSION

SKIN: 0.036 Clad 24S-T3
DIMENSIONS OF OPENING:
 2.5 inches in Shear
 2.25R x 3 = 6.75 inches in Tension
RIVET CHOSEN: MS20426AD4 (Holes dimpled)
RIVETS REQUIRED FROM RIVET TABLES:
 2.5 inches x 3.2 rivets per inch = 8 rivets
 6.75 inches x 5 rivets per inch = 34 rivets
REPAIR DOUBLER: 0.040 Clad 24S-T3
RIVET DISTRIBUTION: To maintain staggered pattern in this example, 9 and 35 rivets respectively are used on each side of the dimension of opening.

LIMITATION

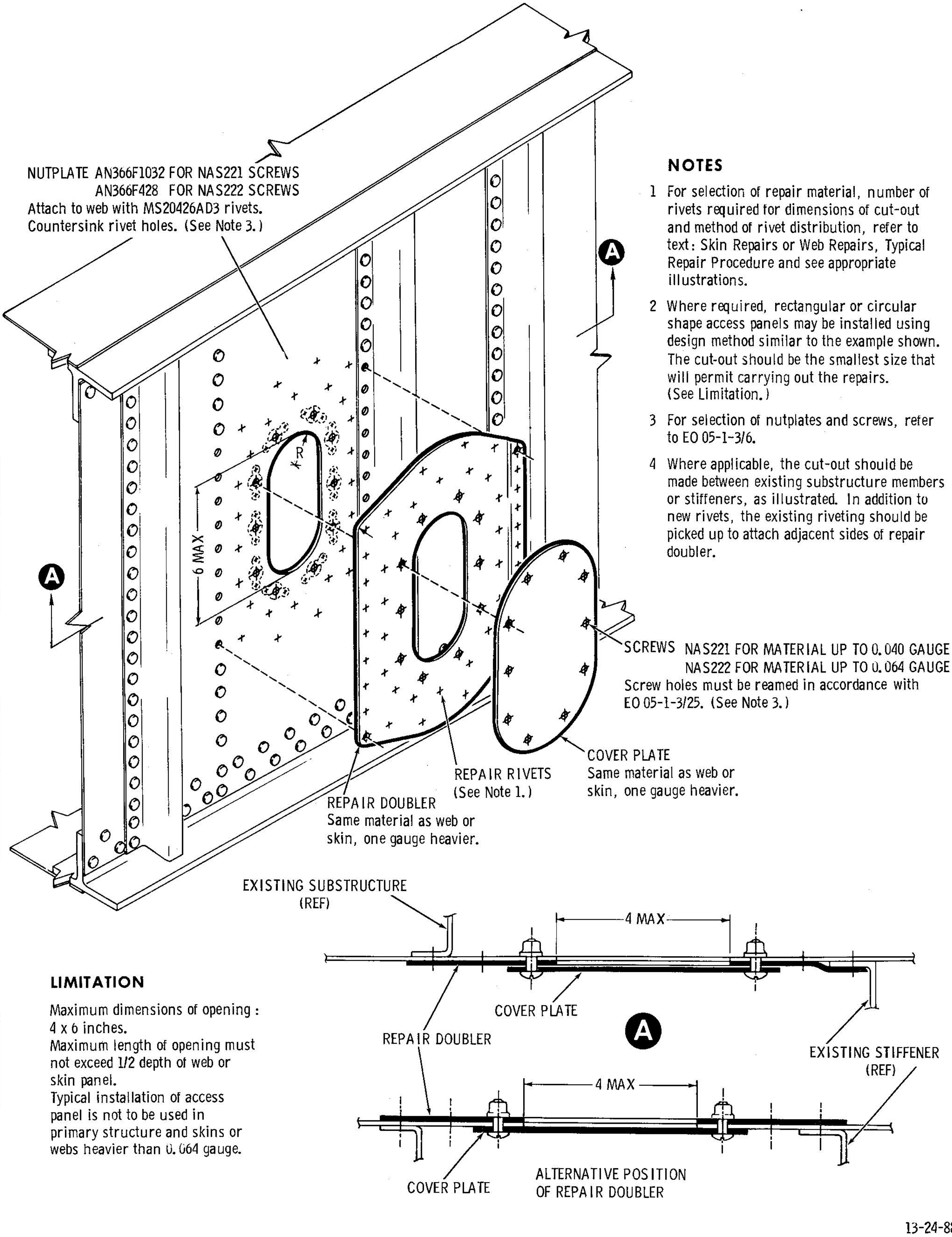
Maximum dimensions of opening: 4 x 6 inches.
Maximum length of opening must not exceed 1/2 depth of web or skin panel.
Typical installation of access panel is not to be used in primary structure and skins or webs heavier than 0.064 gauge.

NOTES

1. For selection of repair material and other pertinent repair data, refer to text: Skin Repairs, Typical Repair Procedure.
2. Where required, rectangular or circular shape access panels may be installed using design method similar to the example shown, and calculating repair material in accordance with Typical Repair Procedure in the text.
3. For selection of nutplates and screws, refer to EO 05-1-3/6, and see Sheet 2.

13-24-87

Figure 40 (Sheet 1 of 2) Installation of Access Panels - Flush Type



NOTES

1. For selection of repair material, number of rivets required for dimensions of cut-out and method of rivet distribution, refer to text: Skin Repairs or Web Repairs, Typical Repair Procedure and see appropriate illustrations.
2. Where required, rectangular or circular shape access panels may be installed using design method similar to the example shown. The cut-out should be the smallest size that will permit carrying out the repairs. (See Limitation.)
3. For selection of nutplates and screws, refer to EO 05-1-3/6.
4. Where applicable, the cut-out should be made between existing substructure members or stiffeners, as illustrated. In addition to new rivets, the existing riveting should be picked up to attach adjacent sides of repair doubler.

LIMITATION

Maximum dimensions of opening: 4 x 6 inches.
Maximum length of opening must not exceed 1/2 depth of web or skin panel.
Typical installation of access panel is not to be used in primary structure and skins or webs heavier than 0.064 gauge.

Figure 40 (Sheet 2 of 2) Installation of Access Panels - Lap Type

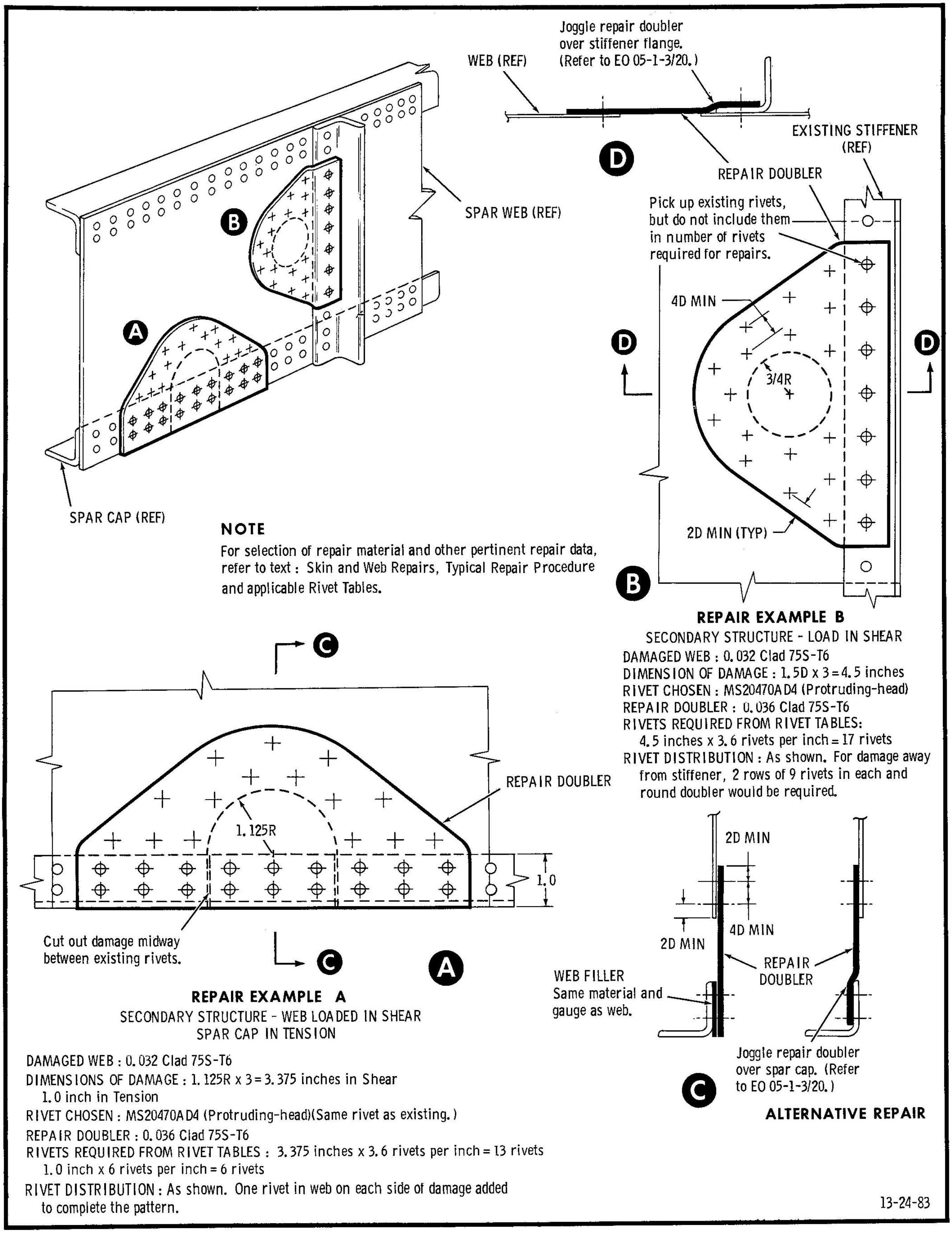
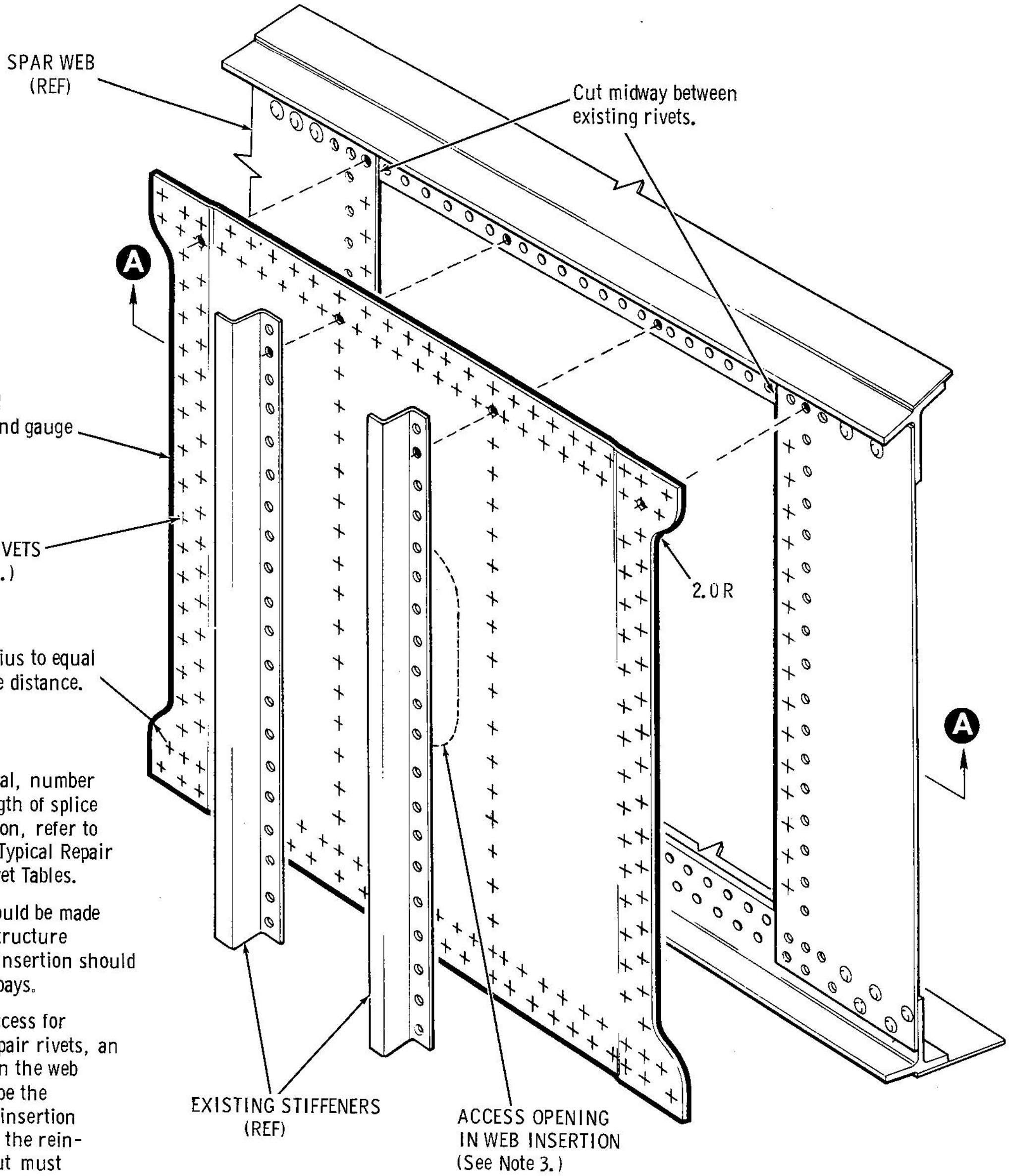
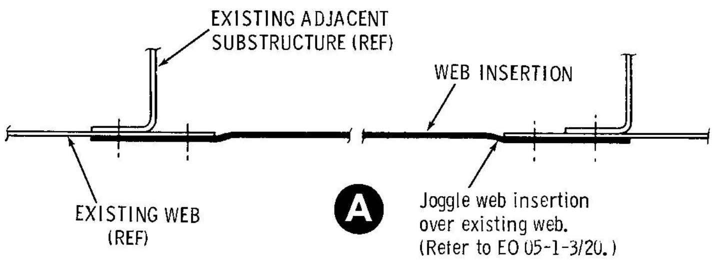


Figure 41 Spar Web - Repair



NOTES

1. For selection of repair material, number of rivets required for the length of splice and method of rivet distribution, refer to text: Skin and Web Repairs, Typical Repair Procedure and applicable Rivet Tables.
2. Where possible the joints should be made at existing stiffeners or substructure members. The length of web insertion should be a minimum of 3 stiffener bays.
3. Where there is no existing access for installation of solid shank repair rivets, an access cut-out may be made in the web insertion. The cut-out must be the smallest size that will permit insertion of bucking tools. The edges of the reinforcing doubler for the cut-out must be one clear bay from the joint of the web insertion. See repair illustrations showing applicable installation of access panels.

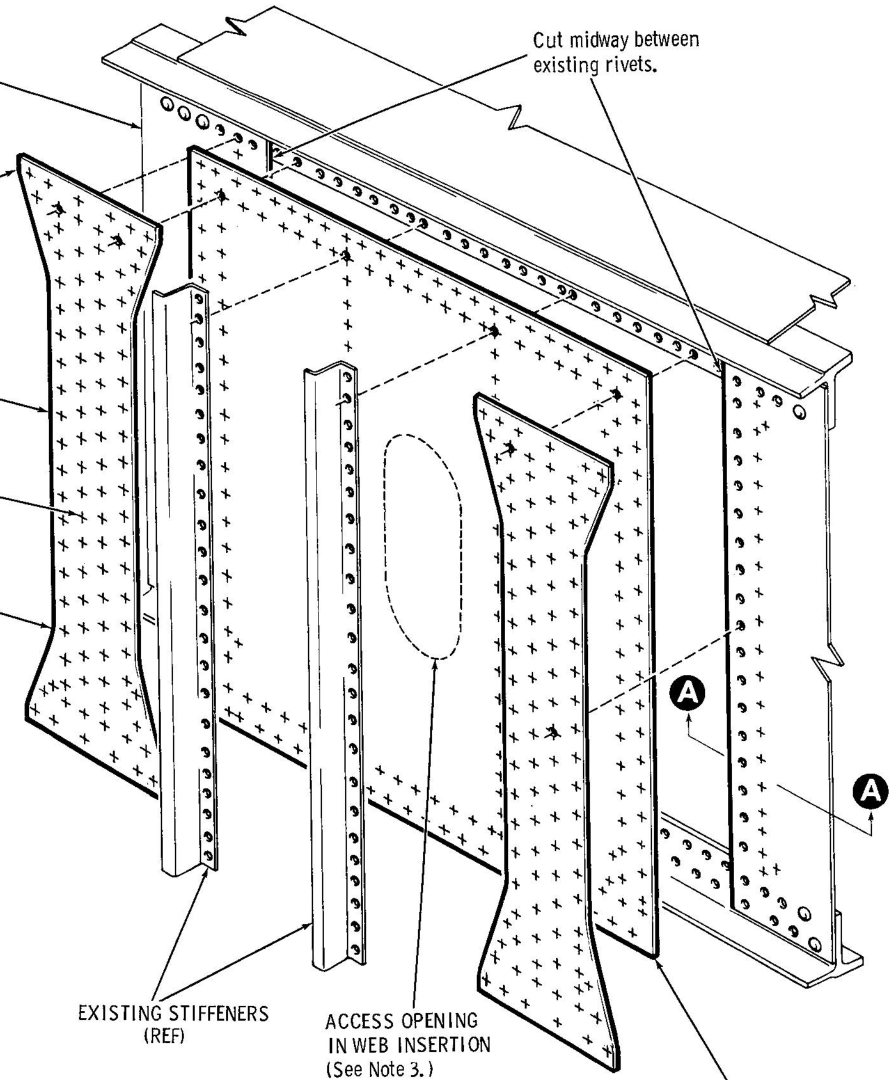


LIMITATION

Typical web insertion repairs must not be used in primary structure components carrying heavy loads (wing box-spar webs, horizontal and vertical stabilizer box-spar webs and pressurized bulkhead webs).

13-24-81

Figure 42 (Sheet 1 of 2) Web Insertion - Joggled Lap Splice

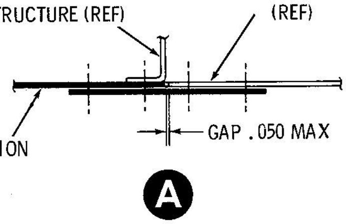


NOTES

1 For selection of repair material, number of rivets required for the length of splice, and method of rivet distribution, refer to text: Skin and Web Repairs, Typical Repair Procedure and applicable Rivet Tables.

2 Where possible the joints should be made at existing stiffeners or substructure members. The length of web insertion should be a minimum of 3 stiffener bays.

3 Where there is no existing access for installation of solid shank repair rivets, an access cut-out may be made in the web insertion. The cut-out must be the smallest size that will permit insertion of bucking tools. The edges of the reinforcing doubler for the cut-out must be one clear bay from the joint of the web insertion. See repair illustrations showing applicable installation of access panels.



LIMITATION

Typical web insertion repairs must not be used in primary structure components carrying heavy loads (wing box-spar webs, horizontal and vertical stabilizer box-spar webs and pressurized bulkhead webs).

13-24-80

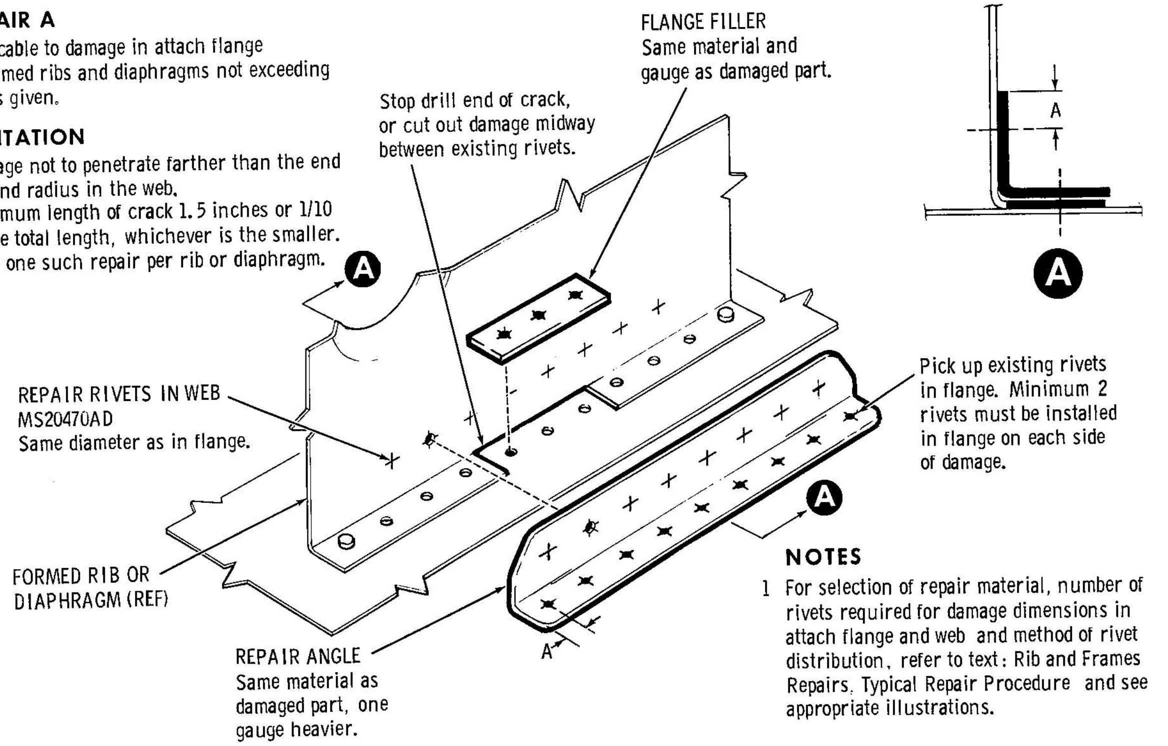
Figure 42 (Sheet 2 of 2) Web Insertion - Butt Splice

REPAIR A

Applicable to damage in attach flange of formed ribs and diaphragms not exceeding limits given.

LIMITATION

Damage not to penetrate farther than the end of bend radius in the web.
Maximum length of crack 1.5 inches or 1/10 of the total length, whichever is the smaller.
Only one such repair per rib or diaphragm.



NOTES

1 For selection of repair material, number of rivets required for damage dimensions in attach flange and web and method of rivet distribution, refer to text: Rib and Frames Repairs, Typical Repair Procedure and see appropriate illustrations.

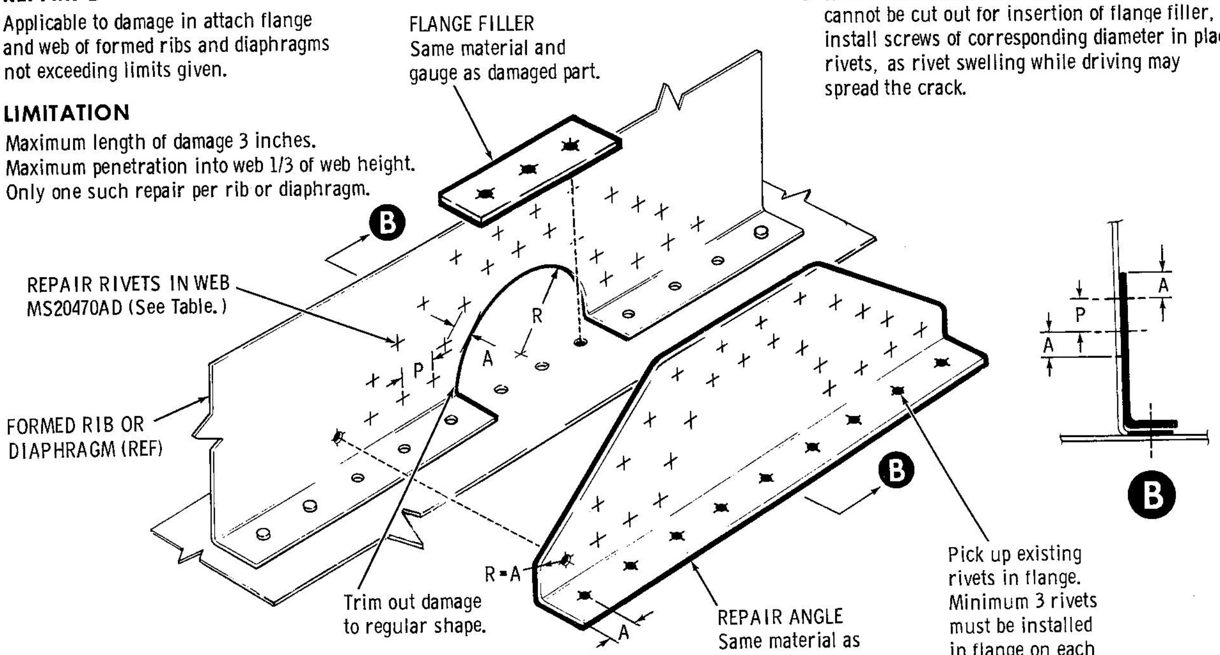
2 Where rivet holes are cracked, and the damage cannot be cut out for insertion of flange filler, install screws of corresponding diameter in place of rivets, as rivet swelling while driving may spread the crack.

REPAIR B

Applicable to damage in attach flange and web of formed ribs and diaphragms not exceeding limits given.

LIMITATION

Maximum length of damage 3 inches.
Maximum penetration into web 1/3 of web height.
Only one such repair per rib or diaphragm.



PART THICKNESS	RIVETS	DIMENSION A	PITCH (P) MIN	PITCH (P) MAX
.018 to .020	AD3	.25	.50	.70
.022 to .036	AD4	.30	.60	.75
.040 to .063	AD5	.40	.70	.90

13-24-52

Figure 43 (Sheet 1 of 2) Rib or Frame Flange and Web - Repair

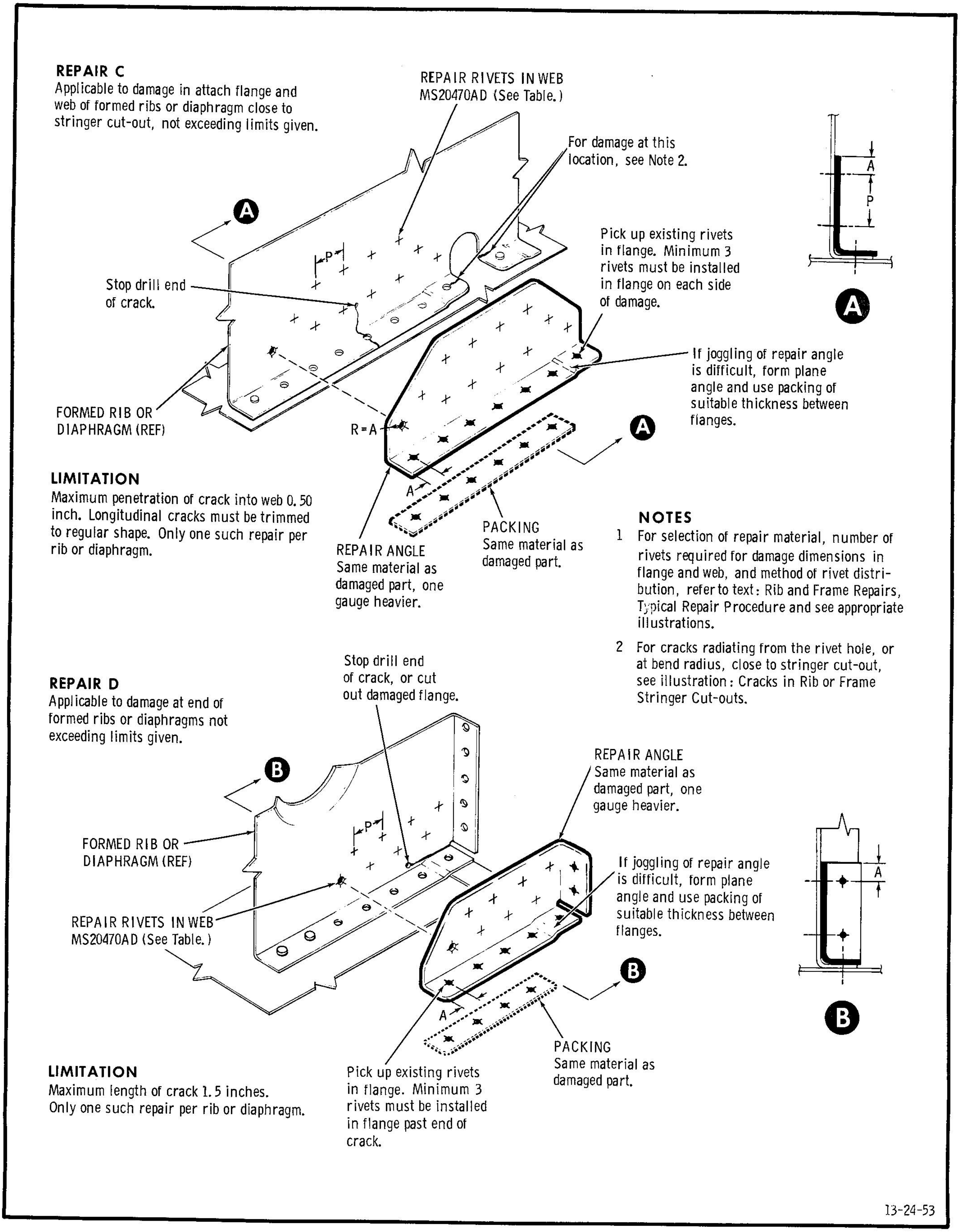
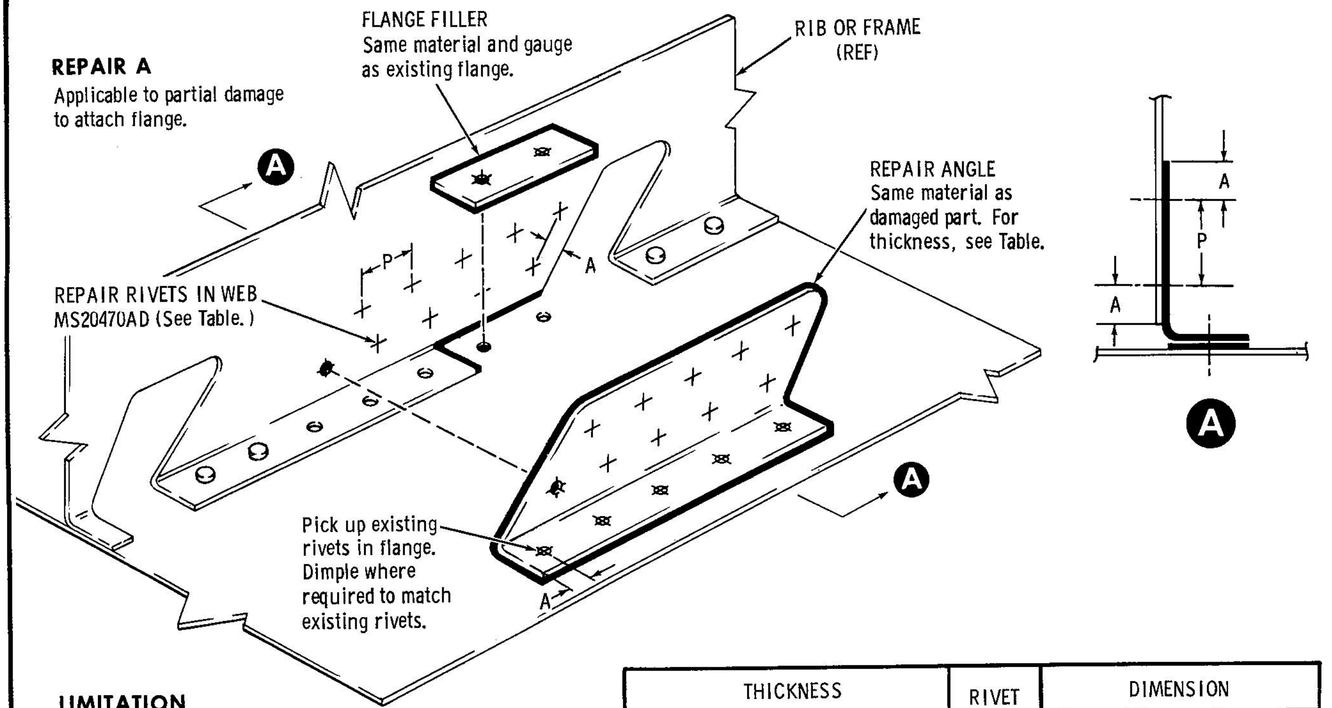


Figure 43 (Sheet 2 of 2) Rib or Frame Flange and Web - Repair

REPAIR A

Applicable to partial damage to attach flange.



LIMITATION

Damage must not penetrate farther than the end of bend radius in the web. Only one such repair per rib flange of frame sector.

NOTE

For selection of repair material and other pertinent repair data, refer to text: Rib and Frame Repairs, Typical Repair Procedure.

THICKNESS		RIVET DIA	DIMENSION		
RIB OR FRAME	ANGLE		A	P MIN	P MAX
.028	.036	AD4	.30	.50	.65
.036	.048	AD4	.30	.50	.65
.048	.056	AD5	.35	.65	.85
.063	.063	AD5	.35	.65	.85

REPAIR B

Applicable to skin repair where existing flange must be cut off to permit insertion of skin repair doubler, or where the flange is totally damaged.

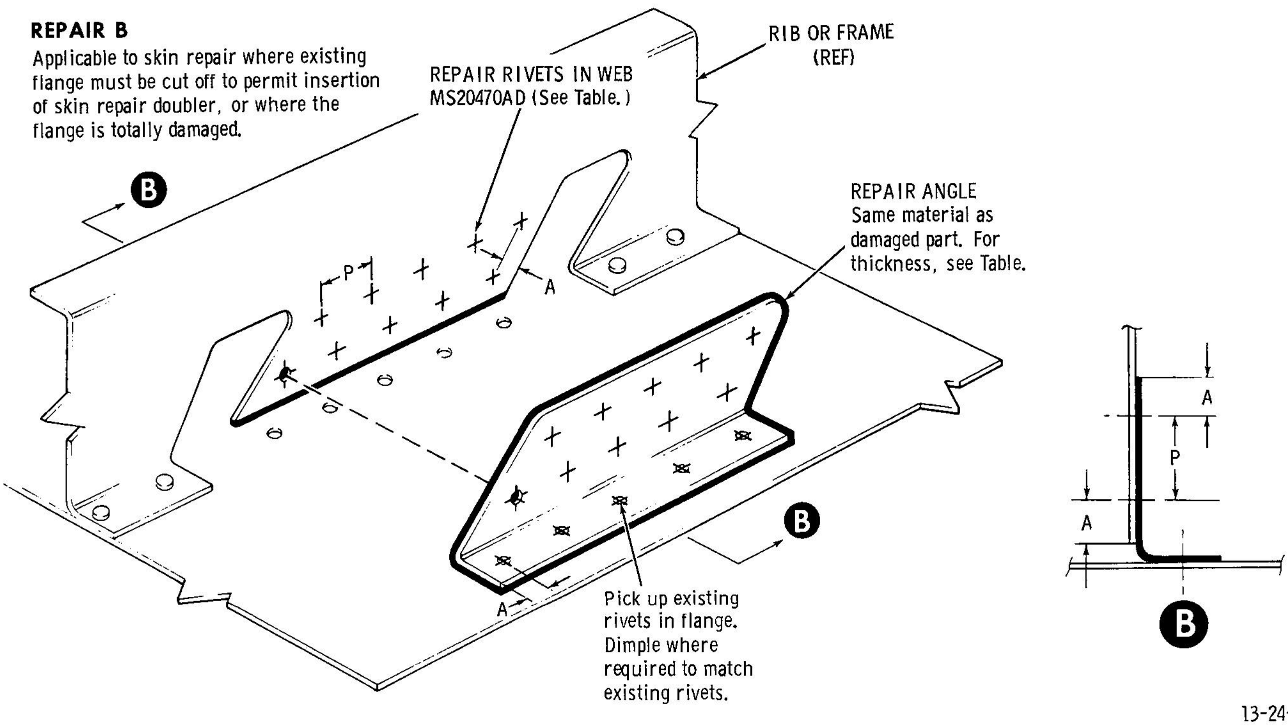
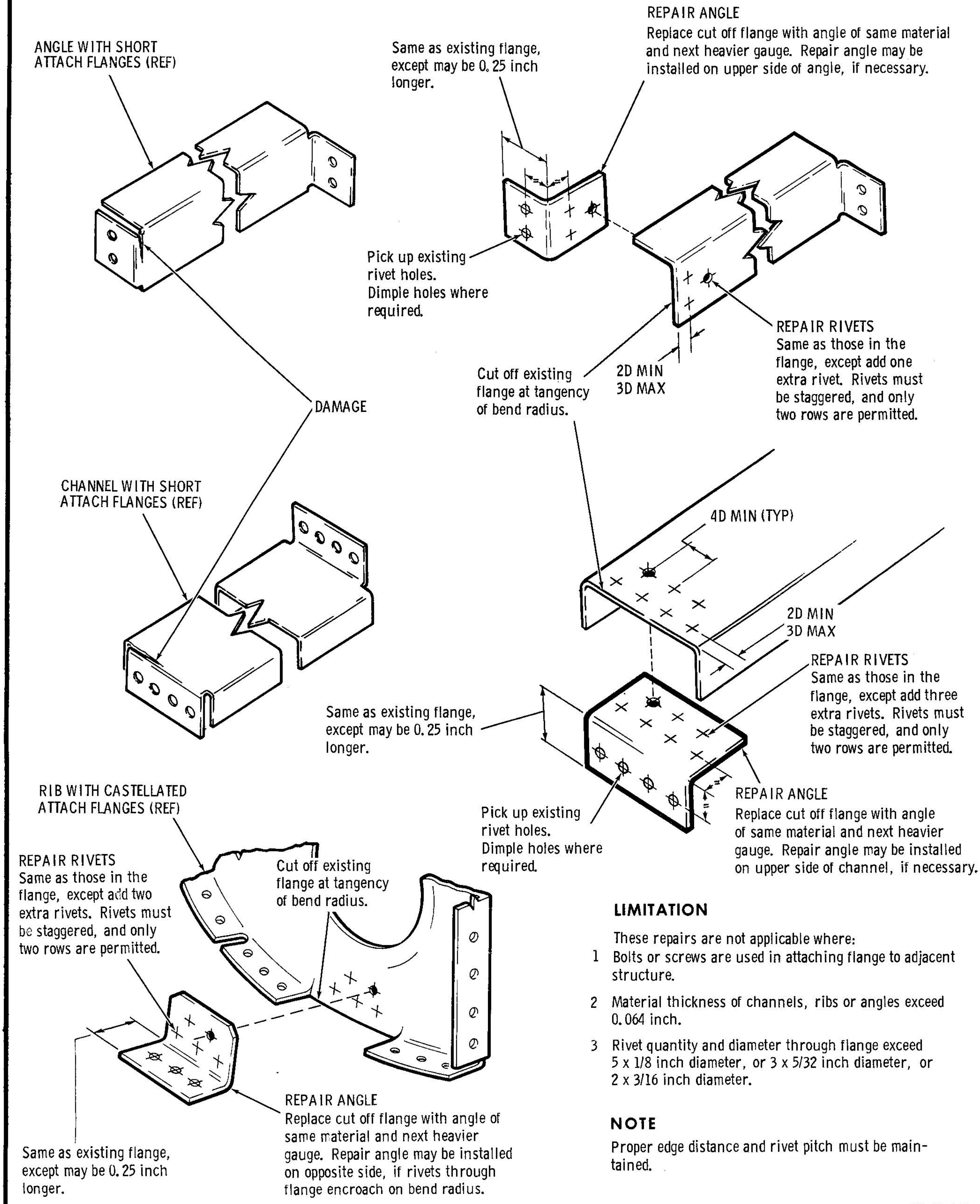


Figure 44 Rib or Frame Castellations - Repair



LIMITATION

These repairs are not applicable where:

1 Bolts or screws are used in attaching flange to adjacent structure.

2 Material thickness of channels, ribs or angles exceed 0.064 inch.

3 Rivet quantity and diameter through flange exceed 5 x 1/8 inch diameter, or 3 x 5/32 inch diameter, or 2 x 3/16 inch diameter.

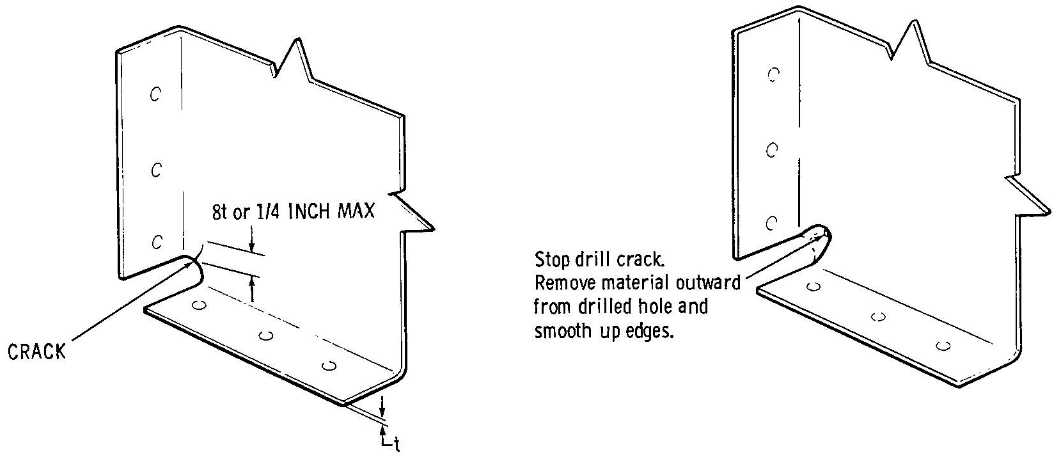
NOTE

Proper edge distance and rivet pitch must be maintained.

13-24-103

Figure 45 Replacement of Attach Flanges with Angle Clips

CRACK REPAIR BY BLENDING

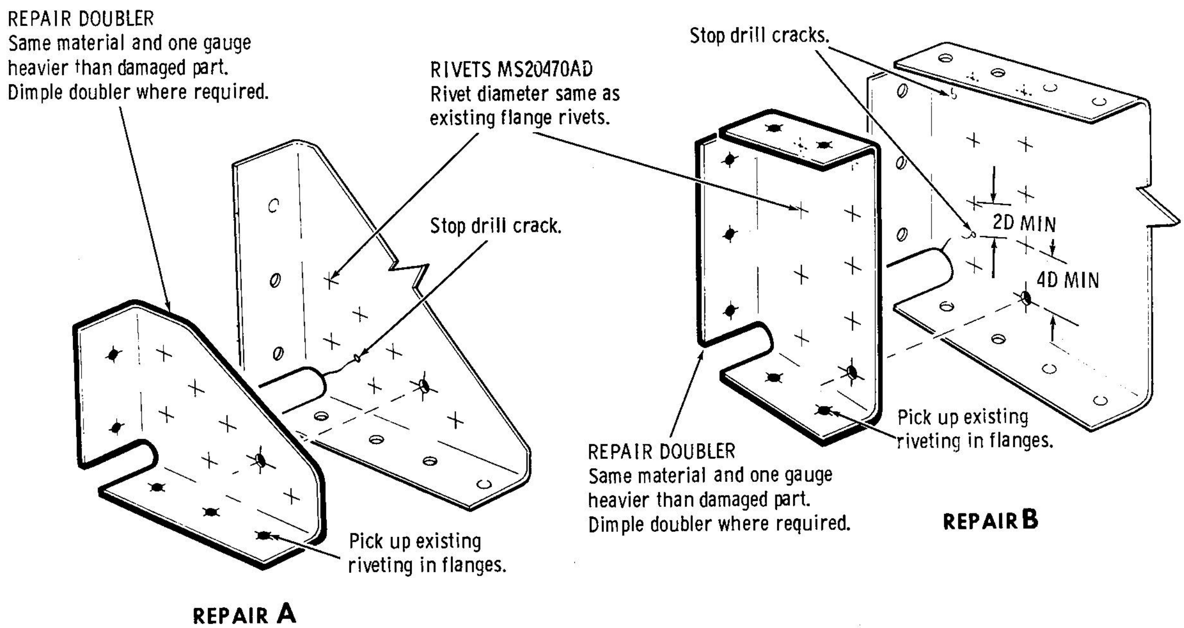


LIMITATION

Cracks in 0.032 inch and thinner material not to exceed 8 times sheet thickness (t).
Cracks in heavier material not to exceed 1/4 inch in length.
Cracks exceeding these limits must be repaired as shown below.

NOTE

t - denotes thickness of sheet.



LIMITATION

Cracks not to exceed 3/4 inch in length, or 25 times the thickness (t) of sheet, whichever is smaller.

Maximum of two A repairs per rib. Minimum distance between repairs 1/2 inch.

Maximum of one B repair per rib.

NOTE

Maintain proper edge distance and rivet spacing.

13-24-50

Figure 46 Cracks in Corners of Formed Ribs - Repair

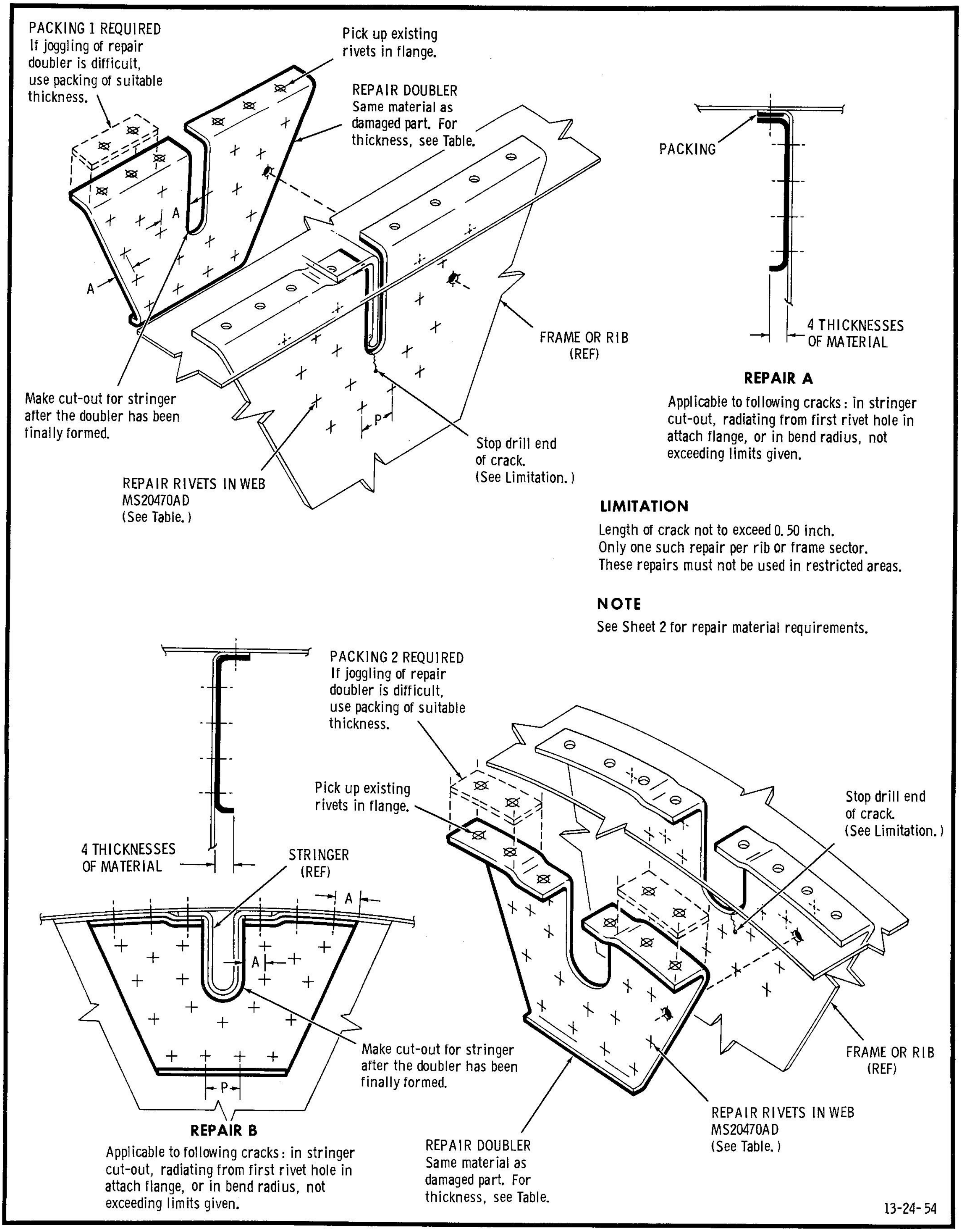
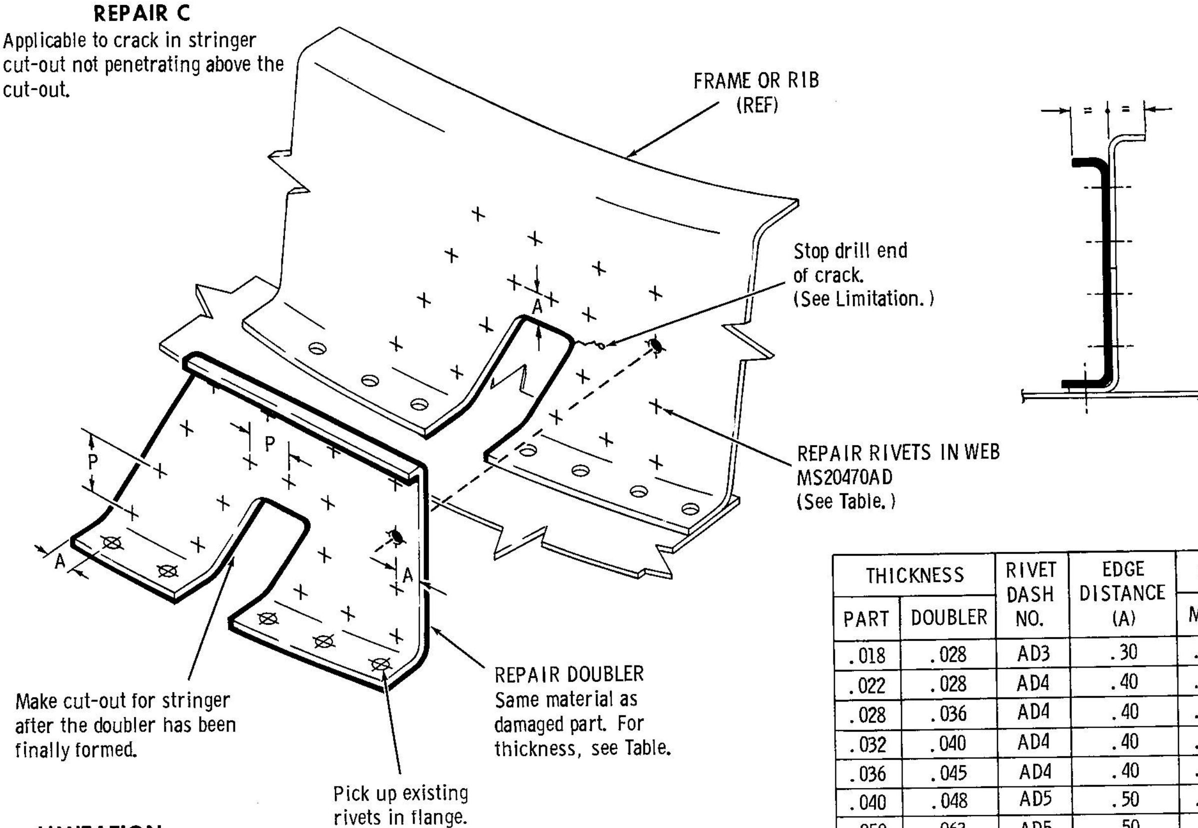


Figure 47 (Sheet 1 of 2) Cracks in Rib or Frame Stringer Cut-outs - Repair



THICKNESS		RIVET DASH NO.	EDGE DISTANCE (A)	PITCH (P)	
PART	DOUBLER			MIN	MAX
.018	.028	AD3	.30	.50	.70
.022	.028	AD4	.40	.60	.75
.028	.036	AD4	.40	.60	.75
.032	.040	AD4	.40	.60	.75
.036	.045	AD4	.40	.60	.75
.040	.048	AD5	.50	.75	1.00
.050	.063	AD5	.50	.75	1.00
.063	.080	AD5	.50	.75	1.00

LIMITATION

Length of crack not to exceed 0.50 inch.
Only one such repair per rib or frame sector.
These repairs must not be used in restricted areas.

NOTE

For selection of repair material and other pertinent repair data, refer to text: Rib and Frame Repairs, Typical Repair Procedure.

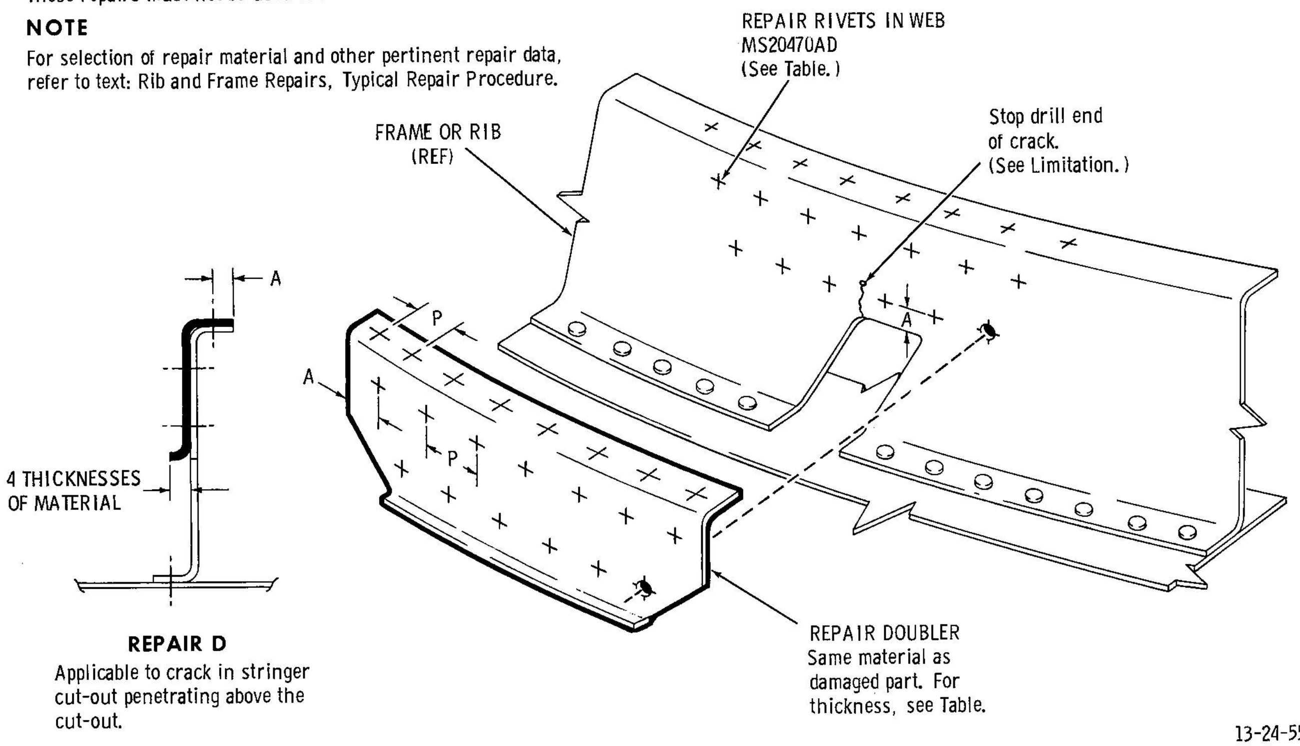
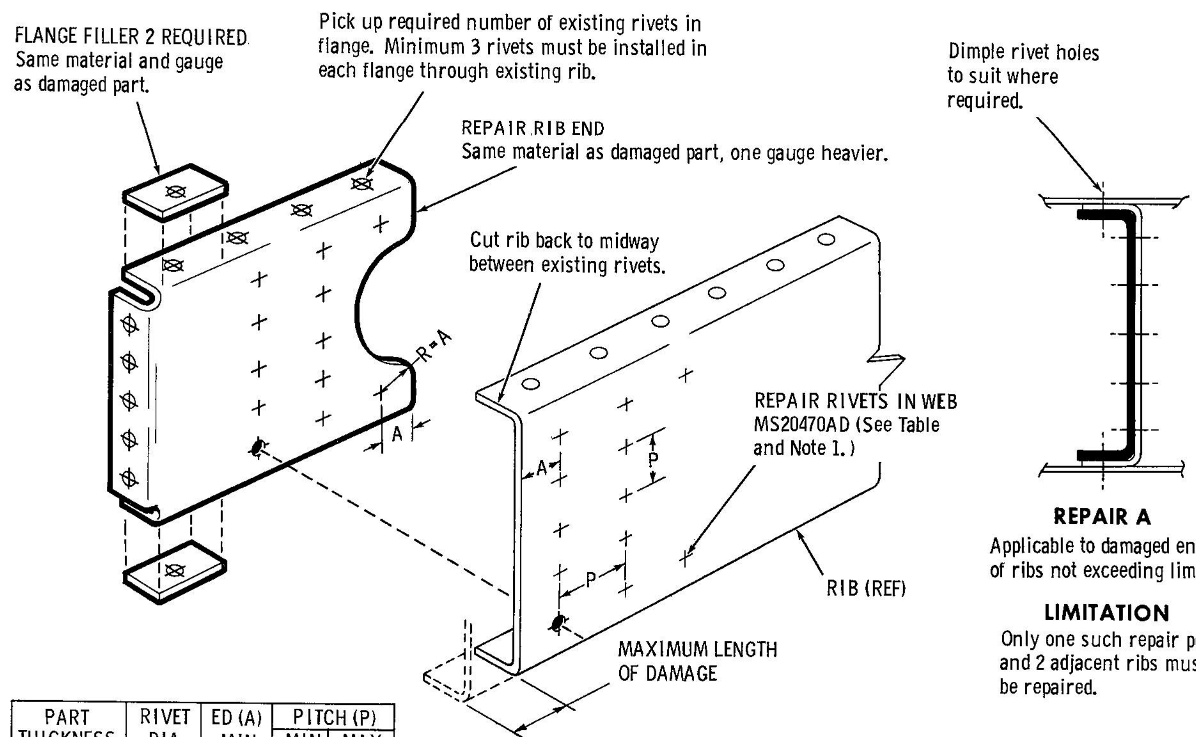


Figure 47 (Sheet 2 of 2) Cracks in Rib or Frame Stringer Cut-outs - Repair



REPAIR A

Applicable to damaged end flange of ribs not exceeding limits given.

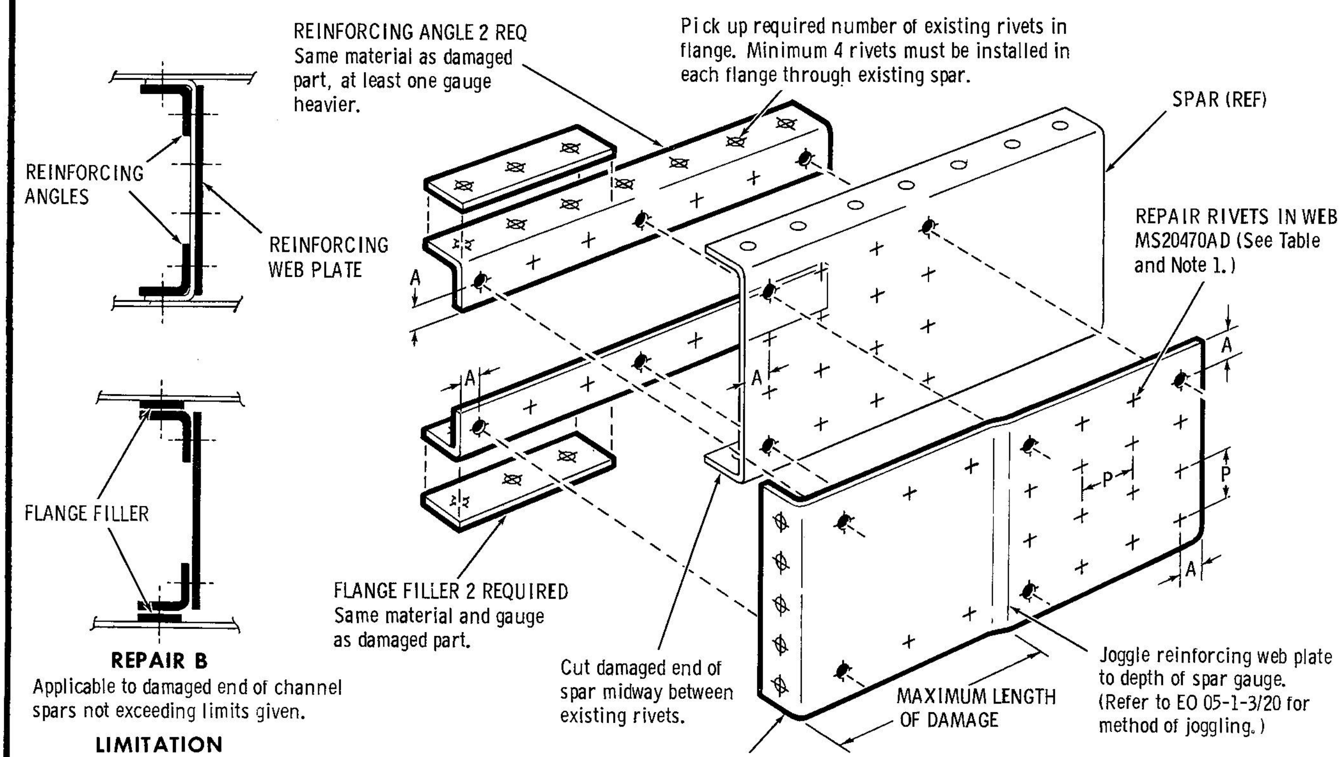
LIMITATION

Only one such repair per rib, and 2 adjacent ribs must not be repaired.

PART THICKNESS	RIVET DIA	ED (A) MIN	PITCH (P)	
			MIN	MAX
Up to .022	AD3	.25	.50	.65
.025 to .036	AD4	.30	.60	.80
.040 to .064	AD5	.40	.70	1.00

NOTE

For selection of repair material, number of rivets required for damage dimensions in flange and web, and method of rivet distribution, refer to text: Rib and Frame Repairs, Typical Repair Procedure and see appropriate illustrations.



REPAIR B

Applicable to damaged end of channel spars not exceeding limits given.

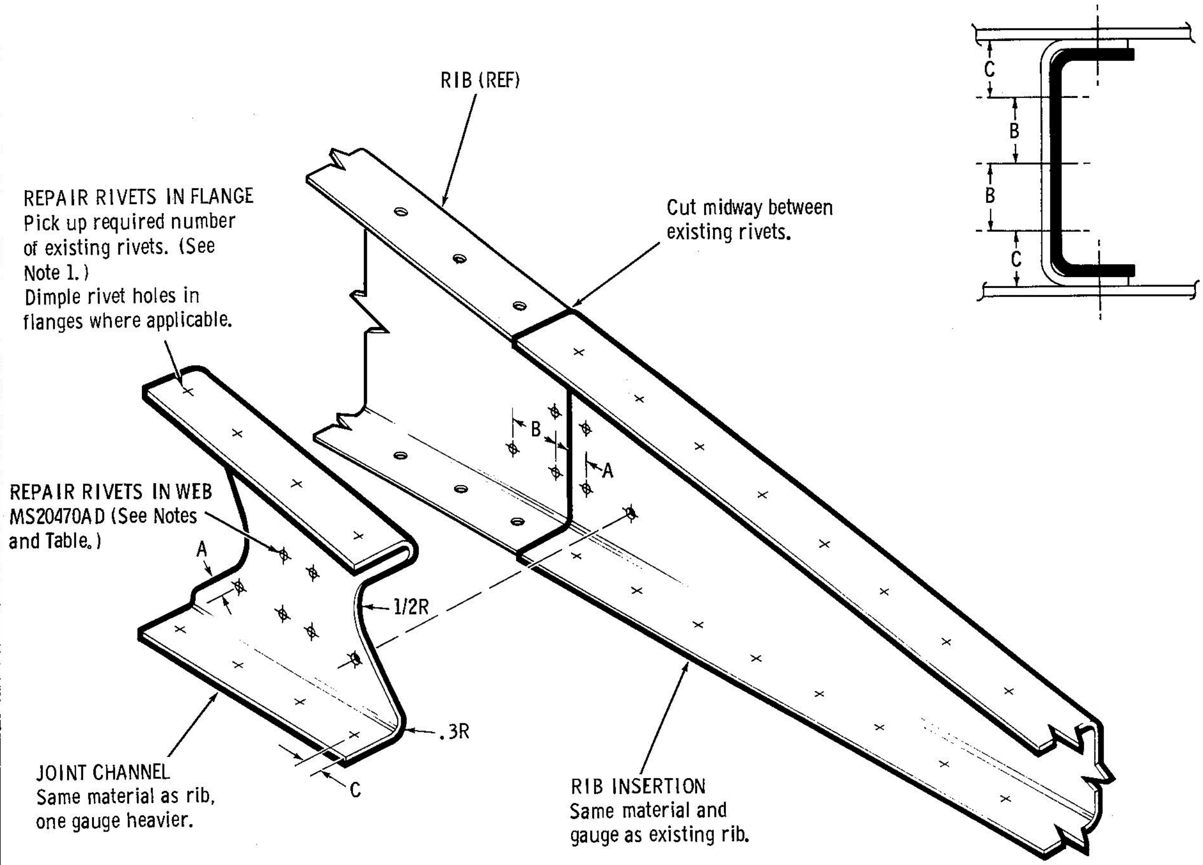
LIMITATION

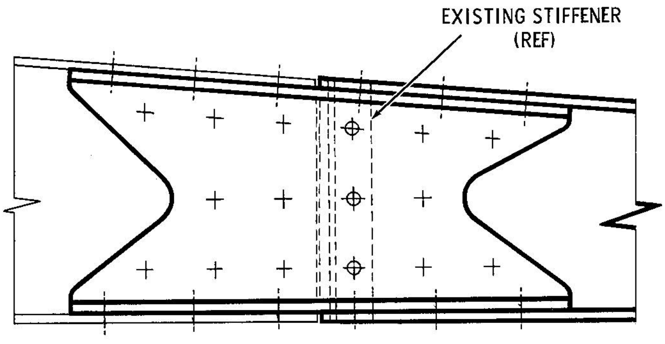
Only one such repair per spar. This repair must not be used for heavily stressed spars in primary structure.

13-24-84

Figure 48 Flanged Rib End - Repair

LIMITATION
Minimum of 3 existing rivets must be installed in flanges each side of joint.





RIB GAUGE	RIVET DIAMETER	DIMENSIONS			
		A	B		C
		MIN	MIN	MAX	MIN
.018	3/32	.20	.4	.6	.25
.022	3/32	.20	.4	.6	.25
.028	1/8	.25	.5	.8	.30
.036	1/8	.25	.5	.8	.35
.040	5/32	.32	.63	1.0	.40

ALTERNATIVE REPAIR
Rivet pattern is shown where 3 rivets are required in flange each side of joint. For rib splicing requiring greater number of repair rivets, the rivet pattern will be similar.

NOTES

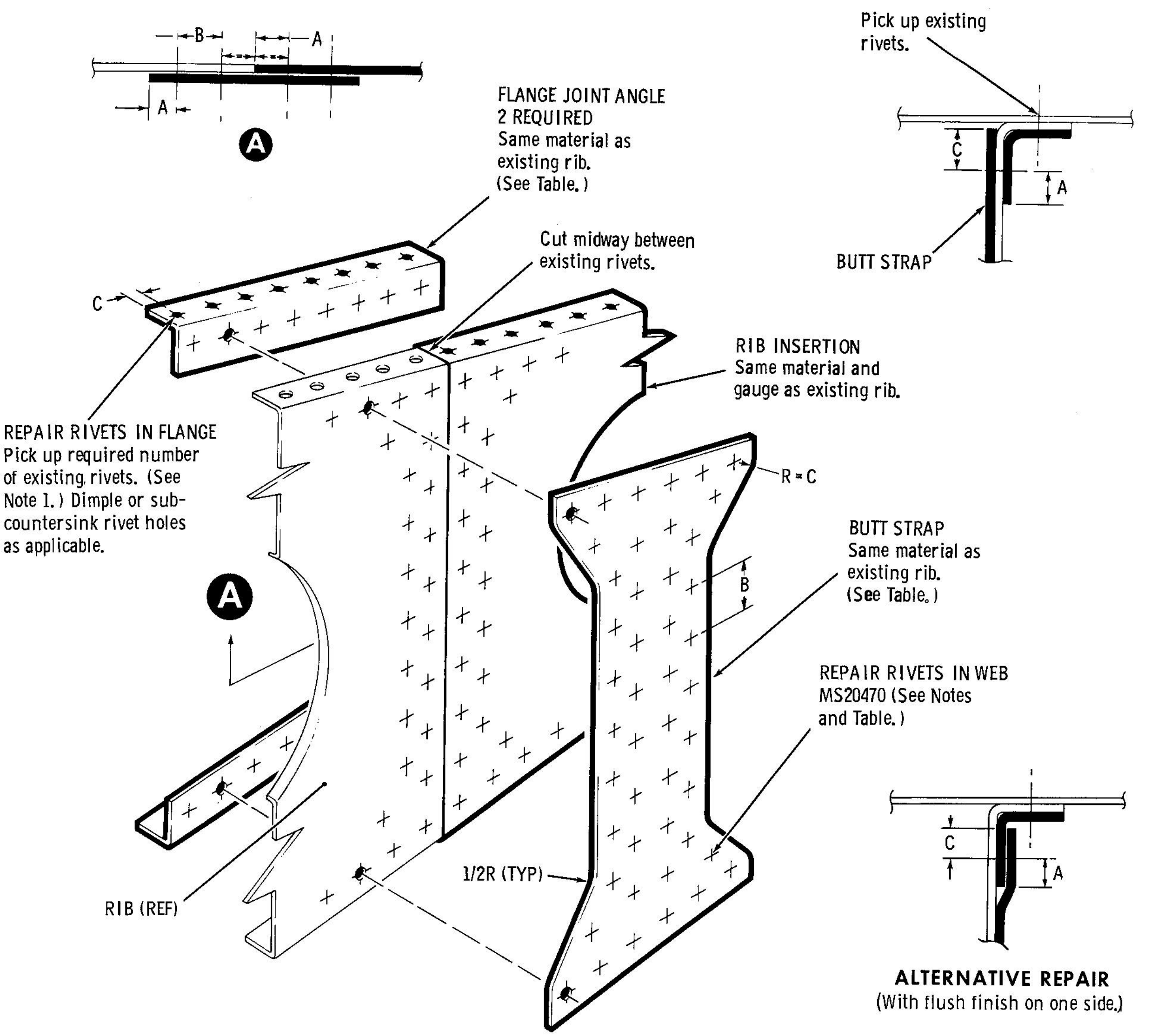
1 For required number of repair rivets on each side of the joint, refer to text: Rib and Frame Repairs, Typical Repair Procedure, and applicable Rivet Tables.

2 Space required number of rivets for rib web in a pattern similar to the examples shown, installing more rivets close to the flange than in the middle of the web. Additional rivets, if necessary, should be installed to maintain symmetrical pattern.

3 Where possible the joint should be made at an existing stiffener, and rivets picked up through the stiffener may be counted as repair rivets.

13-24-47

Figure 49 Formed Trailing Edge Rib - Splice



NOTES

1 For required number of repair rivets on each side of the joint, refer to text: Rib and Frame Repairs, Typical Repair Procedure, and applicable Rivet Tables.

2 Space required number of rivets for rib web in a pattern similar to the example shown, installing more rivets close to the flange than in the middle of the web. Additional rivets, if necessary, should be installed to maintain symmetrical pattern.

3 Where possible the joint should be made at an existing stiffener, and rivets picked up through the stiffener may be counted as repair rivets.

4 Where a flush finish is required, the butt strap should be located on the opposite face of the web and joggled over the flange joint angle. Use MS20426 rivets and dimple holes. Edge distance and rivet pitch shown in the Table must be increased to suit dimple joint (refer to EO 05-1-3/5).

RIB GAUGE	BUTT STRAP AND FLANGE ANGLE	RIVET DIAMETER	DIMENSIONS FOR MS20470 RIVETS			
			A	B		C
			MIN	MIN	MAX	MIN
.018	.028	3/32	.20	.40	.60	.25
.022	.028	3/32	.20	.40	.60	.25
.025	.032	1/8	.25	.50	.80	.31
.028	.036	1/8	.25	.50	.80	.31
.032	.040	1/8	.25	.50	.80	.32
.036	.045	1/8	.25	.50	.80	.35
.040	.050	5/32	.32	.63	1.00	.40

LIMITATION

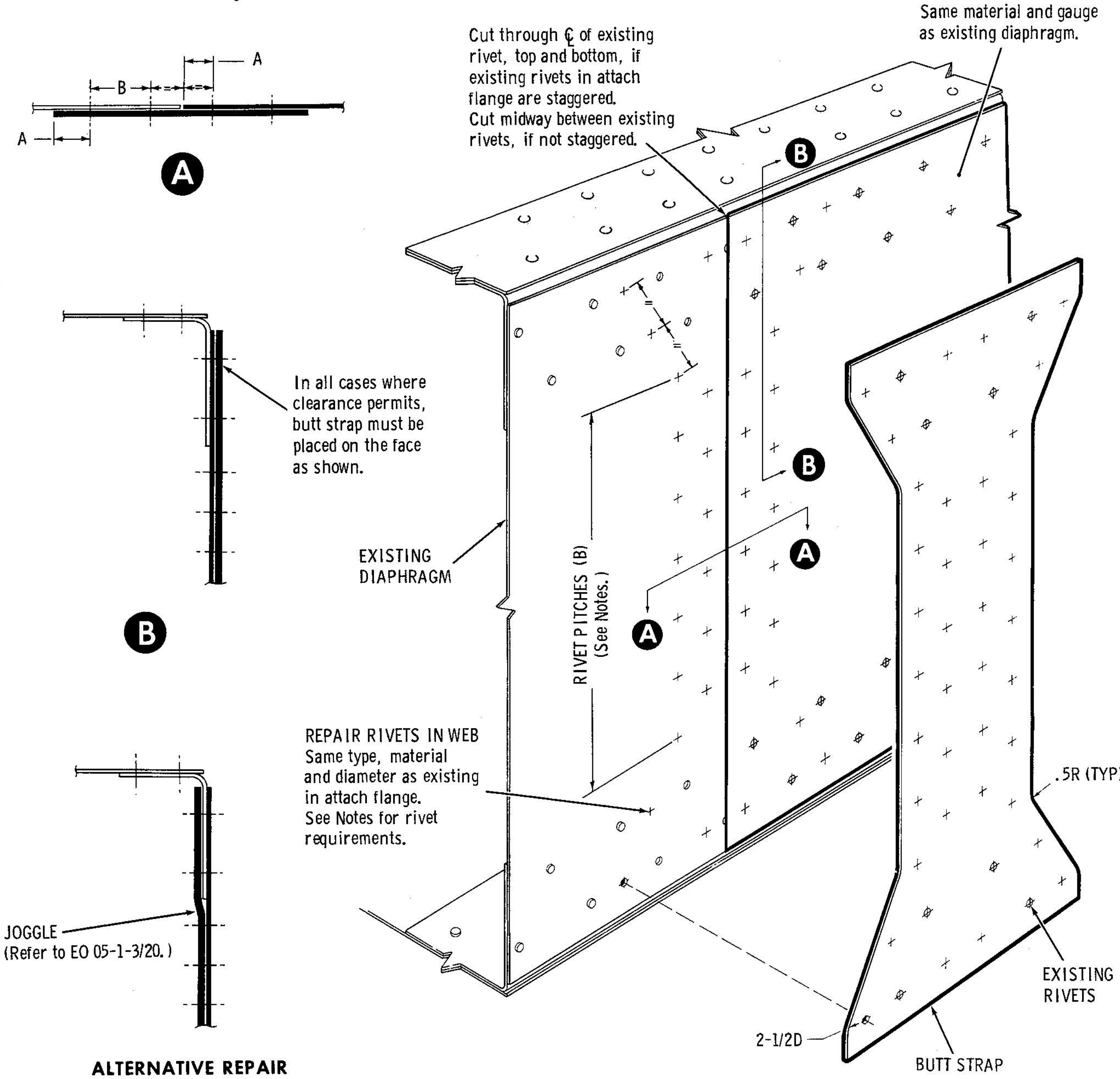
Minimum of 4 rivets must be installed in flange joint angle each side of joint.

13-24-48

Figure 50 Formed Rib - Splice

LIMITATIONS

Only one such repair per rib diaphragm. A minimum of 5 rivets must be installed in flange on each side of the joint.



ALTERNATIVE REPAIR

Where clearance does not permit, butt strap may be placed as shown and joggled over attach angle.

B

NOTES

1 For required number of repair rivets on each side of the joint, refer to text: Rib and Frame Repairs, Typical Repair Procedure, and applicable Rivet Tables.

2 Space required number of rivets for web in a pattern similar to the example shown.

3 Wherever possible the joint should be made at an existing stiffener, and rivets picked up through the stiffener may be counted as repair rivets.

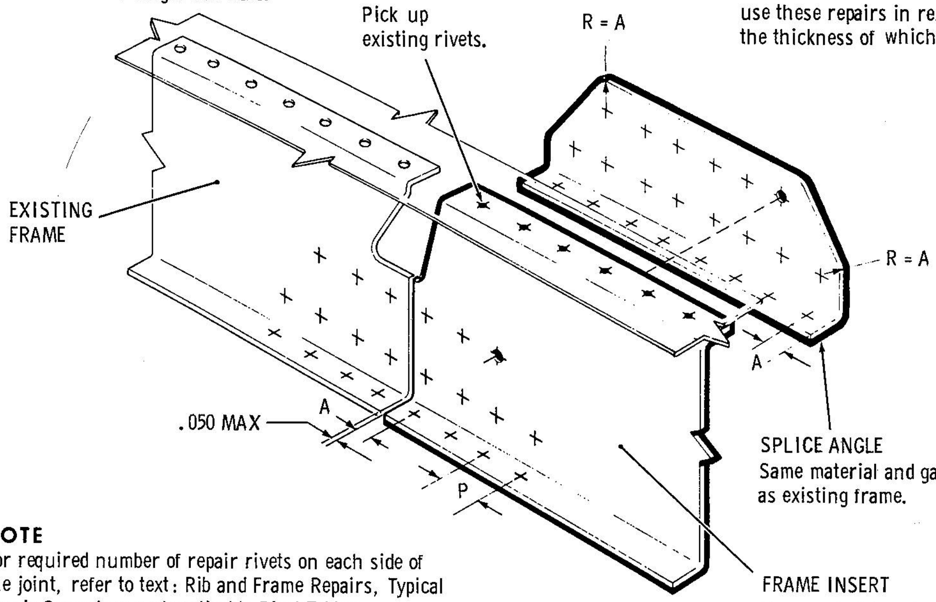
4 Minimum edge distance (A): 2D for protruding-head rivets; 2-1/2D for countersunk-head rivets. Minimum rivet pitch (B): 4D for protruding-head rivets; 5D for countersunk-head rivets.

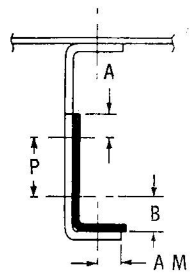
13-24-49

Figure 51 Rib Diaphragm - Splice

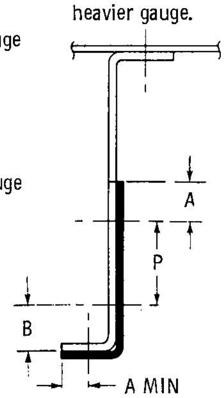
REPAIR A
Shallow frames of Z-section and C-section with stringer cut-outs.

LIMITATION
Joints must be at least one stringer bay apart. Do not use these repairs in restricted areas and for frames the thickness of which exceeds 0.063 inch.



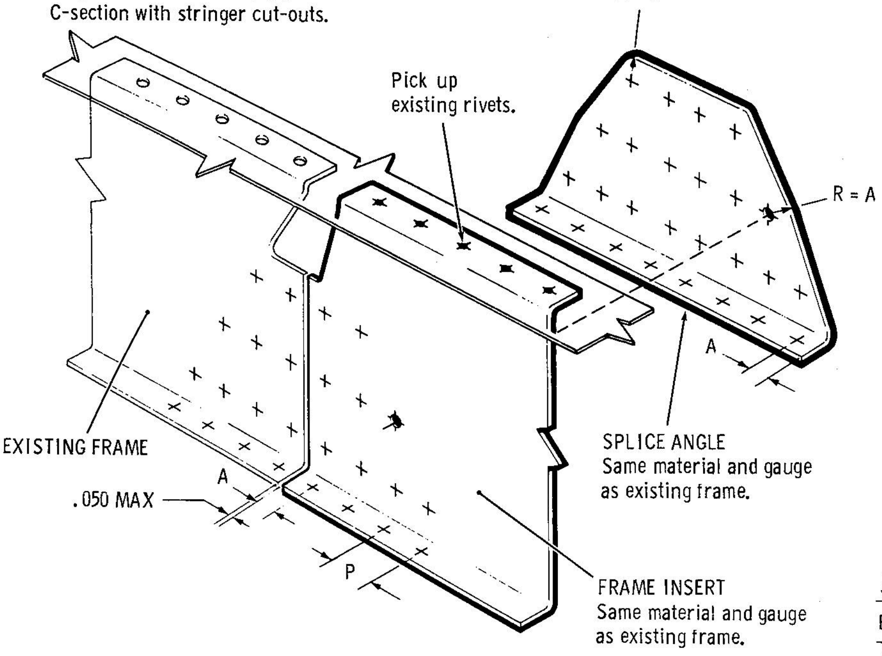


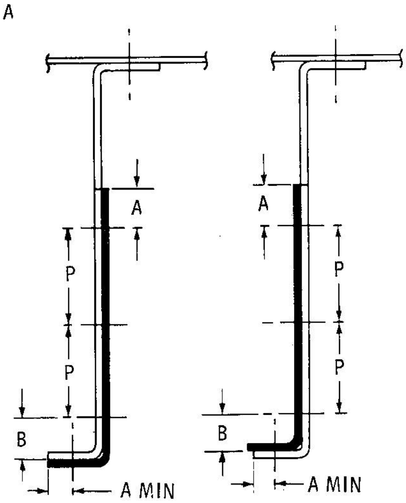
ALTERNATIVE REPAIR
Splice angle next heavier gauge.



NOTE
For required number of repair rivets on each side of the joint, refer to text: Rib and Frame Repairs, Typical Repair Procedure, and applicable Rivet Tables.

REPAIR B
Deep frames of Z-section and C-section with stringer cut-outs.





FRAME THICKNESS	RIVETS		DIMENSION			
	IN WEB	IN FLANGE	A	B	P MIN	P MAX
UP TO .036	MS20470AD4		.30	.35	.50	.75
.040 TO .050	MS20470AD5	MS20470D4	.35	.40	.65	.90
.056 TO .063	MS20470DD6	MS20470D5	.40	.45	.75	1.00

ALTERNATIVE REPAIR
Splice angle next heavier gauge.

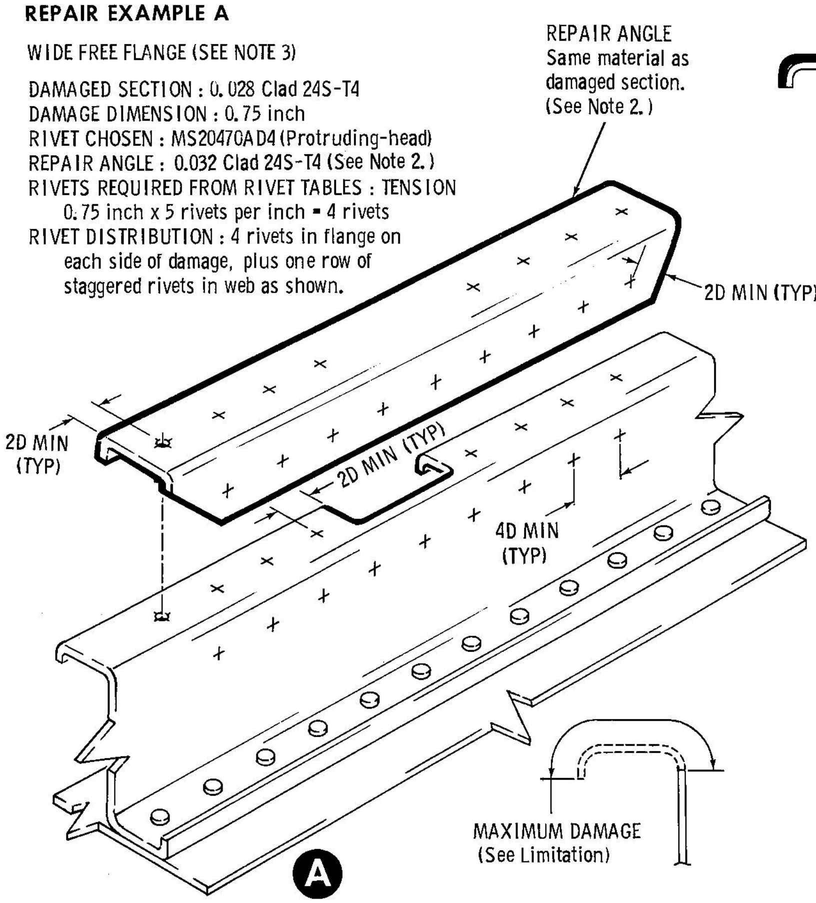
13-24-82

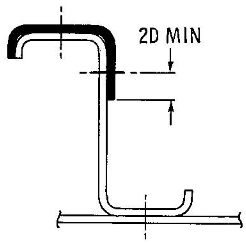
Figure 52 Frame - Splice

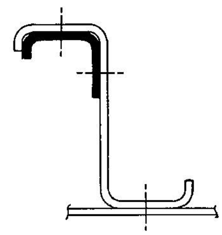
REPAIR EXAMPLE A

WIDE FREE FLANGE (SEE NOTE 3)

DAMAGED SECTION : 0.028 Clad 24S-T4
DAMAGE DIMENSION : 0.75 inch
RIVET CHOSEN : MS20470AD4 (Protruding-head)
REPAIR ANGLE : 0.032 Clad 24S-T4 (See Note 2.)
RIVETS REQUIRED FROM RIVET TABLES : TENSION
0.75 inch x 5 rivets per inch = 4 rivets
RIVET DISTRIBUTION : 4 rivets in flange on each side of damage, plus one row of staggered rivets in web as shown.







ALTERNATIVE POSITION OF REPAIR ANGLE

NOTES

1 For selection of repair material, number of rivets required for repair and method of rivet distribution, refer to text: Formed Sections Repairs, Typical Repair Procedure and see appropriate illustrations.

2 If repair angle is installed on outside, the angle may be of the same thickness as damaged section; if on inside, heavier gauge must be used.

3 Repairs to free flange shown in Example A are applicable only to flanges the widths of which are sufficient to maintain minimum rivet spacing. Otherwise a repair as shown in Example B should be used. See Illustration : Edge Distance and Rivet Spacing.

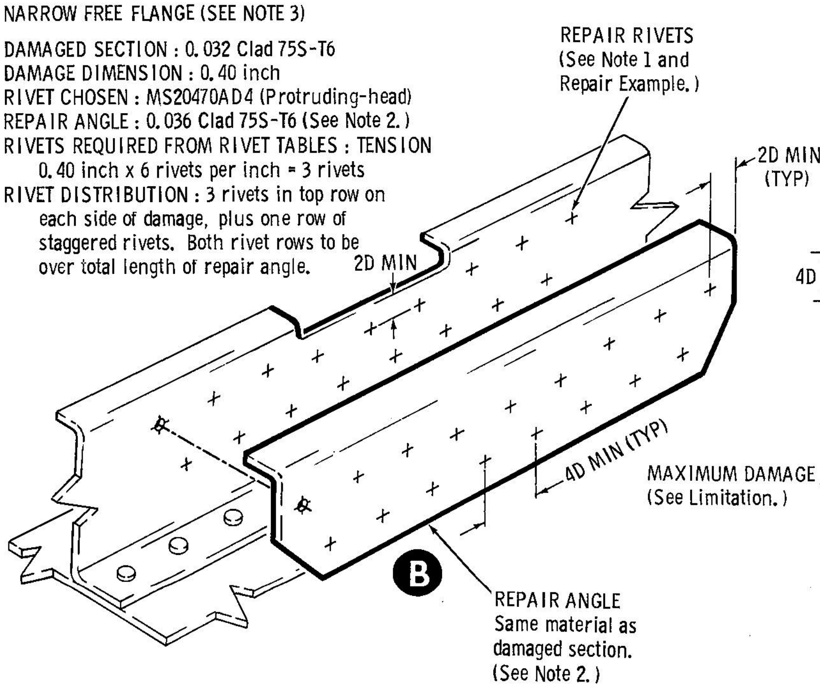
LIMITATION

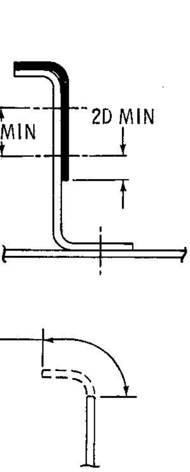
Damage not to penetrate farther than the end of flange bend radius after trimming. These repairs are not applicable to restricted areas, heavily stressed stringers in primary structure, and to struts attached at ends and loaded in compression. Refer to text for detailed limitation of typical repairs.

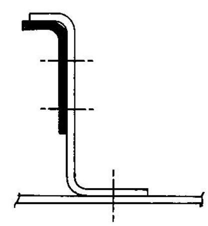
REPAIR EXAMPLE B

NARROW FREE FLANGE (SEE NOTE 3)

DAMAGED SECTION : 0.032 Clad 75S-T6
DAMAGE DIMENSION : 0.40 inch
RIVET CHOSEN : MS20470AD4 (Protruding-head)
REPAIR ANGLE : 0.036 Clad 75S-T6 (See Note 2.)
RIVETS REQUIRED FROM RIVET TABLES : TENSION
0.40 inch x 6 rivets per inch = 3 rivets
RIVET DISTRIBUTION : 3 rivets in top row on each side of damage, plus one row of staggered rivets. Both rivet rows to be over total length of repair angle.







ALTERNATIVE POSITION OF REPAIR ANGLE

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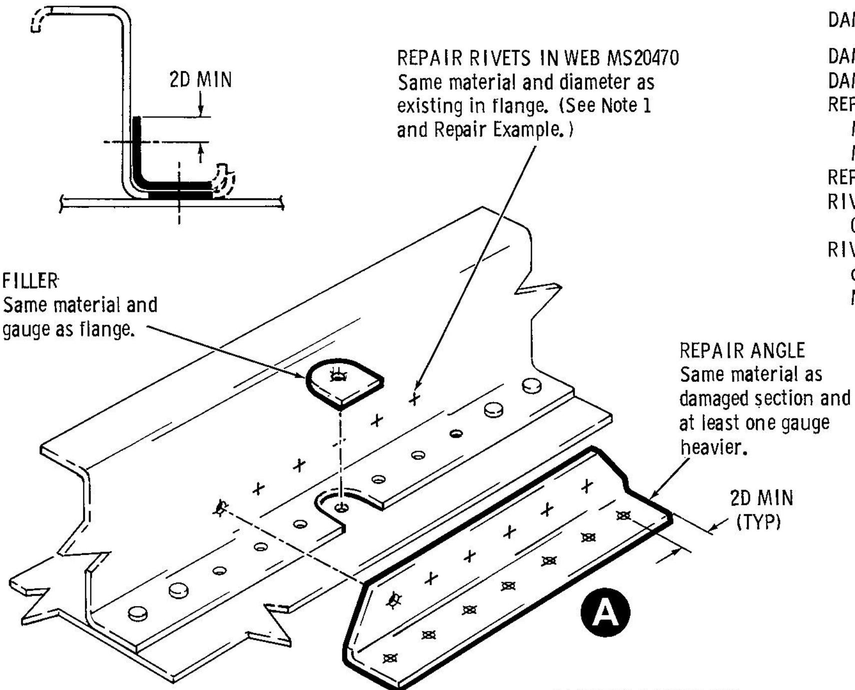
Figure 53 Formed Sections - Free Flange Repair

REPAIR EXAMPLE A

DAMAGE NOT PENETRATING INTO BEND RADIUS

DAMAGED SECTION: 0.040 Clad 75S-T6
DAMAGE DIMENSION: 0.70 inch
REPAIR RIVETS:
MS20426AD5 in flange (Rivet holes dimpled)
MS20470AD5 in web (Protruding-head)
REPAIR ANGLE: 0.050 Clad 75S-T6
RIVETS REQUIRED FROM RIVET TABLES: TENSION
0.70 inch x 4.2 rivets per inch = 3 rivets in flange
RIVET DISTRIBUTION: 3 MS20426AD5 rivet in flange on each side of damage, plus one row of staggered MS20470AD5 rivets in web as shown.



NOTES

1 For selection of repair material, number of rivets required for repair and method of rivet distribution, refer to text: Formed Sections Repairs, Typical Repair Procedure and see appropriate illustrations.

2 Calculation of repair rivet requirement for damage dimension across the flange must be based on the strength of existing rivets in attach flange, using either Protruding-head Rivet Tables or Dimpled Hole Rivet Tables, as applicable.

3 Repairs with superimposed angle over existing flange may be made only if the distance between the existing rivets and repair angle is sufficient to maintain minimum bend line clearance.

4 Repair B is applicable to skin or web repairs where the attach flange of adjacent substructure must be cut out to permit insertion of skin or web repair doubler.

REPAIR EXAMPLE B

CUT-OUT IN FLANGE NOT EXTENDING BEYOND THE END OF BEND RADIUS IN WEB

DAMAGED SECTION: 0.040 Clad 75S-T6
DAMAGE DIMENSION: 0.80 inch
REPAIR RIVETS:
MS20426AD5 in flange (Rivet holes dimpled)
MS20470AD5 in web (Protruding-head)
REPAIR ANGLE: 0.050 Clad 75S-T6
RIVETS REQUIRED FROM RIVET TABLES: TENSION
0.80 inch x 4.2 rivets per inch = 4 rivets in flange
RIVET DISTRIBUTION: 4 MS20426AD5 rivets in flange on each side of damage, plus one row of staggered MS20470AD5 rivets in web as shown.

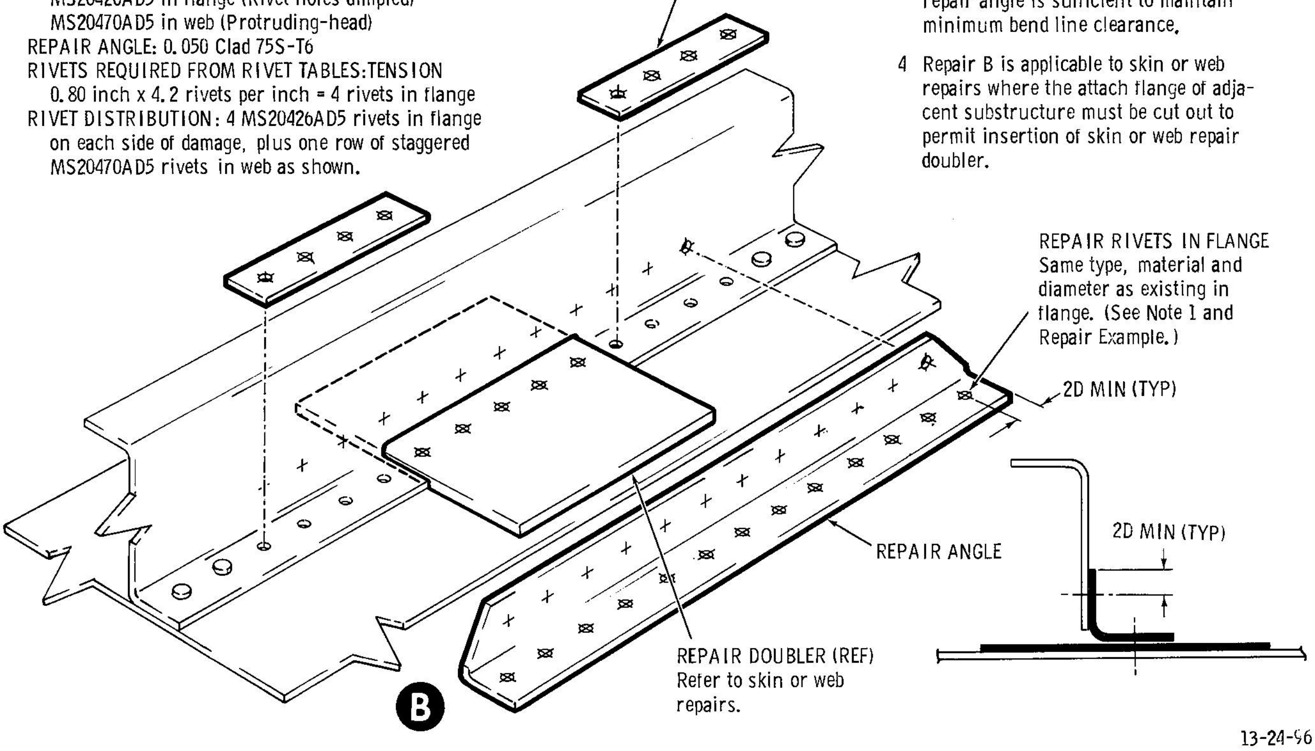
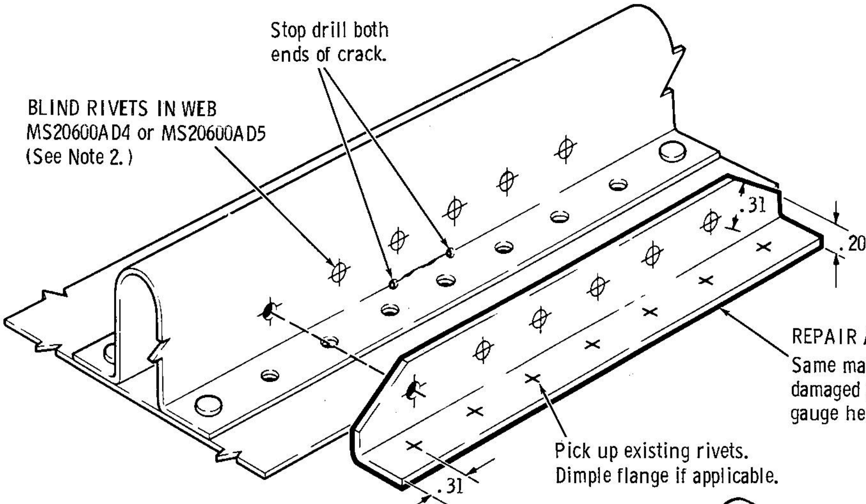


Figure 54 Formed Sections - Attach Flange Repair



REPAIR A

Repair A is applicable to crack along the bend, within limits given.

LIMITATION

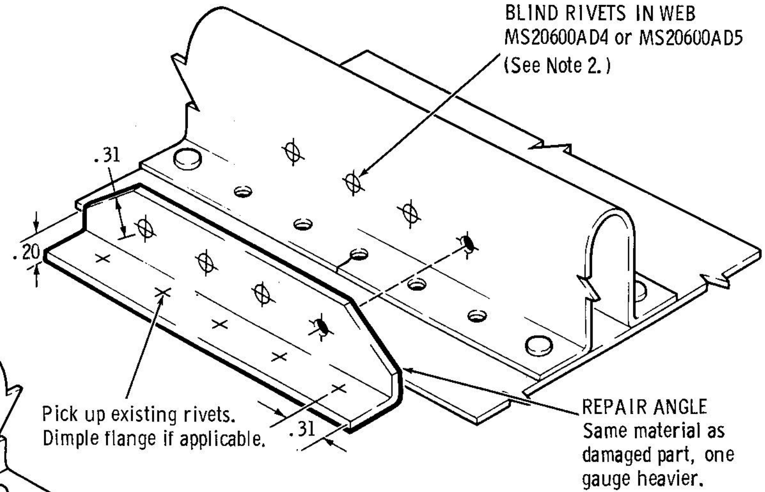
Maximum length of crack is limited to one rivet pitch. Pick up a minimum of 3 rivets in flange each side of crack. (See Note 3.)

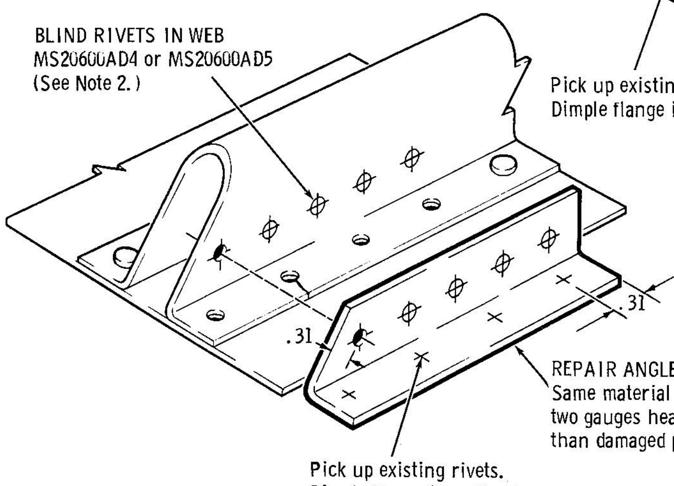
REPAIR B

Repair B is applicable to crack radiating from rivet hole to edge of flange, at two or more pitches from end of stringer.

LIMITATION

Isolated crack only. Pick up a minimum of 2 rivets in flange each side of crack. (See Note 3.)





REPAIR C

Repair C is applicable to crack radiating from the first or second rivet hole from the end of stringer.

LIMITATION

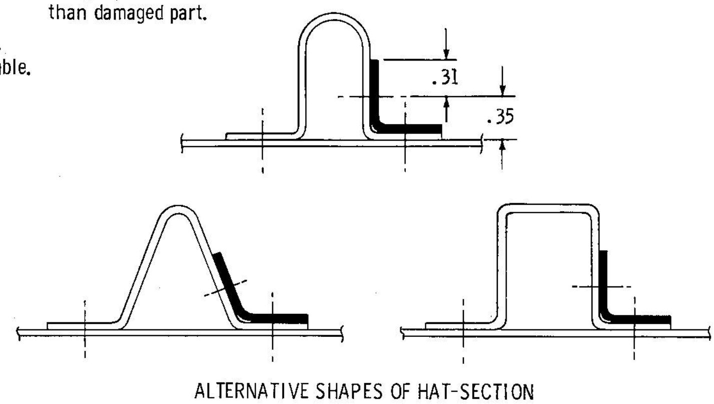
Isolated crack only. Pick up a minimum of 2 rivets in flange on one side of the crack. (See Note 3.)

NOTES

1 Where damage exceeds limitations given, refer to text: Formed Sections, Typical Repair Procedure and illustrations of alternative repairs.

2 Use 1/8 diameter blind rivets in web section gauge not exceeding 0.028 inch, and 5/32 diameter for 0.032 to 0.040 inch sections.

3 Damage to section of heavier gauge than 0.040 inch must be repaired in accordance with specific repair contained in applicable -3 EOs.



ALTERNATIVE SHAPES OF HAT-SECTION

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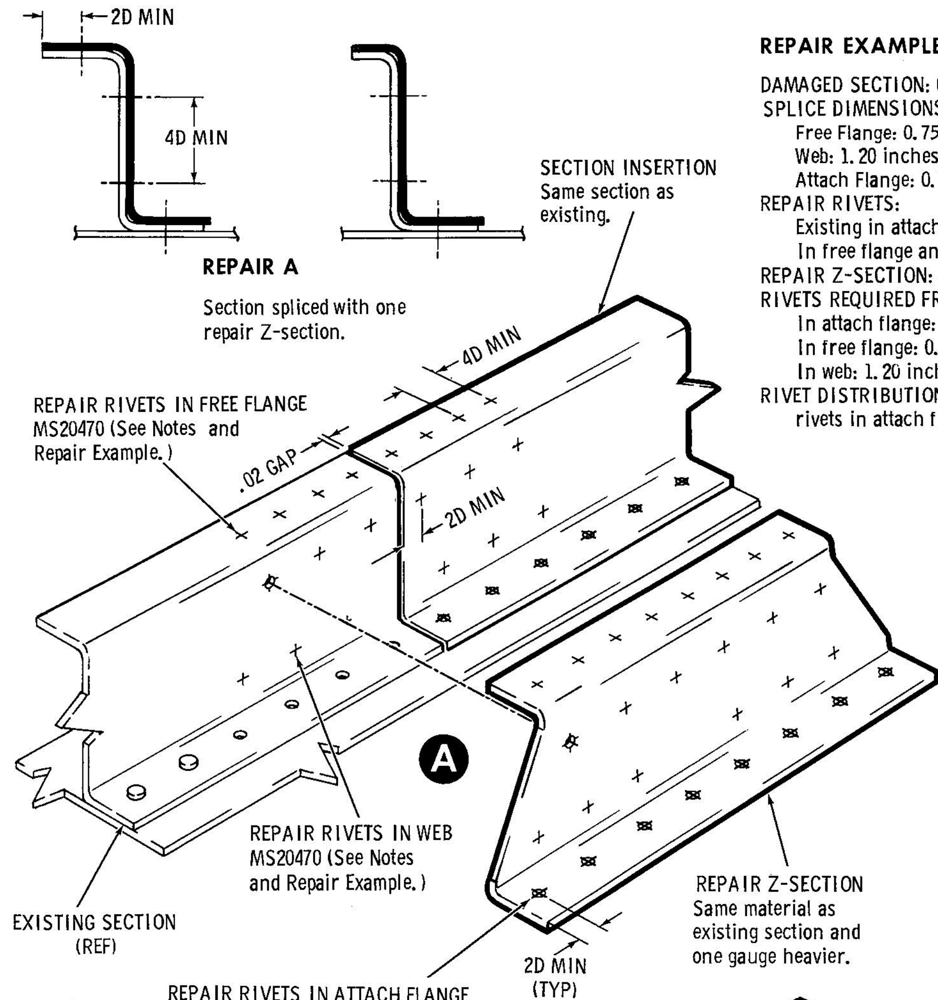
Figure 55 Formed Hat-section - Attach Flange Repair



REPAIR EXAMPLE A

DAMAGED SECTION: 0.028 Clad 24S-T4
SPLICE DIMENSIONS:
  Free Flange: 0.75 inch
  Web: 1.20 inches
  Attach Flange: 0.75 inch
REPAIR RIVETS:
  Existing in attach flange: MS20426AD4 (Holes dimpled)
  In free flange and web: MS20470AD4 (Protruding-head)
REPAIR Z-SECTION: 0.032 Clad 24S-T4
RIVETS REQUIRED FROM RIVET TABLES: TENSION
  In attach flange: 0.75 inch x 4.4 rivets per inch = 4 rivets.
  In free flange: 0.75 inch x 5 rivets per inch = 4 rivets
  In web: 1.20 inches x 5 rivets per inch = 6 rivets
RIVET DISTRIBUTION: Staggered pattern in relation to existing rivets in attach flange, as shown.

NOTES

1 For selection of repair material, number of rivets required for repair and method of rivet distribution, refer to text: Formed Sections Repairs, Typical Repair Procedure and see appropriate illustrations.

2 For splicing section with narrow free flange, distribute required number of rivets for both free flange and web in web only. Rivets for free flange must be added to rivet row adjacent to free flange.

LIMITATION

Typical splicing of stringers must not be used in restricted areas, or applied to heavily stressed primary structure. Refer to text for detailed limitation of typical repairs.

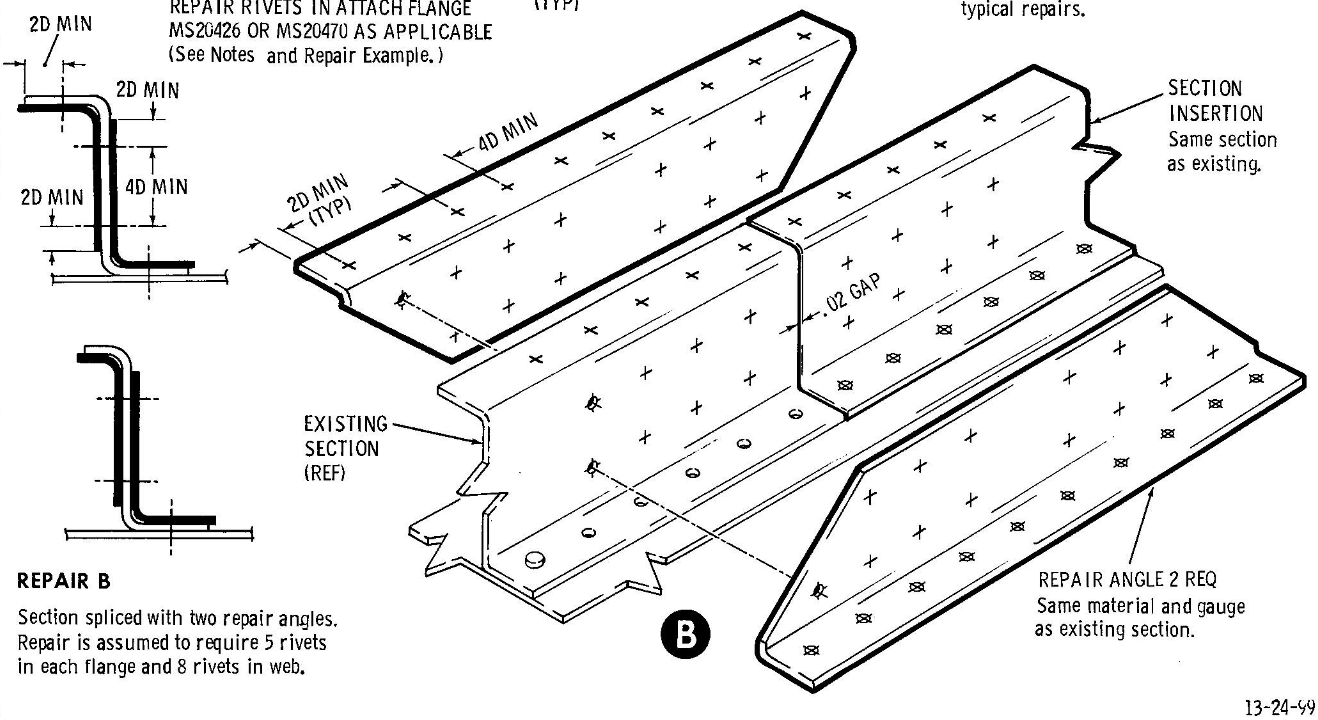
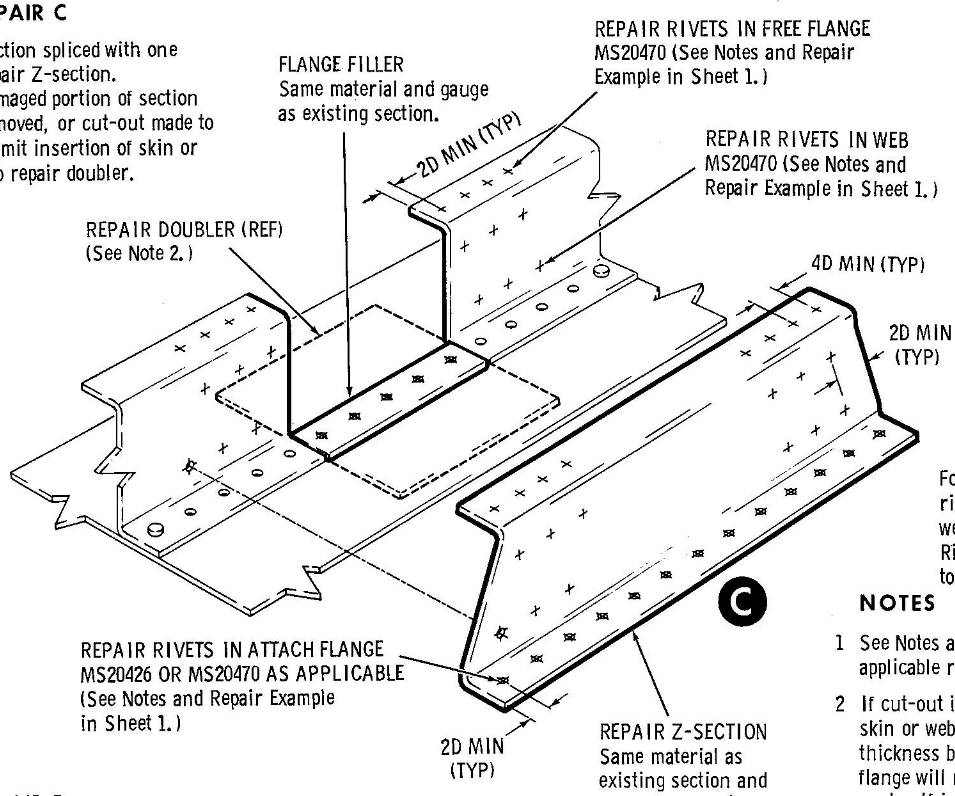
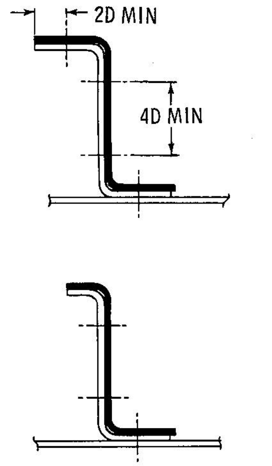


Figure 56 (Sheet 1 of 2) Formed Section Splice - Repair by Insertion

REPAIR C

Section spliced with one repair Z-section. Damaged portion of section removed, or cut-out made to permit insertion of skin or web repair doubler.





ALTERNATIVE REPAIR

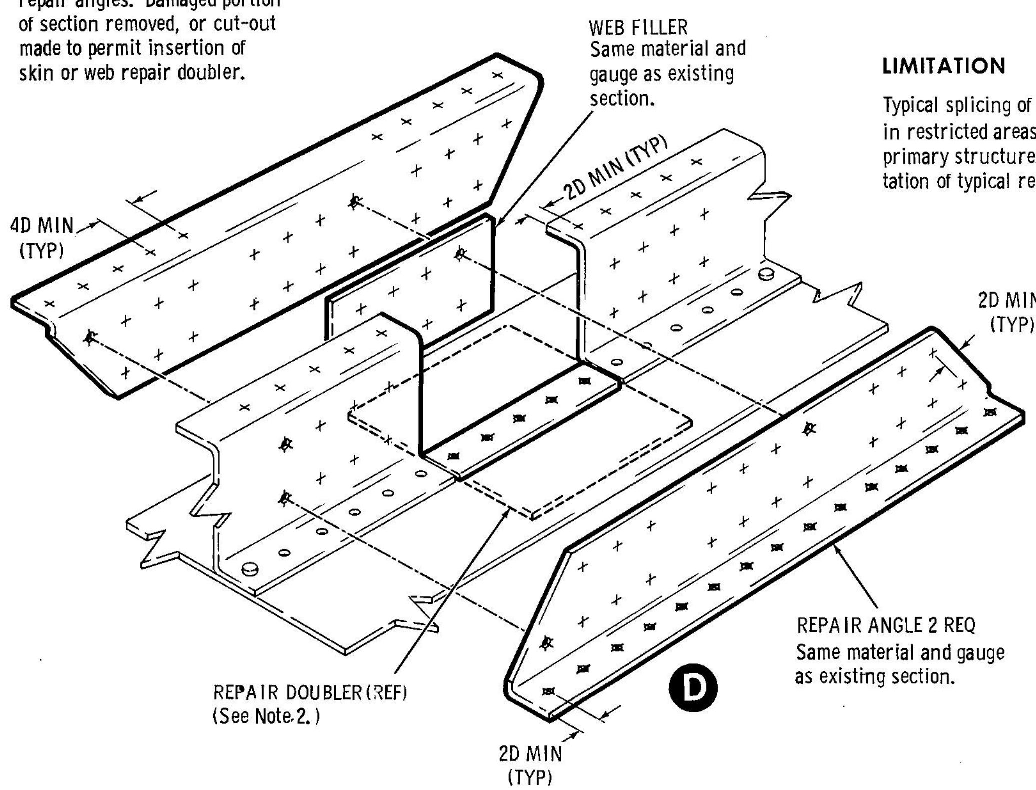
For section with narrow free flange, rivets required for free flange and web are to be installed in web only. Rivets for free flange must be added to rivet row adjacent to free flange.

NOTES

1. See Notes and Repair Example in Sheet 1 for applicable repair information.
2. If cut-out in section is made for insertion of skin or web repair doubler, the difference in thickness between repair doubler and attach flange will require joggling of bottom repair angle. If joggling cannot be done, packings of the same material and suitable thickness may be used as necessary.

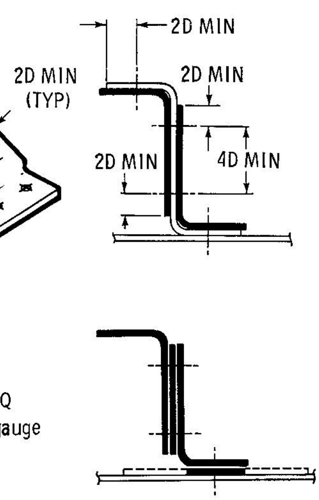
REPAIR D

Section spliced with two repair angles. Damaged portion of section removed, or cut-out made to permit insertion of skin or web repair doubler.



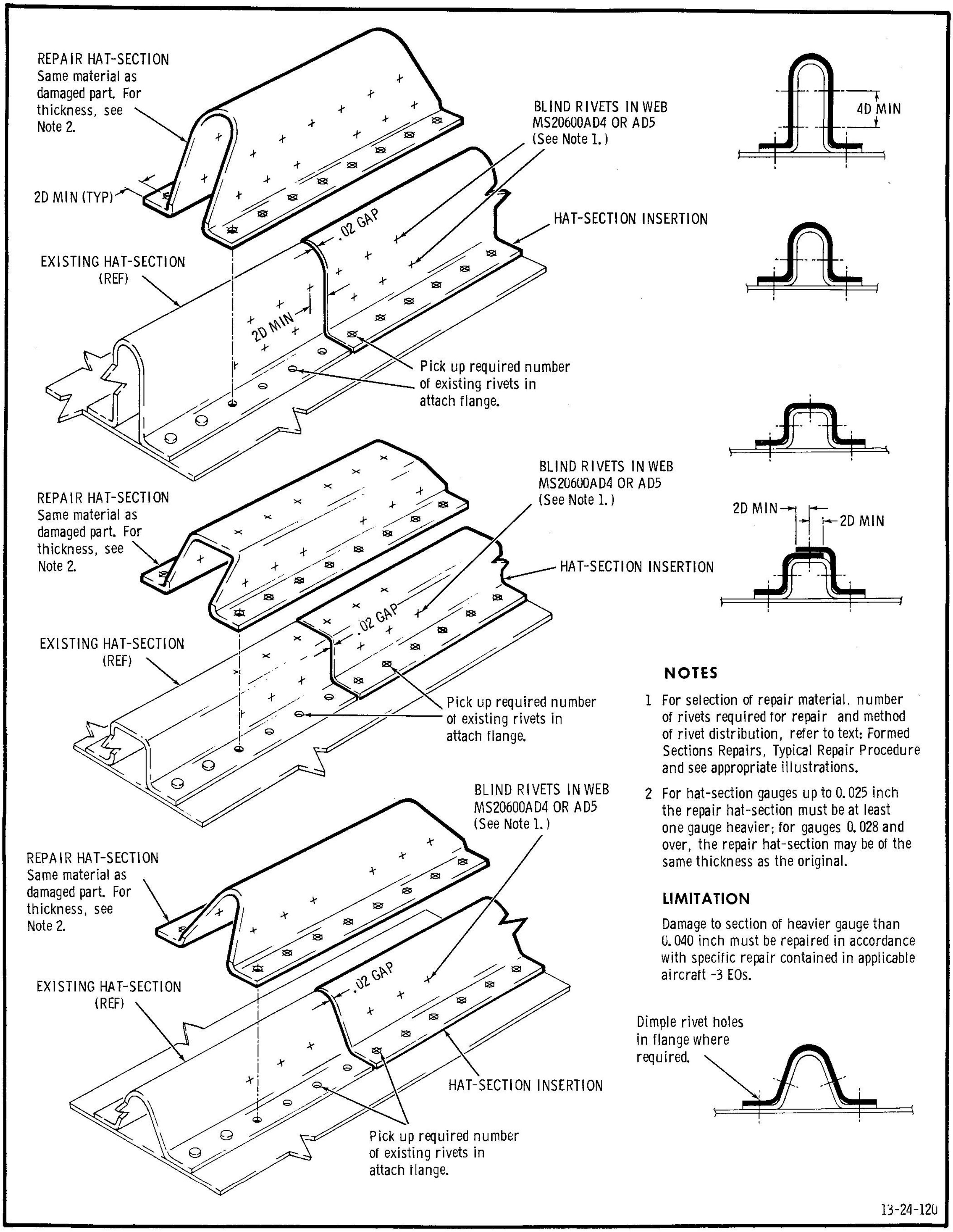
LIMITATION

Typical splicing of stringers must not be used in restricted areas, or applied to heavily stressed primary structure. Refer to text for detailed limitation of typical repairs.



13-24-100

Figure 56 (Sheet 2 of 2) Formed Section Splice - Cut-out Repair



NOTES

1 For selection of repair material, number of rivets required for repair and method of rivet distribution, refer to text: Formed Sections Repairs, Typical Repair Procedure and see appropriate illustrations.

2 For hat-section gauges up to 0.025 inch the repair hat-section must be at least one gauge heavier; for gauges 0.028 and over, the repair hat-section may be of the same thickness as the original.

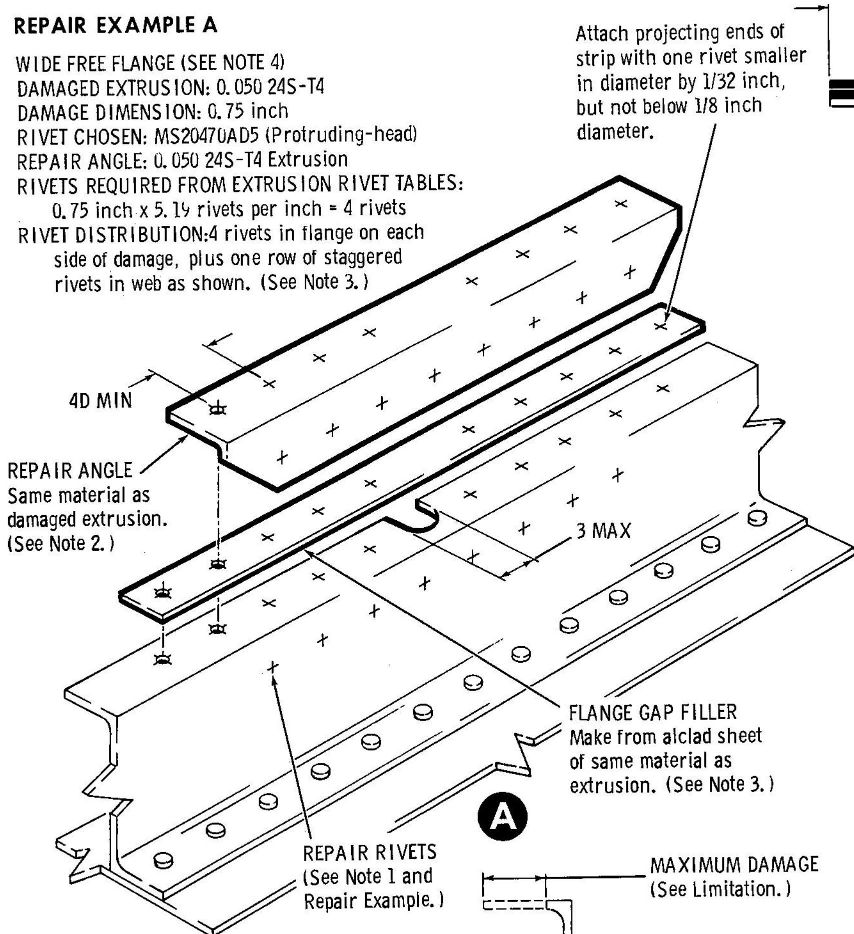
LIMITATION

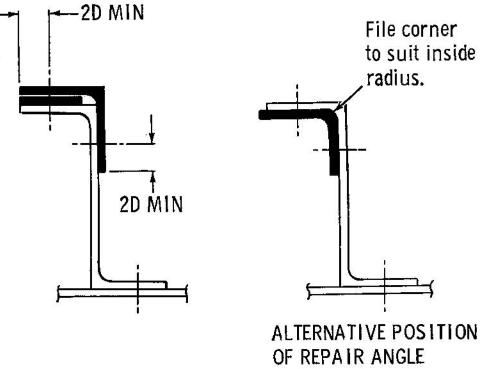
Damage to section of heavier gauge than 0.040 inch must be repaired in accordance with specific repair contained in applicable aircraft -3 EOs.

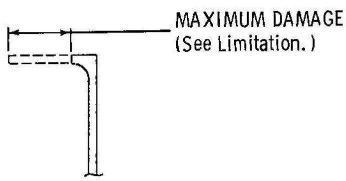
Figure 57 Formed Section Splice - Hat-section

REPAIR EXAMPLE A

WIDE FREE FLANGE (SEE NOTE 4)
DAMAGED EXTRUSION: 0.050 24S-T4
DAMAGE DIMENSION: 0.75 inch
RIVET CHOSEN: MS20470AD5 (Protruding-head)
REPAIR ANGLE: 0.050 24S-T4 Extrusion
RIVETS REQUIRED FROM EXTRUSION RIVET TABLES:
0.75 inch x 5.19 rivets per inch = 4 rivets
RIVET DISTRIBUTION: 4 rivets in flange on each side of damage, plus one row of staggered rivets in web as shown. (See Note 3.)







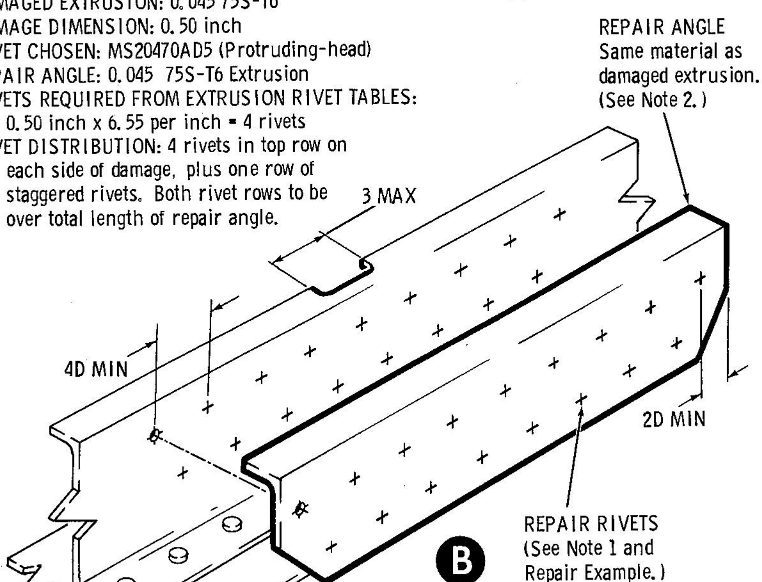
NOTES

1. For selection of repair material, number of rivets required for repair and method of rivet distribution, refer to text: Extruded Sections Repairs, Typical Repair Procedure and see appropriate illustrations.
2. If repair angle is installed on outside, the angle may be of the same thickness as damaged section; if on inside, heavier gauge must be used.
3. To avoid excessive filing of extrusion outside radius for flush fit of flanges, alclad filler of required thickness may be used to fill the gap between the flanges. Attach projecting ends of filler as shown.
4. Repairs to free flange shown in Example A and C are applicable only to flanges the width of which is sufficient to maintain minimum rivet spacing. Otherwise a repair as shown in Example B and D should be used. See illustration: Edge Distance and Rivet Spacing.

REPAIR EXAMPLE B

NARROW FREE FLANGE (SEE NOTE 4)

DAMAGED EXTRUSION: 0.045 75S-T6
DAMAGE DIMENSION: 0.50 inch
RIVET CHOSEN: MS20470AD5 (Protruding-head)
REPAIR ANGLE: 0.045 75S-T6 Extrusion
RIVETS REQUIRED FROM EXTRUSION RIVET TABLES:
0.50 inch x 6.55 per inch = 4 rivets
RIVET DISTRIBUTION: 4 rivets in top row on each side of damage, plus one row of staggered rivets. Both rivet rows to be over total length of repair angle.



LIMITATION

Damage not to penetrate into flange radius after trimming. These repairs are not applicable to restricted areas, heavily stressed stringers in primary structure, and to struts attached at ends and loaded in compression. Refer to text for detailed limitation of typical repairs.

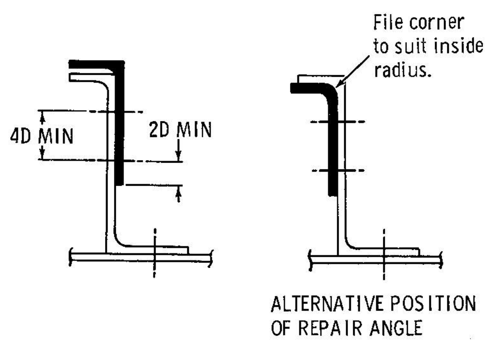


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Figure 58 (Sheet 1 of 2)
Extruded Sections - Free Flange Repair (Damage not Penetrating into Bend Radius)

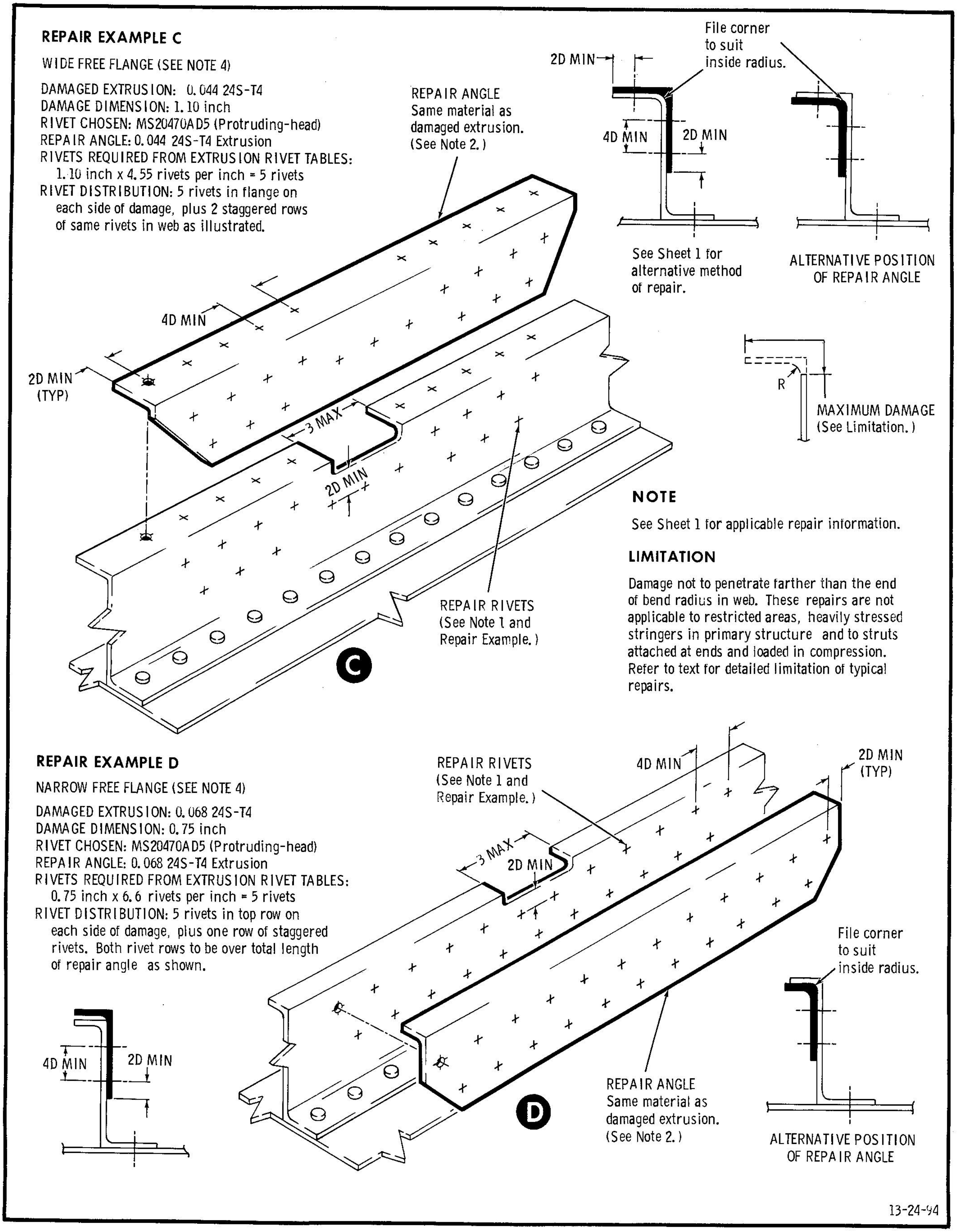
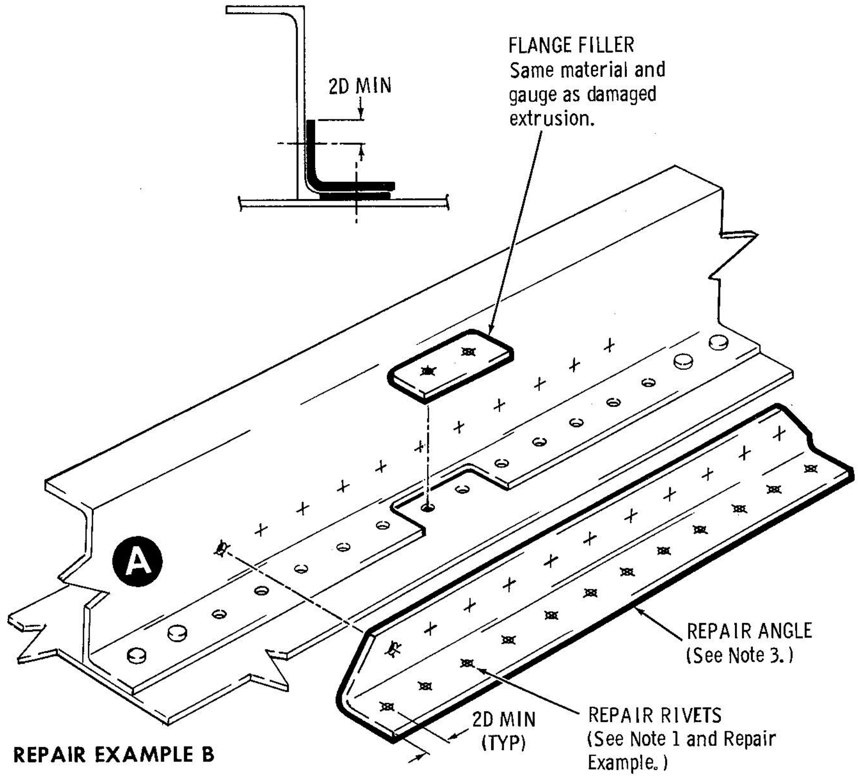


Figure 58 (Sheet 2 of 2)
Extruded Sections - Free Flange Repair (Damage Penetrating into Bend Radius)



REPAIR EXAMPLE A

DAMAGE NOT PENETRATING BEND RADIUS

DAMAGED EXTRUSION: 0.064 75S-T6
DAMAGE DIMENSION: 0.75 inch
EXISTING RIVET IN FLANGE: MS20426D5
REPAIR ANGLE: 0.071 Clad 75S-T6
RIVETS REQUIRED FROM EXTRUSION RIVET
TABLES: 0.75 inch x 6.62 rivets per inch = 5 rivets
RIVETS DISTRIBUTION: Pick up 5 existing rivets in flange on each side of damage, and add one row of MS20470D5 staggered rivets in web as shown.

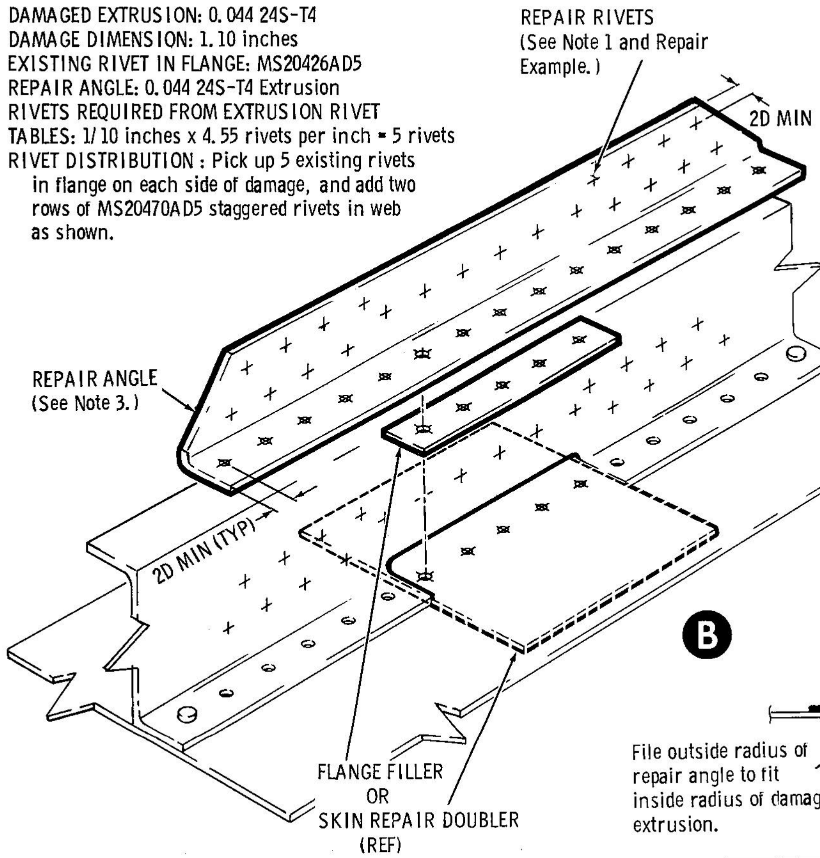
NOTES

1. For selection of repair material, number of rivets required for repair and method of rivet distribution, refer to text: Extruded Sections Repairs, Typical Repair Procedure and see appropriate illustrations.
2. Calculation of repair rivet requirement for damage dimension across the flange must be based on the strength of existing rivets in attach flange, using either Protruding-head Rivet Tables or Dimpled Hole Rivet Tables, as applicable.
3. Repair angle made from extruded section may be of the same thickness as the damaged part. Repair angle formed from alclad sheet of the same material must have cross-sectional area increases by 10%.
4. Repairs with superimposed angle over existing flange may be made only if the distance between the existing rivets and repair angle is sufficient to maintain minimum bend line clearance.
5. Repair B is applicable to damage in attach flange or where the flange must be cut out to permit insertion of skin or web repair doubler.

REPAIR EXAMPLE B

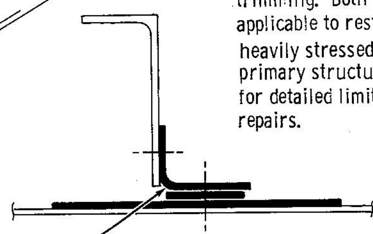
DAMAGE PENETRATING BEND RADIUS

DAMAGED EXTRUSION: 0.044 24S-T4
DAMAGE DIMENSION: 1.10 inches
EXISTING RIVET IN FLANGE: MS20426AD5
REPAIR ANGLE: 0.044 24S-T4 Extrusion
RIVETS REQUIRED FROM EXTRUSION RIVET
TABLES: 1/10 inches x 4.55 rivets per inch = 5 rivets
RIVET DISTRIBUTION: Pick up 5 existing rivets in flange on each side of damage, and add two rows of MS20470AD5 staggered rivets in web as shown.



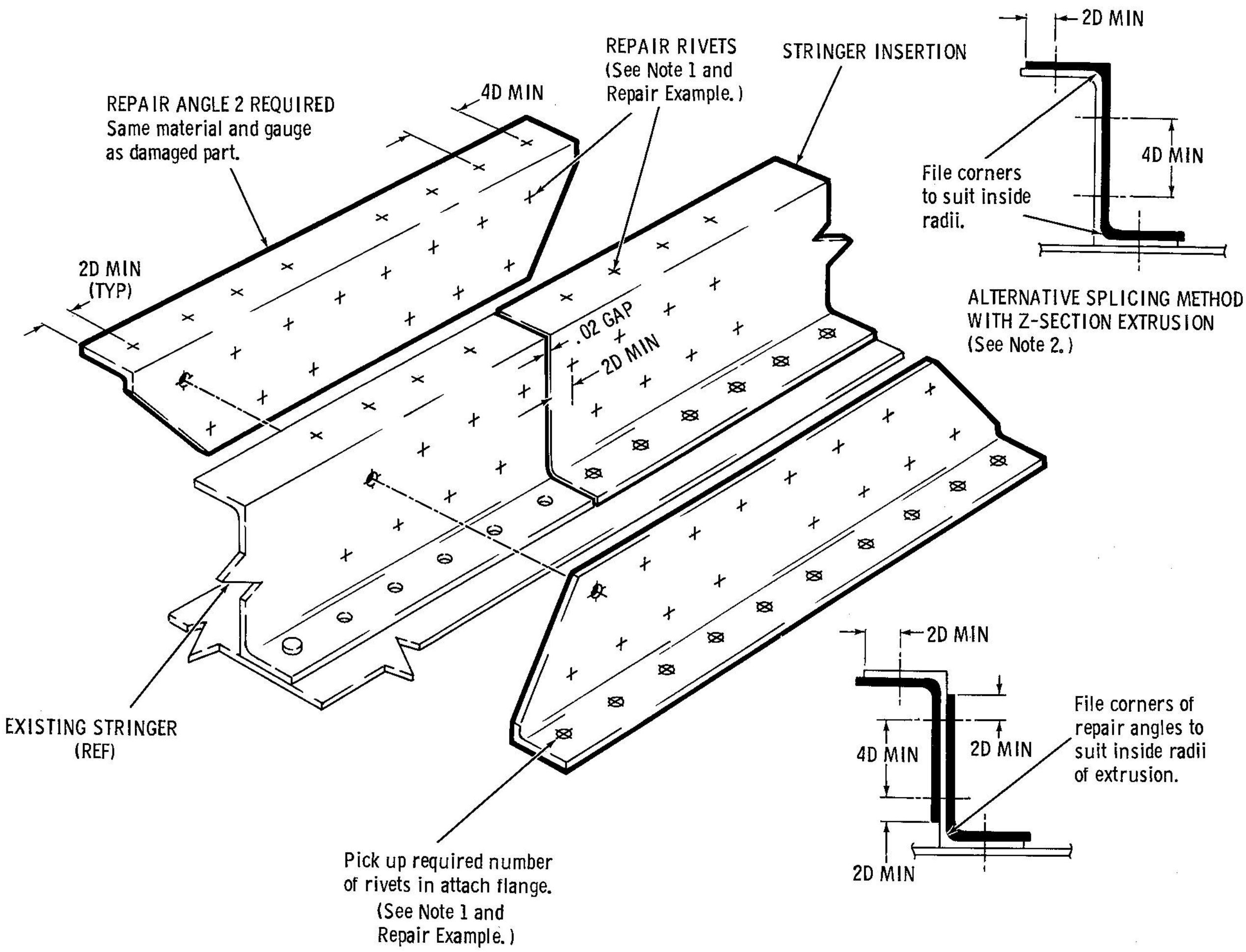
LIMITATION

Repair A is limited to damage not penetrating into bend radius after trimming.
Repair B is limited to damage not penetrating farther than the end of bend radius in web after trimming. Both repairs are not applicable to restricted areas and heavily stressed stringers in primary structure. Refer to text for detailed limitation of typical repairs.



13-24-95

Figure 59 Extruded Sections - Attach Flange Repair



REPAIR EXAMPLE

DAMAGED EXTRUSION: 0.050 24S-T4
SPLICE DIMENSIONS:
Free Flange - 0.85 inch
Web - 1.50 inches
Attach Flange - 1.00 inch
REPAIR RIVETS: Existing in Attach Flange - MS20426D5
In Web - MS20470D5
In Free Flange- MS20470D5
REPAIR ANGLE: 0.050 24S-T4 Extrusion
RIVETS REQUIRED FROM EXTRUSION RIVET TABLES:
0.85 inch x 4.09 rivets per inch = 4 rivets in Free Flange
1.50 inches x 4.09 rivets per inch = 7 rivets in Web
1.00 inch x 4.09 rivets per inch = 5 rivets in Attach Flange
RIVETS DISTRIBUTION: As shown. See splicing of formed sections for alternative rivet pattern.

NOTES

1 For selection of repair material, number of rivets required for repair, and method of rivet distribution, refer to text: Extruded Sections Repairs, Typical Repair Procedure and see appropriate illustrations.

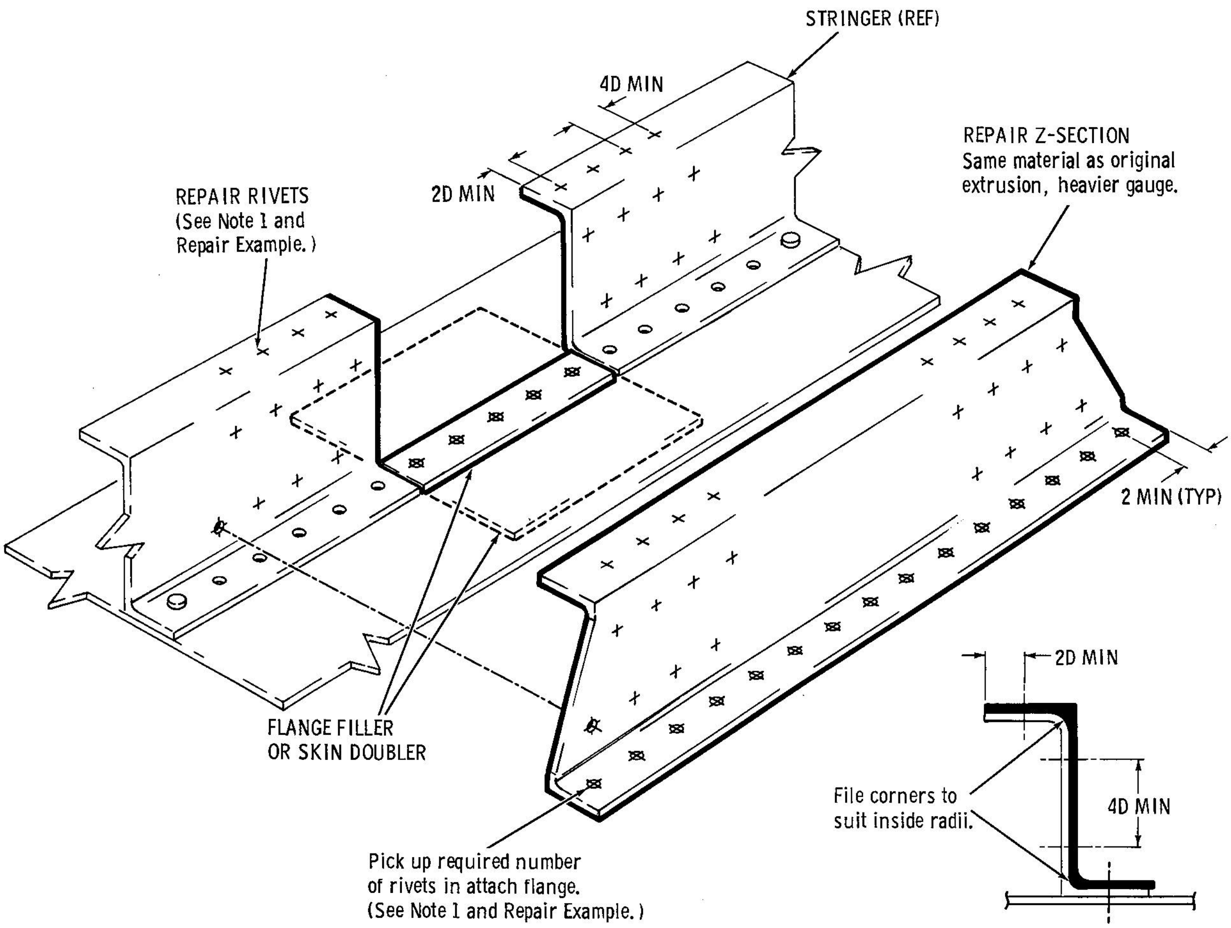
2 For splicing stringer with one Z-section, use extruded section of the same material as existing stringer and one gauge heavier. Calculate and distribute required repair rivets in a manner similar to the example shown.

LIMITATION

This repair is not applicable to restricted areas or heavily stressed stringers in primary structure. Refer to text for detailed limitation of typical repairs.

13-24-97

Figure 60 (Sheet 1 of 2) Extruded Section Splice - Repair by Insertion



REPAIR EXAMPLE

DAMAGED EXTRUSION: 0.050 24S-T4
SPLICE DIMENSIONS:
Free Flange - 0.85 inch
Web - 1.50 inches
Attach Flange - 1.00 inch
REPAIR RIVETS: Existing in Attach
Flange - MS20426D5
In Web - MS20470D5
In Free Flange - MS20470D5
REPAIR Z-SECTION: 0.055 24S-T4 Extrusion
RIVETS REQUIRED FROM EXTRUSION RIVET TABLES:
0.85 inch x 4.09 rivets per inch = 4
rivets in Free Flange
1.50 inches x 4.09 rivets per inch = 7
rivets in Web
1.00 inch x 4.09 rivets per inch = 5
rivets in Attach Flange
RIVETS DISTRIBUTION: As shown. One extra
rivet added in web on each side of cut-out
to maintain required pattern.

NOTES

1 For selection of repair material, number of rivets required for repair and method of rivet distribution, refer to text: Extruded Sections Repairs, Typical Repair Procedure and see appropriate illustrations.

2 This repair is applicable to damaged portion of stringer or where the stringer must be cut out to permit insertion of skin or web repair doubler.

LIMITATION

This repair is not applicable to restricted areas or to heavily stressed stringers in primary structure. Refer to text for detailed limitation of typical repairs.

13-24-98

Figure 60 (Sheet 2 of 2) Extruded Section Splice - Cut-out Repair

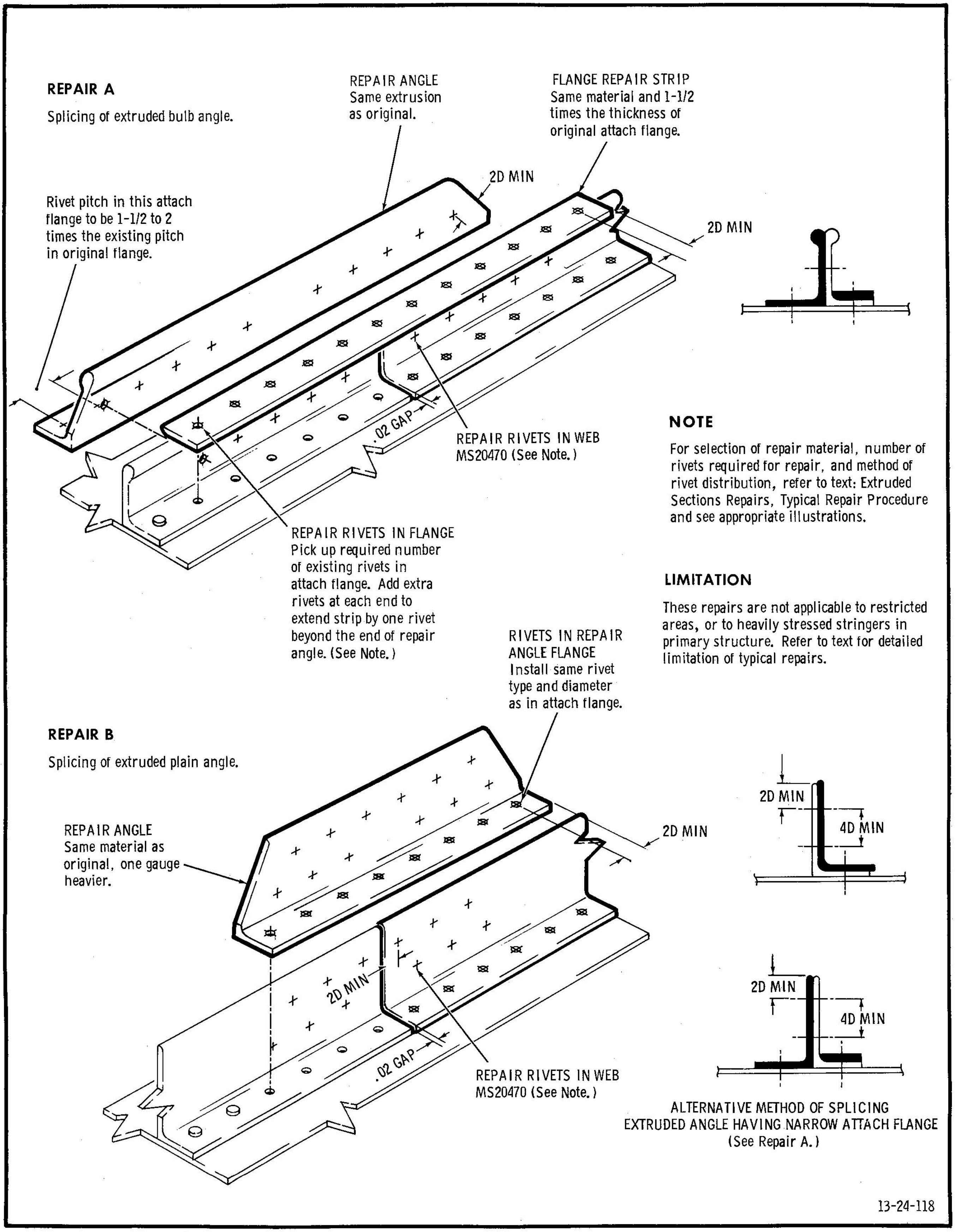
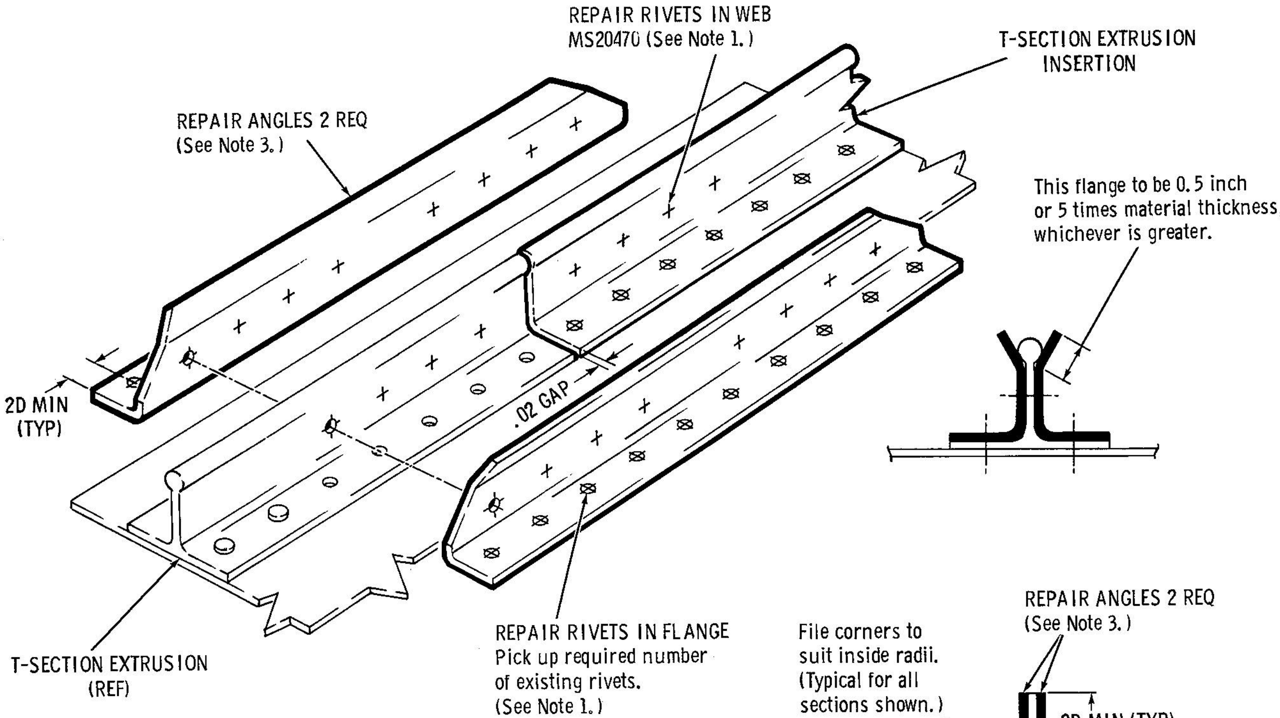
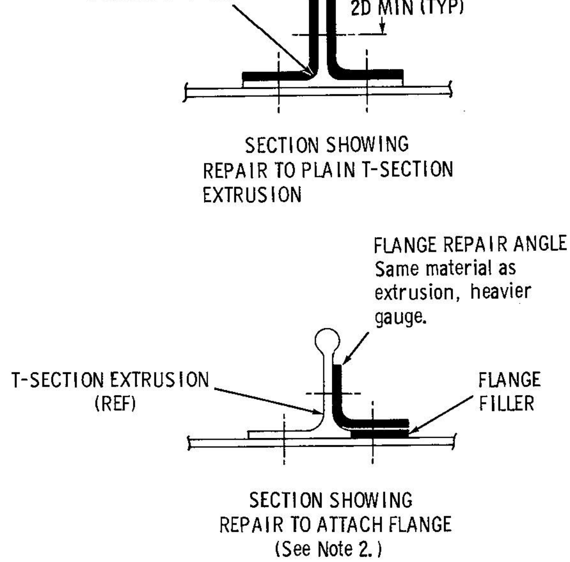


Figure 61 Extruded Section Splice - Angle Repair





NOTES

1 For selection of repair material, number of rivets required for repair, and method of rivet distribution, refer to text: Extruded Sections Repairs, Typical Repair Procedure and see appropriate illustrations.

2 Repair to damage in attach flange with one reinforcing angle may be used only if the damage does not penetrate into radius after trimming.

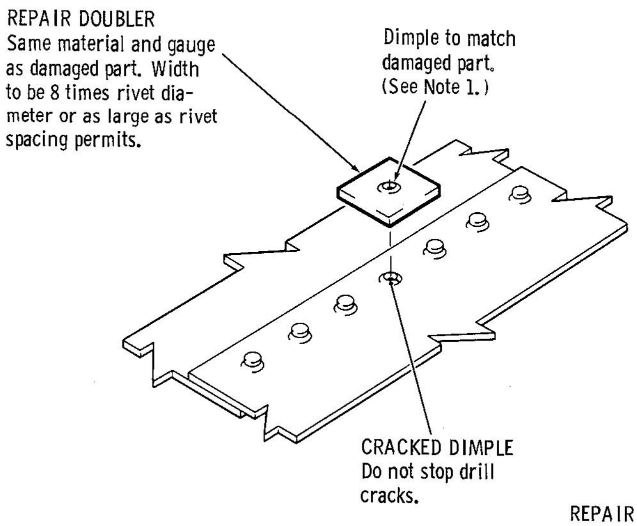
3 Make repair angles from same material as original extrusion. Gauge for repair angles to be same as flanges of original extrusion, but not less than one-half thickness of web of original extrusion. Repair angles for bulb T-section may be formed from alclad sheet.

LIMITATION

These repairs are not applicable to restricted areas, or to heavily stressed stringers in primary structure. Refer to text for detailed limitation to typical repairs.

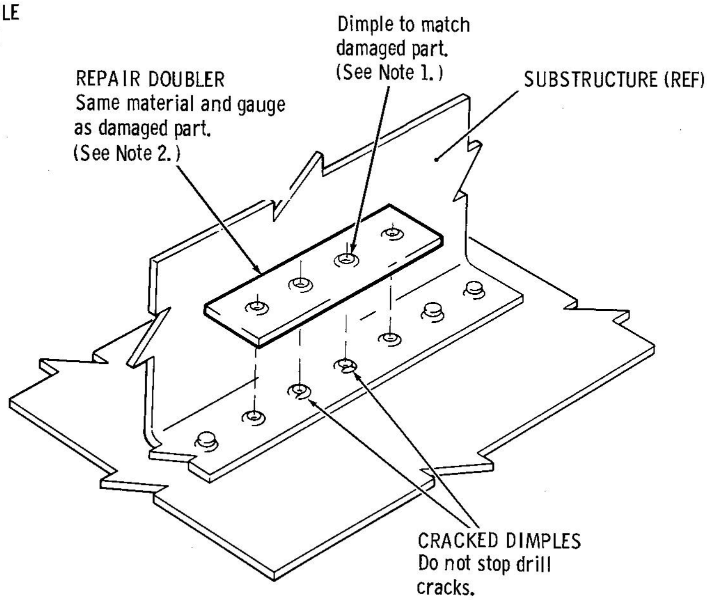
13-24-119

Figure 62 Extruded Section Splice - T-section



REPAIR A SINGLE DIMPLE

This repair is applicable to a single dimple where not more than 2 cracks exist. The crack must be radial and must not extend into the flat area. There must be at least 6 good dimples on each side of the cracked dimple.



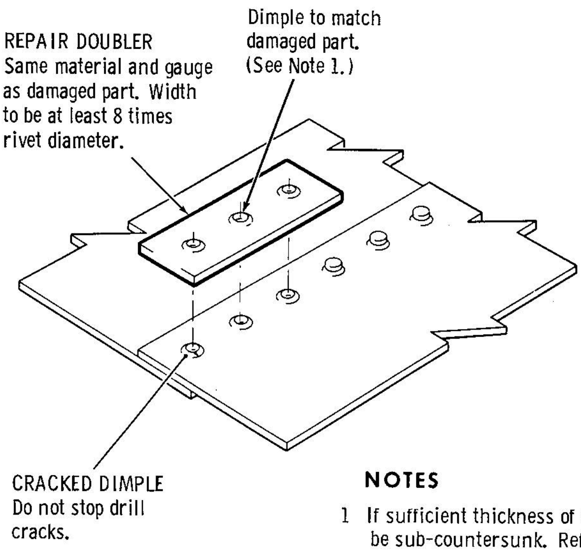
REPAIR B TWO OR MORE DIMPLES

This repair is applicable when the following conditions exist:

(a) Less than 6 good dimples exist on each side of damage.
(b) More than 2 cracks exist per dimple, but not extending into flat area.
(c) Adjacent dimples are cracked.

The repair doubler must pick up one good dimple at each end. If fastener spacing permits, add one AD3 rivet between each dimple.

Adjacent repair must not be closer than 6 inches.



REPAIR C END DIMPLE

This repair is applicable to one cracked dimple on end of rib or frame flange, or inner skin. The cracks must not extend into flat area. Repair doubler must pick up 2 good dimples.

NOTES

1 If sufficient thickness of repair doubler is used, rivet holes may be sub-countersunk. Refer to Table of Minimum Thickness for Sub-countersinking in EO 05-1-3/5.

2 Edge distance not to be less than 2-1/2D.

13-24-43

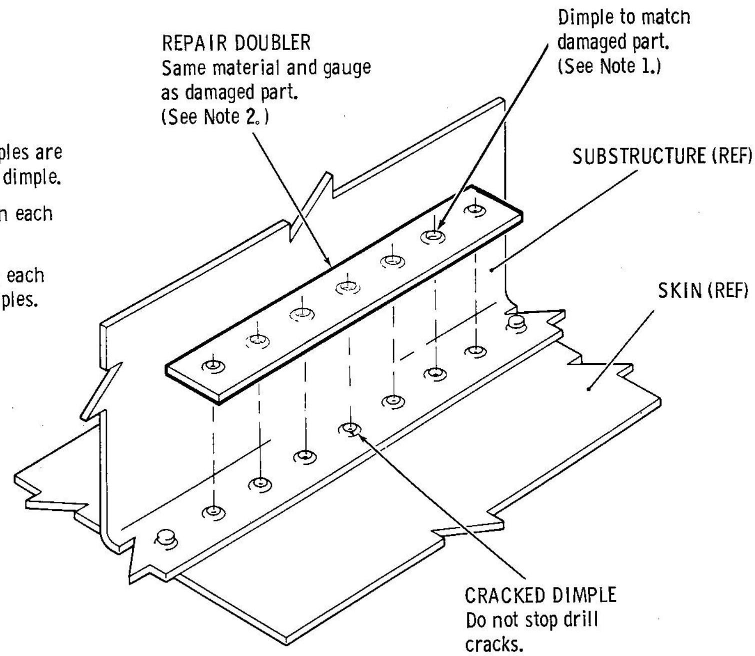
Figure 63 (Sheet 1 of 2)
Cracked Dimples in Rib or Frame Flanges and Inner Skin - Repair in 24S-T3 and -T4

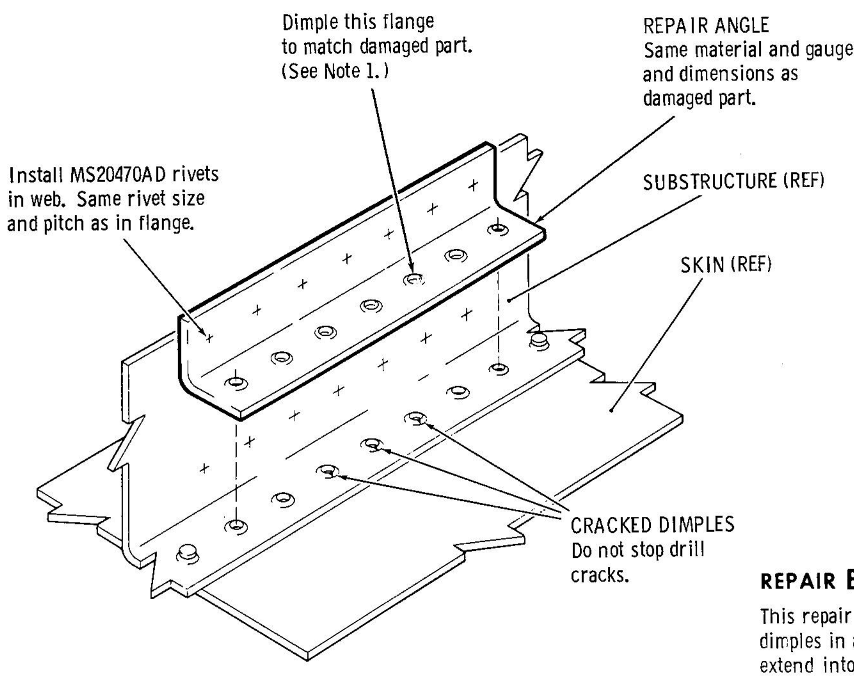
REPAIR A SINGLE DIMPLE

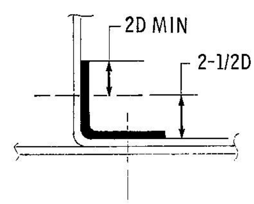
This repair is applicable where cracks in dimples are radial and do not extend into flat area beyond dimple.

Repair doubler must pick up 3 good dimples on each side of cracked dimple.

If fastener spacing permits, add AD3 rivet on each side between cracked dimple and adjacent dimples.







REPAIR B TWO OR MORE DIMPLES

This repair is applicable where less than half of the dimples in a flange are damaged. Cracks must not extend into flat area.

Pick up 2 good dimples on each side of cracked dimples.

NOTES

1 If sufficient thickness of repair doubler is used, holes in doubler may be sub-countersunk to match existing dimpling. Refer to Table of Minimum Sheet Thickness for Sub-countersinking in EO 05-1-3/5.

2 Edge distance for dimpled holes not to be less than 2-1/2D.

13-24-44

Figure 63 (Sheet 2 of 2)
Cracked Dimples in Rib or Frame Flanges and Inner Skin - Repair in 26S-T6 and 75S-T6

NOTES

1 Use repair rivets of the same type, material and diameter as existing in attachment of substructure to skin.
Where countersunk-head rivets are used, dimple rivet holes in skin and sub-countersink holes in repair block. Rivet holes in skin filler may be countersunk. If dimpling is not possible, repair rivet holes in skin may be countersunk in accordance with EO 05-1-3/5. For countersinking in light gauge skin, see Limitation.

2 To facilitate insertion of trailing edge repair block, the block may be machined in two pieces. The final shape of both pieces must conform to the profile of the tab.

3 If repair is in magnesium alloy tab, paint all repair members with at least 3 coats of zinc chromate primer.

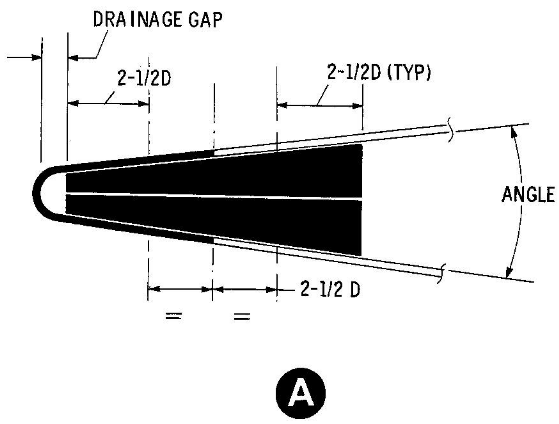
4 Control surface must be balanced after repair.

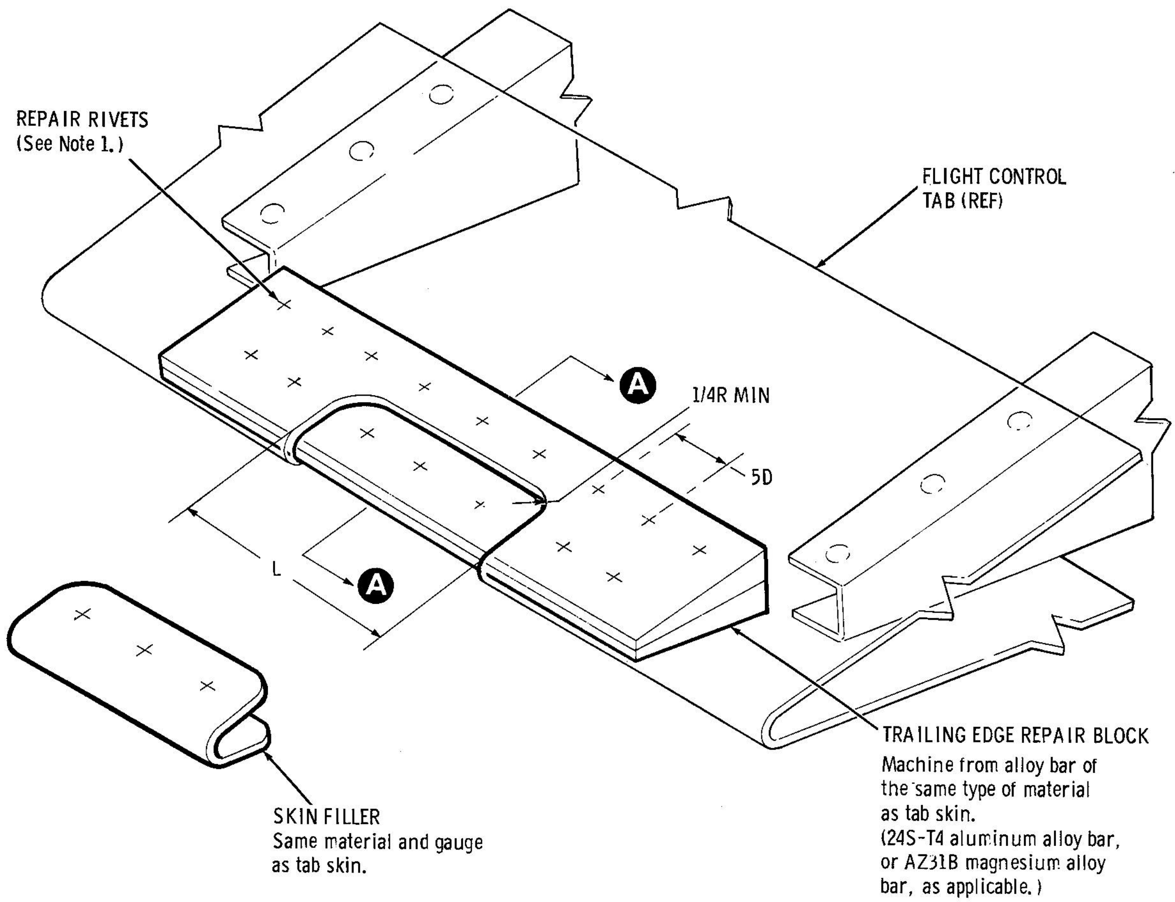
LIMITATION

Maximum length (L) of damage: 2 inches with 3 rivets each side of damage; or 4 inches with 5 rivets each side of damage (as shown).

Only one such repair per tab.

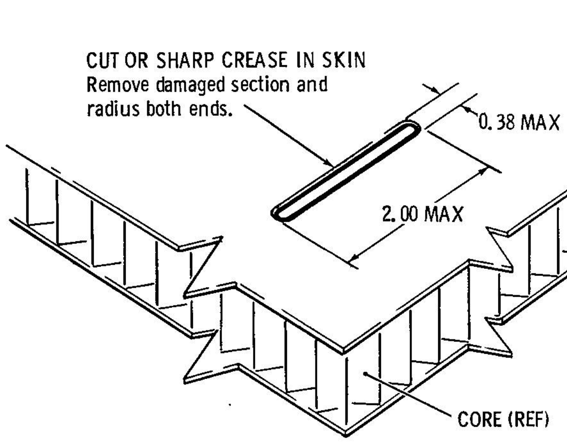
When repair rivet holes have to be countersunk in light gauge skins, below the limits for countersinking given in EO 05-1-3/5, the maximum length (L) of damage must not exceed 2 inches and a minimum of 5 rivets must be installed each side of damage.





13-24-79

Figure 64 Flight Control Tab Trailing Edge Skin - Repair

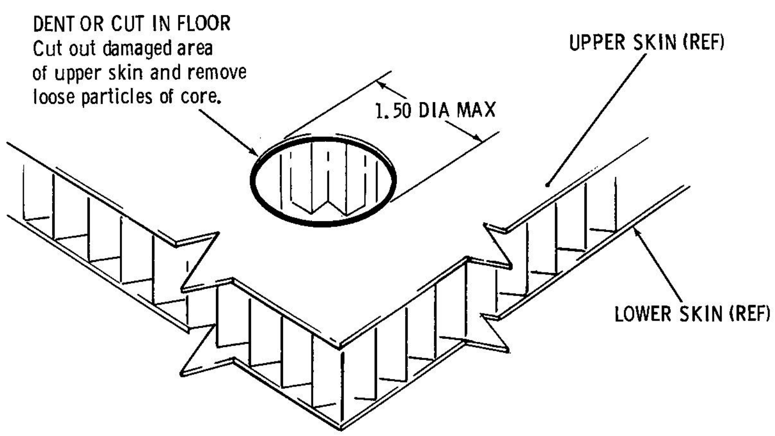


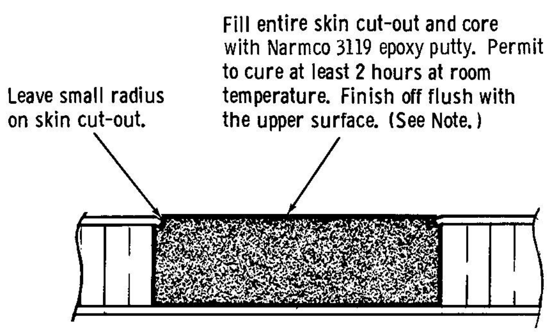
LIMITATION

This repair is applicable only to secondary structure where lower skin is not damaged, and the following distances can be maintained: Adjacent repairs must be at least 24 inches apart on centres in any one panel.

At least 3 inches between flooring attachment point and any adjacent repair.

At least 10 inches between seat attachment and nearest point of any repair.





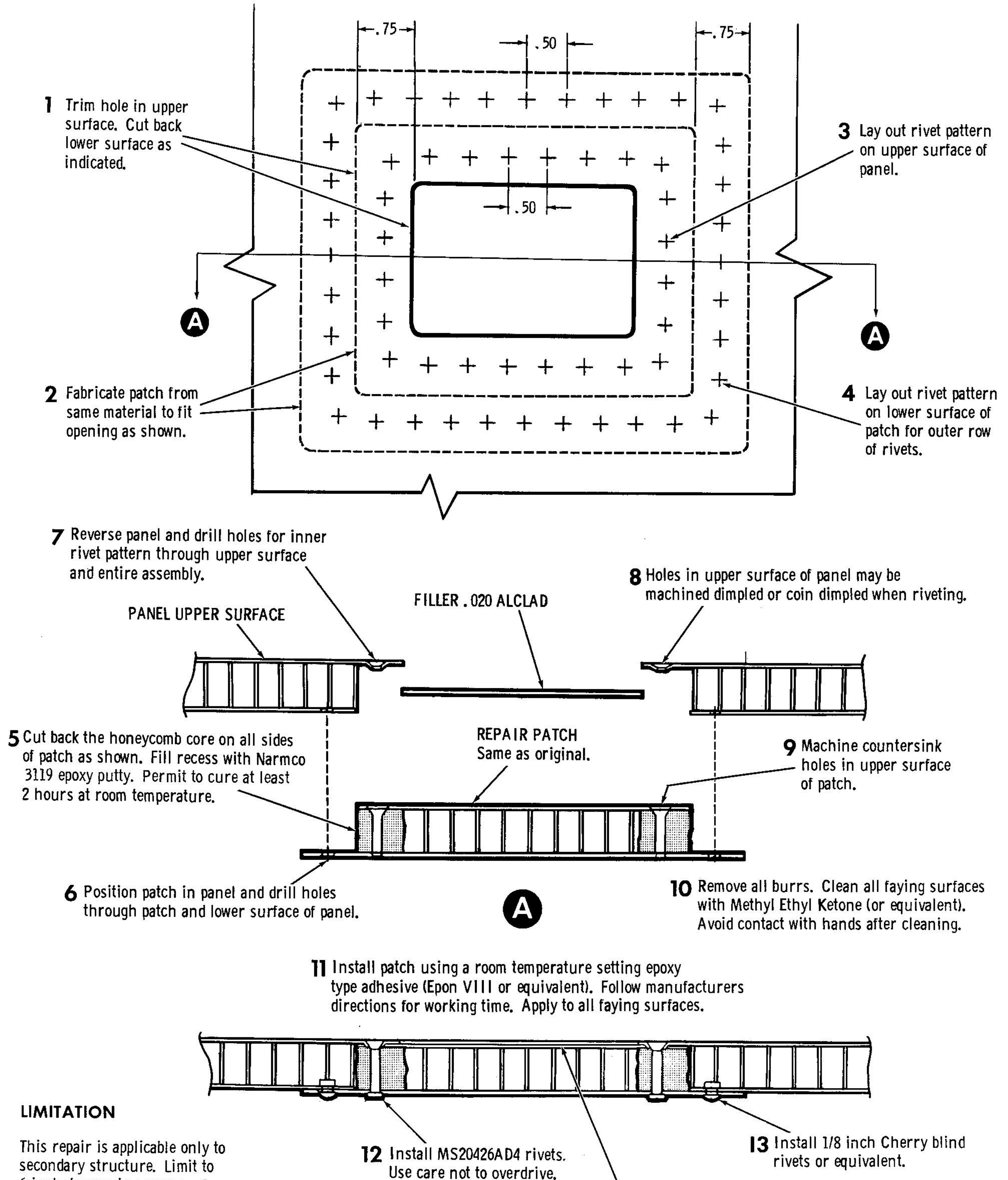
TYPICAL SECTION FOR ALL REPAIRS

NOTE

Alternatively the cut-out may be filled with a mixture of 100 parts by weight of EPON 828, 10 parts by weight of Hardener No. 951, and addition of mill-ends or silica pellets. Mix and cure per manufacturers specification. (Aluminum powder may be added for colouring.)

13-24-131

Figure 65 Honeycomb Core Floor Panel - Repair



LIMITATION

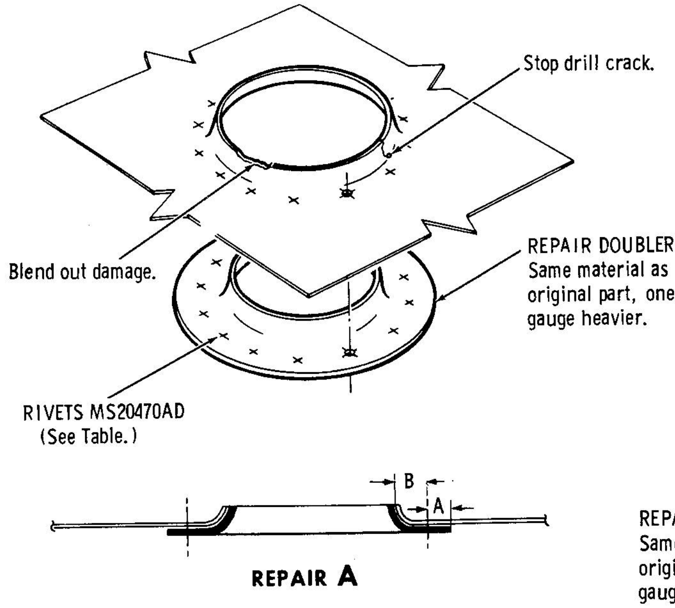
This repair is applicable only to secondary structure. Limit to 6 inch damage in upper surface.

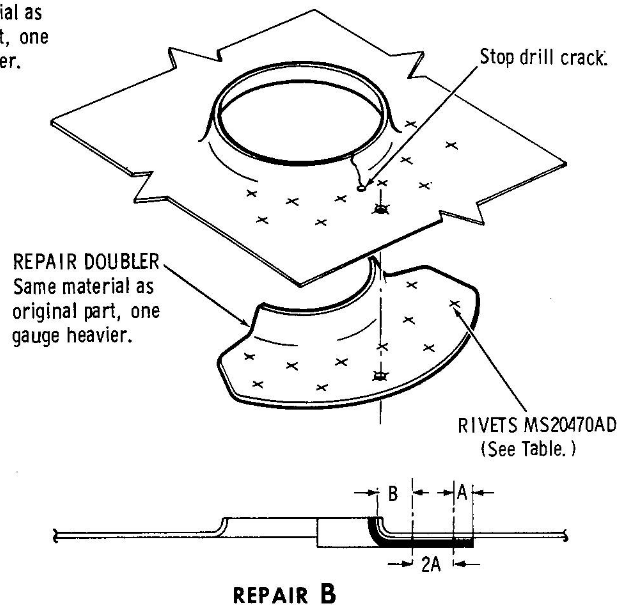
NOTE

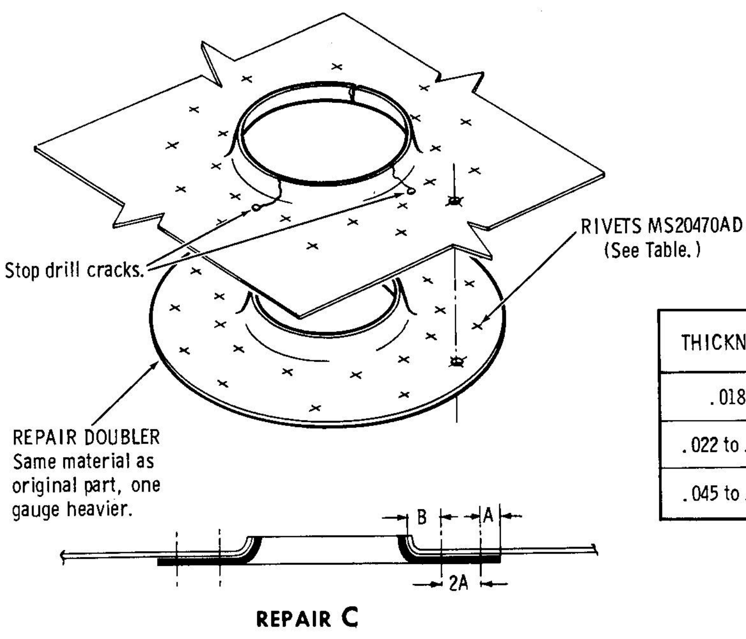
This method may be used to repair a honeycomb core floor panel in which both upper and lower surfaces are damaged. Repair may be either square or circular.

13-24-130

Figure 66 Honeycomb Core Panel - Repair







RIVET TABLE

THICKNESS	RIVETS	A DIMENSION	B DIMENSION	MAX PITCH
.018	MS20470AD3	.30	.35	.65
.022 to .040	MS20470AD4	.30	.35	.75
.045 to .064	MS20470AD5	.35	.40	.90

LIMITATION

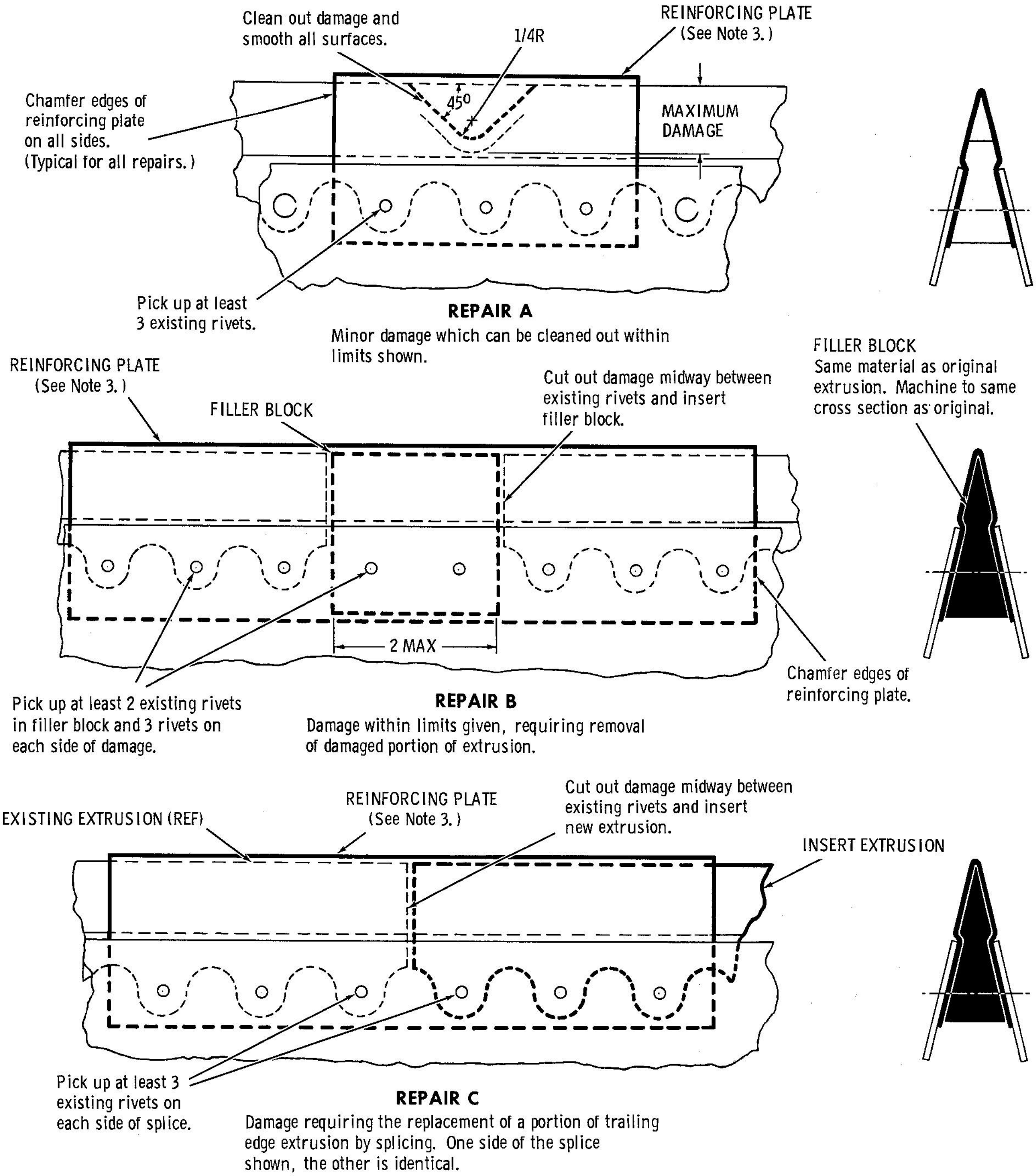
Repair A is applicable to damage not penetrating farther than bend radius in the web.

Repair B is applicable to single damage not penetrating farther than 1/2 inch in the web.

Repair C is applicable to multiple damage not penetrating farther than 1/2 inch in the web.

13-24-57

Figure 67 Lightening Holes - Repair



NOTES

1 Repairs to flight control surfaces will require checking for static balance.

2 Where trailing edge is made from magnesium alloy, proceed as follows:
(a) Chrome pickle all freshly exposed magnesium surfaces.
(b) Apply 3 coats of zinc chromate primer to magnesium surfaces to be covered by reinforcing plates.
(c) Apply 2 coats of zinc chromate primer to inside surfaces of cover plates.
(d) Use only 56S aluminum alloy (B) rivets for repair.

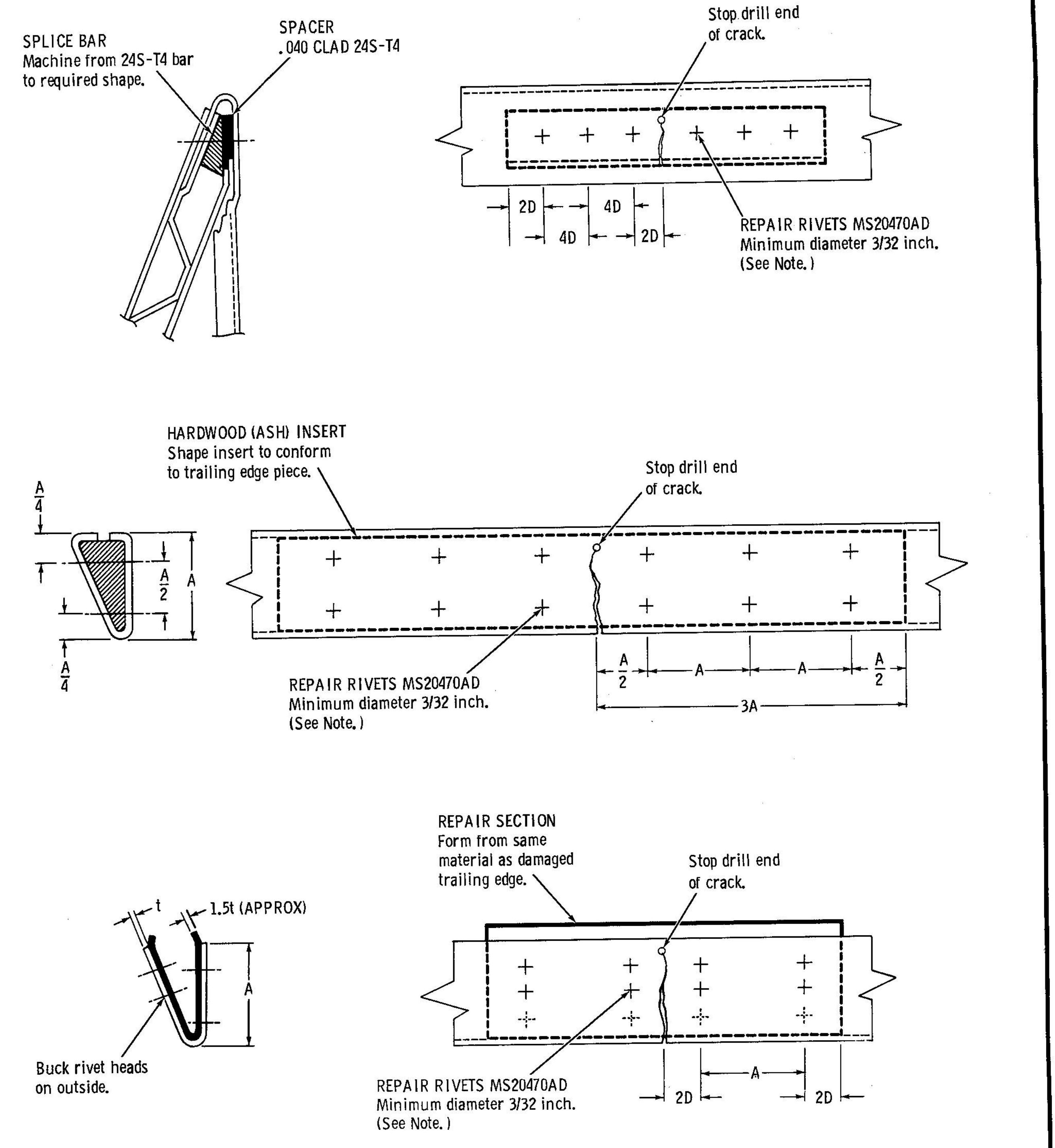
3 Form reinforcing plate from 24S-0 Clad, same gauge as skin. Minimum thickness 0.020 inch. Heat treat to T4 after forming. Joggle plate under skin and dimple rivet holes to suit.

LIMITATION

Not more than 2 repairs per surface and they must be at least 16 inches apart.

13-24-105

Figure 68 Trailing Edge Arrowhead Extrusion - Repair



NOTE

For selection of repair material, number of rivets required for damage dimensions and method of rivet distribution, refer to Typical Repair Procedure in text. Do not use fewer repair rivets than shown.

13-24-122

Figure 69 Trailing Edge Repairs - Small Aircraft

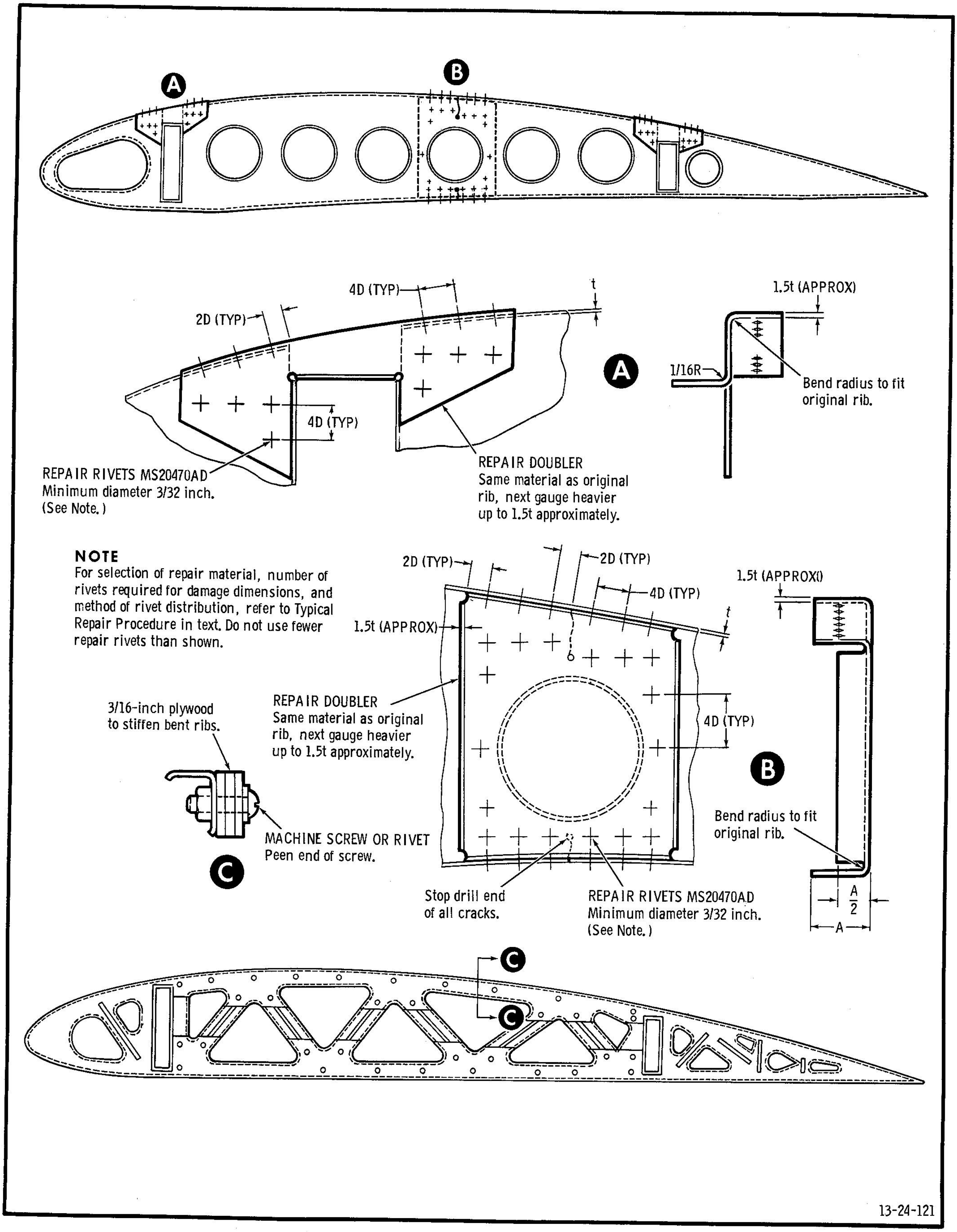


Figure 70 Metal Rib Repairs - Small Aircraft

Item	RCAF Ref	Specification	Vendor	Description
1	33C/182	P-S-661 Type 1 3-GP-8	Shell Chemical Co.	Cleaner Fluid
2	33C/6810-21-572-2566	31-GP-213	Commercial	Trichloroethane 1-1-1
3	33C/672	Technical Grade		Caustic Soda (NaOH)
4	33C/494	Technical Grade		Chromic Acid (CrO_3)
5	33C/1	Technical Grade		Hydrochloric Acid (HCl)
6		Technical Grade		Copper Sulphate ($CuSO_4$)
7		Technical Grade		Sulphuric Acid (H_2SO_4)
8		Commercial	Behr-Manning (Canada) Ltd.	Durite Paper A-OP Nos 100, 150, 320 and 500
9		Commercial	Wynt & Co. Ltd.	Wyco Tissue Paper
10		Commercial	Imperial Oil Ltd.	Velocite Oil, Machine Grade C
11		Commercial	Canadian Hanson & Van Winkle Co. Ltd.	Tripoli Polish ABR Compound No. 10
12	33C/689	MIL-P-6888A	Admiral Sanitation Ltd. Scarborough, Ontario	Aluminum Metal Polish
13		MIL-P-8585		Primer, Zinc Chromate
14	33C/520	15-GP-52 TT-M-261		Methyl Ethyl Ketone
15			Narmco Resins and Coatings Co.	Narmco 3119 Epoxy Resin Cement
16		MIL-A-8623 Type III	Shell Chemical Co.	Epon VIII Epoxy Resin Cement
17			Shell Chemical Co.	Epon 828 Epoxy Resin Cement
18			Tempil Corp. New York, N.Y.	Tempilaq
19			Minnesota Mining & Mfg. Co.	3M, EC-244, Sound deadener

Figure 71 Table of Material Specifications