ROYAL CANADIAN AIR FORCE

RIGID FLUID TUBING REPAIR AND REPLACEMENT

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LIST OF RCAF REVISIONS

DATE	PAGE NO	DATE	PAGE NO
3 May 61	3		
3 May 61	4		
3 May 61	4A		
23 Jun 61	35		
23 Jun 61	36		
28 Aug 61	22		
28 Aug 61	23		
29 Jul 64	34		
29 Jul 64	38		
6 Nov 64	21		
6 Nov 64	22		
30 Apr 65	i		
30 Apr 65	21		
30 Apr 65	22 (Deleted)		
30 Apr 65	23		
30 Apr 65	24		
30 Apr 65	25		
28 Feb 66	ii		
28 Feb 66	28		
28 Feb 66	32 (Deleted)		
28 Feb 66	33		
28 Feb 66	37 (Deleted)		
28 Feb 66	38		
24 Oct 67	ii		
24 Oct 67	19		
24 Oct 67	20		
24 Oct 67	20A		
24 Oct 67	20B		
24 Oct 67	20C		

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont'd)

RIGID FLUID TUBING REPAIR AND REPLACEMENT

REPAIR AND FABRICATION OF RIGID LINES

GENERAL

1 Maintenance of rigid tubing lines is mainly a matter of replacement of tubing damaged due to mishandling; the rerouting of lines due to design changes, and the tightening of joints to stop or prevent leakage of fluids in the system.

JOINTS AND FITTINGS

GENERAL

2 Two types of joints are used at tubing connections, solid type using nipple and nut fittings, and beaded type using flexible hose and clamps. The solid joints used are of two types, flared and flareless.

BEADED TUBE JOINTS

3 Beaded joints are used on low pressure lines. The most practical and rapid way of forming beads is by using a tool with a rolling action. Figure 1 shows the operation of the beading tool. For beading dimensions, see Figure 2. Instructions governing the use of hose clamps and restrictions on installations are detailed in EO 05-1-3/11.

SOLID JOINTS

4 Solid joints are of two types, flared and flareless. Both types of joints use fittings consisting of a body, nut and usually a ferrule or sleeve.

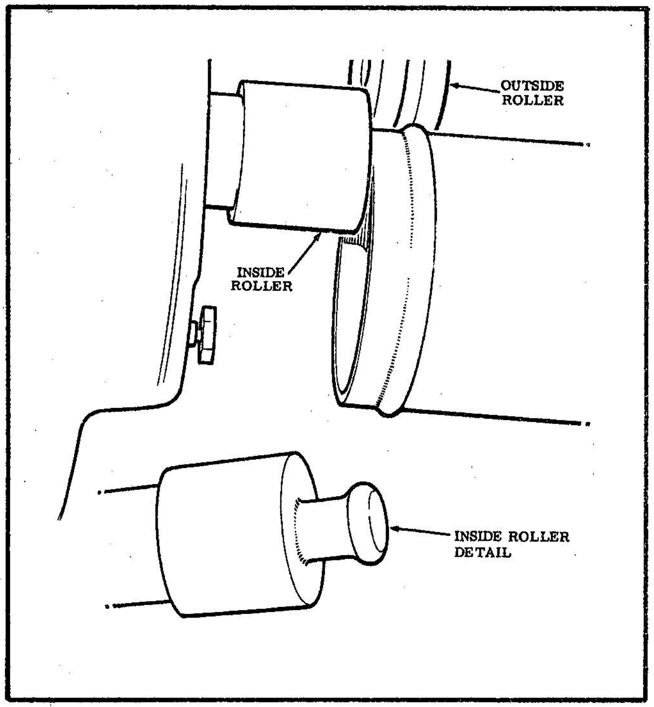


Figure 1 Use of Beading Tool

TUBE CONNECTIONS

5 There are two general types of AN tube connectors commonly used, the three-piece and the two-piece shown in Figure 3.

6 In the past, fittings have been manufactured to three different specifications, as follows; see Figure 4.

(a) NAF (no longer in use).

(b) AN (this type is standard).

(c) AC (still frequently used).

AN FITTINGS

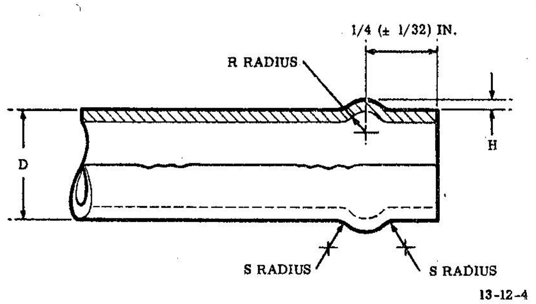
7 For typical AN Fittings, see Figure 5, for threads and dimensions of AN816 fittings, see Figure 6.

CODE OF AN FITTINGS

8 For AN fitting code, see Figure 7.

SIZE

9 The dash number following the AN number indicates the size of the tubing (or hose) for which the fitting is made, in sixteenths of an inch. This size measures the outside diameter of tubing and the inside diameter of hose. Fittings having pipe threads are coded by a dash number indicating the pipe size in eights of an inch. The material code letter, see Figure 7, follows the dash number.



D Outside Diameter of Tube	H Height of Bead	R Radius Max.	S Radii Max.
1/4	.034 - .028	1/8	1/16
5/16	.036 - .030	1/8	1/16
3/8	.038 - .032	1/8	1/16
1/2	.041 - .035	1/8	1/16
5/8	.041 - .035	1/8	1/16
3/4	.041 - .035	1/8	1/16
1	.065 - .059	5/32	3/32
1-1/4	.065 - .059	5/32	3/32
1-1/2	.075 - .069	5/32	3/32
1-3/4	.075 - .069	5/32	3/32
2	.085 - .079	5/32	3/32
2-1/2	.085 - .079	5/32	3/32
3	.085 - .079	5/32	3/32

Figure 2 Dimensions of Rigid Tubing Hose Connection Beads

INTERCHANGEABILITY

10 Certain fittings are interchangeable, although in most cases the pitch of the thread is different. Combinations of end connections nuts, sleeves and tube flares make up a complete fitting assembly. The interchangeable parts, thread sizes, and tube fittings are shown in Figure 8. Where possible, avoid the use of dissimilar metals, especially brass, copper or steel, in contact with aluminum or aluminum alloys as this will cause corrosion.

APPROVED COMBINATIONS OF AN AND AC811 TYPE FITTINGS

11 AN and AC811 sleeves, nuts, tube fittings and tubing flares may be satisfactorily interchanged in cases where the sleeve will

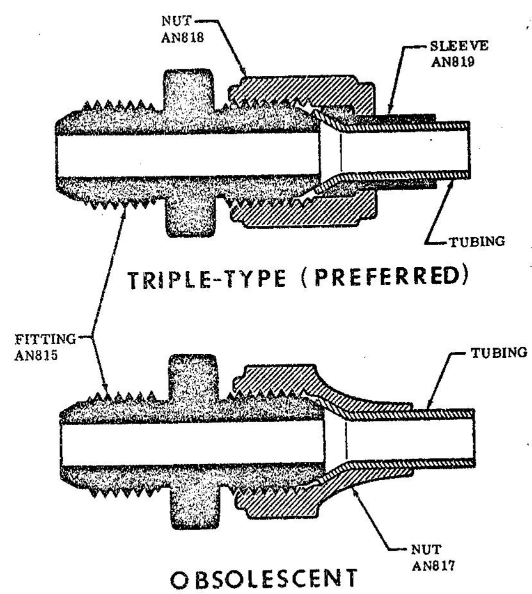


Figure 3 Tube Connectors

fit properly in the nut, where the nut will not bottom on the fitting body and where sufficient thread engagement will result. In Sizes 5 and smaller, the pitch of the thread on each size is the same for the two styles of fittings and can be interchanged with certain conditions as shown in Figure 8. In sizes 6 and larger, except sizes 28 and 32, comparable AN and AC811 fittings are not interchangeable since the pitch of the threads on the two types is not the same.

(a) The following table provides information on the use of AN and AC811 type fittings.

Tube Sizes OD	Male Fitting Thread	Female Nut Thread	Sleeve	Tube Flare
All Sizes *	AN	AN	AN	AN
All Sizes **	811	811	811	811
All Sizes	AN	AN	AN	811
All Sizes	AN	AN	811	811
All Sizes	AN	AN	811	AN
All Sizes	811	811	AN	811
All Sizes	811	811	AN	AN
All Sizes	811	811	811	AN
#2, #3, #4, #5, #28, #32	AN	811	AN	811
#2, #3, #4, #5, #28, #32	AN	811	AN	AN
#2, #3, #4, #5, #28, #32	AN	811	811	811
#2, #3, #4, #5, #28, #32	AN	811	811	AN

* Normal assembly of AN fittings.
** Normal assembly of 811 fittings.

NOTE

Combination other than those listed will NOT seal satisfactorily and will NOT be used.

(b) Wherever possible endeavor to use either complete assemblies of AC811 or AN fittings on a system or particular installation.

TORQUING OF FITTING NUTS

12 It is important to tighten or torque the fitting nuts to the correct tension when installing the tube assembly within the aircraft. Pliers must never be used to tighten fittings, and crescent or monkey wrenches are not desirable. A fitting or open end wrench of the indicating torque type is best. Overtightening of the nuts may severely damage or completely cut off the tube flares, and may also result in damage to sleeve or nut of fitting. If, upon removal of the nut and sleeve, the flare is found to retain less than 50% of the original wall thickness of the tube, if should be rejected. The use of torque wrenches prevents such incorrect torquing.

13 A nut should never be tightened when there is pressure in the line, as this will tend to cut the flare without adding any appreciable torque to the fitting. If tightened properly, a tube fitting assembly may be removed and retorqued many times before reflaring is necessary. Undertightening may be equally serious, as this may allow the line to blow out or leak under system pressure. For torque tables and limitations refer to EO 05-1-3/25.

FLARED TUBE JOINTS

GENERAL

14 Flared joints are used on high-pressure lines. A taper tool is used for producing the flare.

TUBE CUTTING

15 To ensure a good flared tube connection the tube must be cut off squarely. The end must be squared and any burrs removed before it is flared.

(a) Clamp the tube cutter over the tube, see Figure 9.

(b) Rotate the cutter towards its open

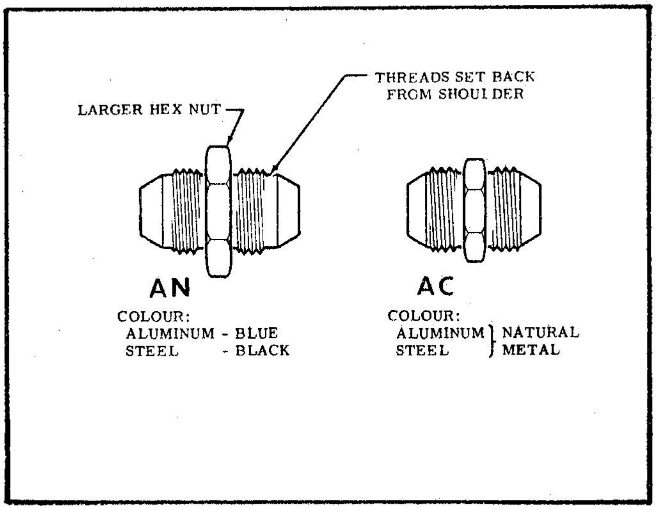


Figure 4 Comparison of AN and AC Unions

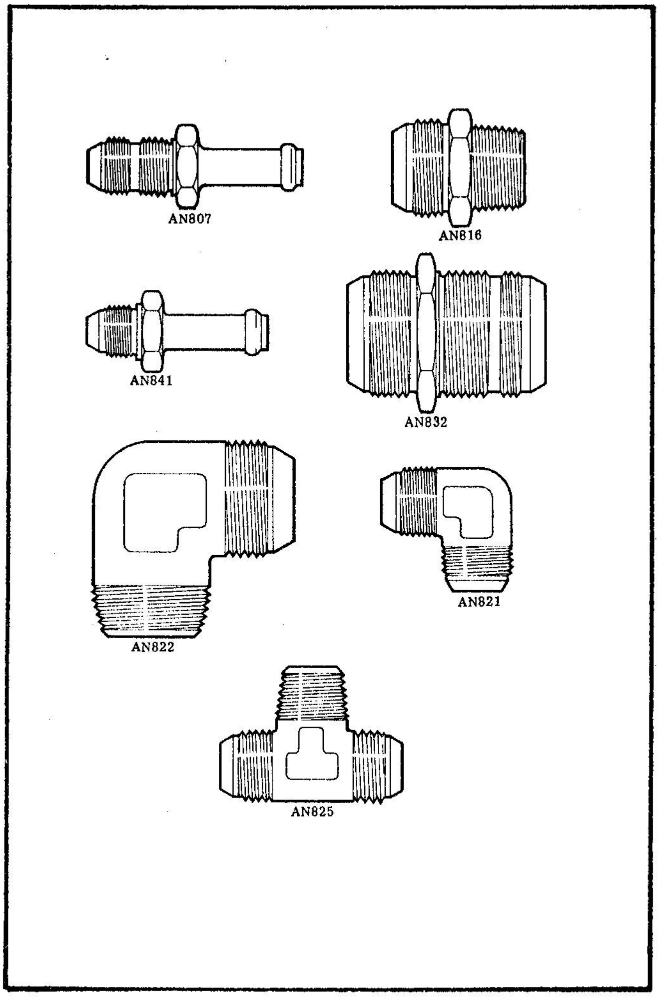
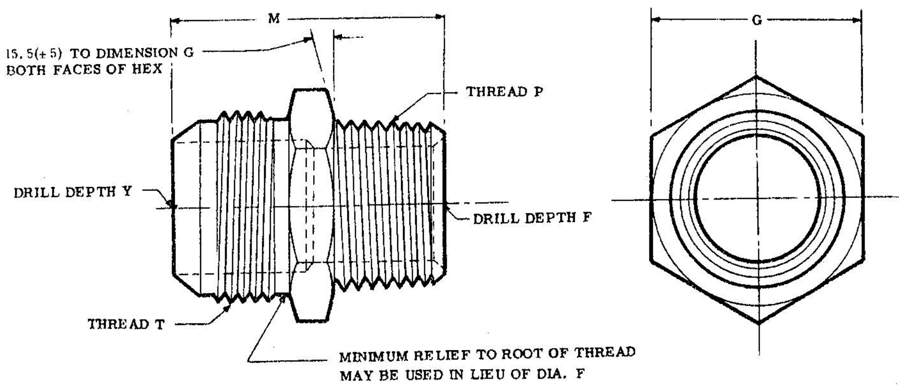


Figure 5 AN Fittings



	Dash Number		Tubing OD	Thd P ANPT	Thread T Ref	F	G		M	Y
Steel	Al Alloy	Copper Alloy								
-2	-2D	-2B	1/8	1/8	5/16-24 NF-3	15/32	.438	+.003 -.004	1-1/64	
-3	-3D	-3B	3/16		3/8-24 NF-3				1-3/64	
-4	-4D	-4B	1/4		7/16-20 NF-3		.500		1-7/64	
-4-4	-4-4D	-4-4B		1/4		11/16	.563	±.004	1-3/8	
-5	-5D	-5B	5/16	1/8	1/2-20 NF-3		.562		1-9/64	5/8
-5-4	-5-4D	-5-4B		1/4		11/16	.563		1-3/8	
-6-2	-6-2D	-6-2B	3/8	1/8	9/16-18 NF-3		.625		1-3/16	11/16
-6	-6D	-6B		1/4		11/16			1-3/8	
-6-6	-6-6D	-6-6B		3/8			.750		1-13/32	
-6-8	-6-8D	-6-8B		1/2		7/8	.875		1-5/8	
-7	-7D	-7B	1/2	1/4	3/4-16 NF-3		.813		1-1/2	27/32
-8	-8D	-8B		3/8		11/16				
-10	-10D	-10B	5/8	1/2	7/8-14 NF-3	29/32	.938		1-53/64	
-10-12	-10-12D	-10-12B		3/4			1.125	±.005	1-27/32	
-12-8	-12-8D	-12-8B	3/4	1/2	1-1/16-12 N-3				1-61/64	1-1/16
-12	-12D	-12B		3/4		29/32				
-12-16	-12-16D	-12-16B		1		1-1/16	1.375		2-3/16	
-16-12	-16-12D	-16-12B	1	3/4	1-5/16-12 N-3				2-1/32	1-3/32
-16	-16D	-16B		1		1-1/8			2-7/32	
-20	-20D	-20B	1-1/4	1-1/4	1-5/8-12 N-3	1-3/16	1.688	±.016	2-23/64	
-21	-21D	-21B		1					2-21/64	1-1/4
-25	-25D	-25B	1-1/2	1-1/4	1-7/8-12 N-3		2.000		2-35/64	1-11/32
-28	-28D	-28B	1-3/4	1-1/2	2-1/4-12 N-3		2.375	±.020	2-53/64	1-7/16
-32	-32D	-32B	2	2	2-1/2-12 N-3	1-7/16	2.625		3-7/64	

Figure 6 (Sheet 1 of 2) Nipple, Flared Tube and Pipe Thread AN816

Specification	Material
QQ-A-354	Aluminum Alloy (AL-24)
QQ-A-355	Aluminum Alloy (AL-24)
QQ-A-367	Aluminum Alloy Forgings
QQ-B-611	Brass, (Commercial)
QQ-B-721	Bronze, Manganese
QQ-S-633	Steel, Carbon Bars
QQ-S-624	Steel, Alloy Bars
QQ-A-266	Aluminum Alloy, (14 S)
QQ-A-351	Aluminum Alloy, (AL-17)
MIL-B-6946	Bronze, Aluminum
MIL-S-6050	Steel, Chrome-Nickel-Molybdenum (SAE 8630)
MIL-S-6049	Steel, Chrome-Nickel-Molybdenum (SAE 8740)
MIL-S-6758	Steel, Chrome-Molybdenum (SAE 4130)
MIL-T-6732	Tubing, Chrome-Nickel-Molybdenum (SAE 8630)
MIL-S-5626	Steel (SAE 4140)
AN-S-9	Steel, Molybdenum (SAE 4037)

Finish: Aluminum Alloy: Anodic Treatment. Steel and other metals: Cadmium Plate. Add S after dash number for corrosion resistant steel, type 304L and 347. Add C after dash number for corrosion resistant steel, type 302, 303, 304 and 321. Examples of part nos: AN816-4: nipple 1/4 tube OD to 1/8 pipe, steel. AN816-4D: nipple 1/4 tube OD to 1/8 pipe, aluminum alloy. AN816-4B: nipple 1/4 tube OD to 1/8 pipe, copper alloy. AN816-8S: nipple 1/2 tubing and 3/8 pipe, corrosion resistant steel, type 304L and 347. AN816-8C: nipple 1/2 tubing and 3/8 pipe, corrosion resistant steel, type 302, 303, 304, 316 and 321.

Figure 6 (Sheet 2 of 2) Nipple, Flared Tube and Pipe Thread AN816

Material	Colour Code	Callout Code
Aluminum Alloy	Light Blue	D
Steel	Black	No letter
Aluminum Bronze	Natural cad plate	B
Copper Base Alloys	Natural cad plate	Z (for AN819 Sleeve)

Figure 7 Code of AN Fittings

Tube Sizes OD	Male Fitting Thread	Female Nut Thread	Sleeve	Tube Flare
All Sizes*	AN	AN	AN	AN
All Sizes**	811	811	811	811
All Sizes	AN	AN	AN	811
	AN	AN	811	811
	AN	AN	811	AN
	811	811	AN	811
	811	811	AN	AN
	811	811	811	AN
#2, #3, #4, #5, #28, #32	AN	811	AN	811
	AN	811	AN	AN
	AN	811	811	811
	AN	811	811	AN

* Normal assembly of AN fittings.
** Normal assembly of 811 fittings.

NOTE

Combinations other than those listed will not seal satisfactorily and will not be used. Wherever possible endeavour to use either complete assemblies of AC811 or AN fittings on a system or particular installation.

Figure 8 Table of Approved Combinations of AN and AC811 Fittings side, gradually feeding the cutting wheel downward by turning the thumbscrew. Do not feed the wheel too rapidly. The cutting wheel should only be fed while the cutter is being rotated, as dents will be caused in tubing when the wheel is fed while the cutter is not moving. Moderate or light tension on the thumbscrew will maintain an even tension on the cutting wheel. This prevents bending and avoids excessive burrs on the tubing.

(c) If a cutter is not available, use a hacksaw blade with 32 teeth per inch.

PREPARATION FOR TUBE FLARING

16 After tube has been cut off, file the end square with any fine-toothed flat file. If a hacksaw has been used, file the end of the tube until all saw marks have been removed. A tube vise or a flaring block makes a good clamp for holding the tube while filing. If a flaring block is used, avoid file marks on the top surface. To square the tube let it protrude only slightly from the block or vise, and file until the file runs flatly across the face of the block. Remove burrs and clean as follows:

(a) Remove burrs from both the inside and the outside of the tube by means of a burring tool. If a burring tool is not available, remove the inside burrs with a knife or scraper and the outside burrs with a flat file. Do not round the edges. Leakage will result if the burrs are not properly removed.

(b) Remove all filings, chips, burrs and grit from the inside of the tube in order to avoid pockmarks or scratches on the inner surface of the flare.

(c) Clean the tube thoroughly by blowing out with dry, filtered compressed air.

(d) Inspect the tube end to be sure it is round, square and clean, free of draw marks, mill scale and scratches. Scratches and draw marks are likely to spread and split the tube when it is flared.

FLARING RESTRICTIONS

17 The type of flare used in the flaring of tubing shall be governed by the flare on the original installation. Copper tubing used for high pressure oxygen systems must not be flared. Use solder type fittings.

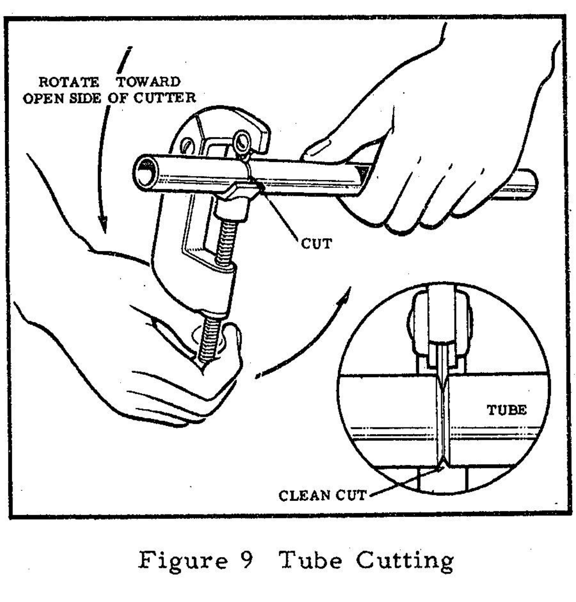


Figure 9 Tube Cutting

18 The tubing should be flared to conform to the flare seat of the fitting. For dimensions of flares see Figures 10 and 11.

19 Aluminum alloy tubing does not have to be annealed for flaring or forming. It is easily flared, is soft enough to be formed by hand tools, and must be handled with care to prevent scratches, dents and nicks.

20 Flares in tubing must conform to the following requirements:

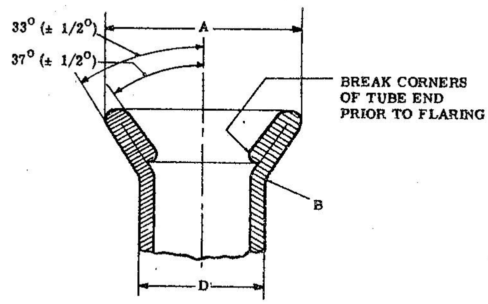
(a) Flares must be concentric and in alignment with the tube. On double flares, the concentricity with the outside diameter of the tube must be within .005 inch full indicator reading.

(b) Flares must be free of cracks, burrs and sharp edges, and the inside surface finished smooth and free from grooves, tool marks and other surface defects.

(c) Superficial marks and checks on the outside surface are not cause for rejection.

(d) The flared area must retain not less than 80% of the original wall thickness.

(e) Form flares so that, when assembling the sleeve, the sleeve contacts the flared surface on pushing together by hand, and does not jam back at the radius.



D Outside Dia. of Tube	A Diameter +.000 -.010	B Radius ±.010	Wall Thick-ness	Minimum Inside Diameter of Flare Lip
3/16	0.302	0.032	0.028 0.035	0.114 0.100
1/4	0.359	0.032	0.028 0.035	0.178 0.159
5/16	0.421	0.032	0.035 0.049	0.224 0.198
3/8	0.484	0.046	0.028 0.035 0.049	0.310 0.288 0.261

NOTE

Maximum diameter of return lip of flare must not exceed largest tube OD plus .040 minus twice the thinnest permissible wall. (See column 4.)

Minimum diameter of return lip; see column 5.

Figure 10 Double Flare Dimensions

FLARING METHODS

21 The flare is usually made by pressure from a conical swage. With earlier flaring tools, the pressure was applied with a hammer. Later tooling uses screw pressure.

HAMMER PRESSURE FLARING

22 The hammer type flaring tool, see Figure 12, consists of a sliding flaring pin with external thread on guide. A separate tool is provided with each size of tubing. To flare tubing with hammer tool, proceed as follows:

(a) Select the proper flaring tool for the tube to be worked.

(b) With a hammer, first tap the tool lightly, then use more force. Avoid cracking tube ends.

COMBINATION TYPE FLARING TOOL

23 To flare tubing with combination type tool, see Figure 13, proceed as follows:

(a) Spread the flaring block by moving yoke aside. Insert tubing flush or with no more than 1/16 inch above top of flaring die jaws.

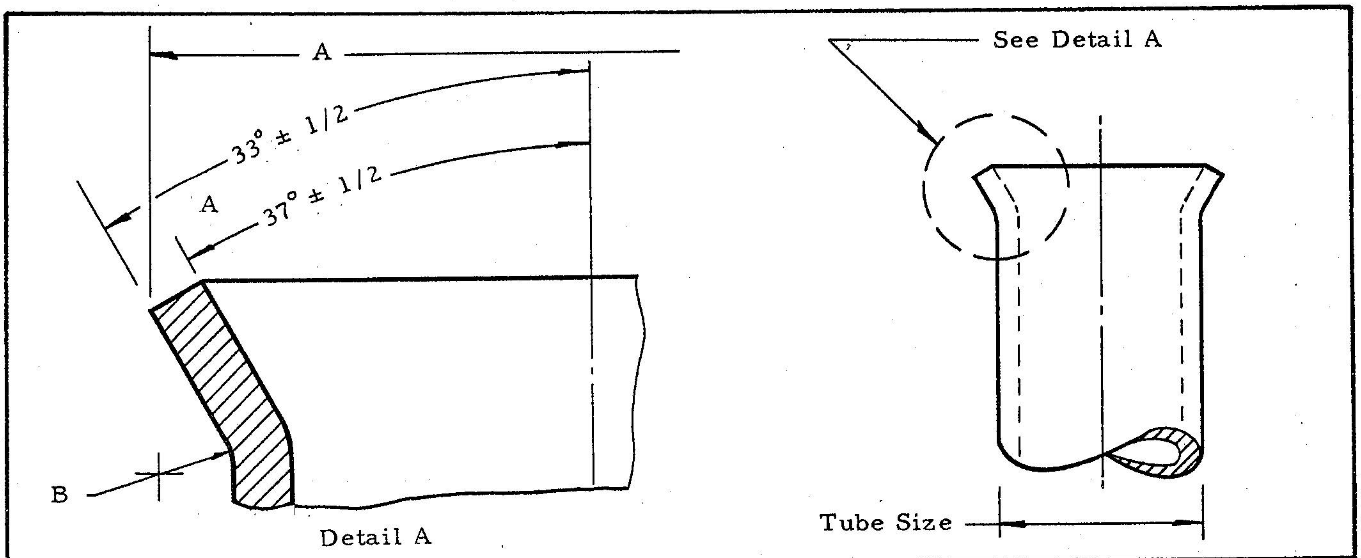
(b) Slide yoke over tubing and clamp tightly in place with adjusting screw.

(c) Lower flaring pin to tube by light tap of hammer.

(d) Start flare with light hammer blows and continue until completed.

NOTE

For stainless steel tubing insert tubing in combination tool. Grip tubing in one



Tube Size Nominal OD	A DIA: AL ALY Tubing		A DIA: Steel Tubing		B ±.010 RAD
1/8	.200	+.000 -.010	.200	+.000 -.010	.032
3/16	.302		.302		
1/4	.359		.359		
5/16	.421		.421		
3/8	.484		.484		.046
1/2	.656		.656		.062
5/8	.781		.781		
3/4	.937		.937		.078
1	1.187	+.000 -.015	1.187	+.000 -.015	A .093
1-1/4	1.500		1.500		
1-1/2	1.721		1.721		.109
1-3/4	2.106		2.106		
2	2.356		2.356		
2-1/2	2.856		2.856		
3	3.356		3.356		

Flare shall be Square with Centerline of Tube within 1/2" Flare shall be Concentric with OD of Tube within .005 TIR. Flare shall be Free of Cracks and Pit Marks. For use with Standard Flared Tube Fittings. Dimensions in Inches.

Figure 11 Single Flare Dimensions

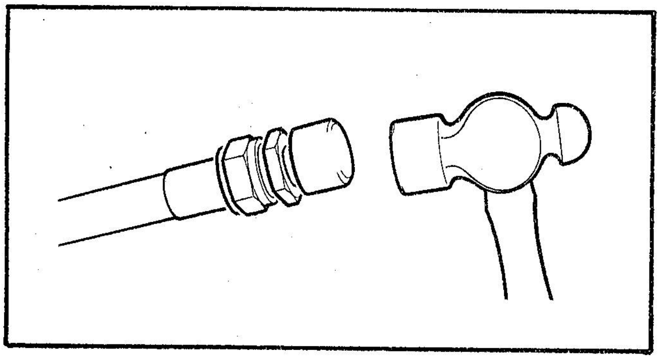


Figure 12 Hammer Flaring Tool

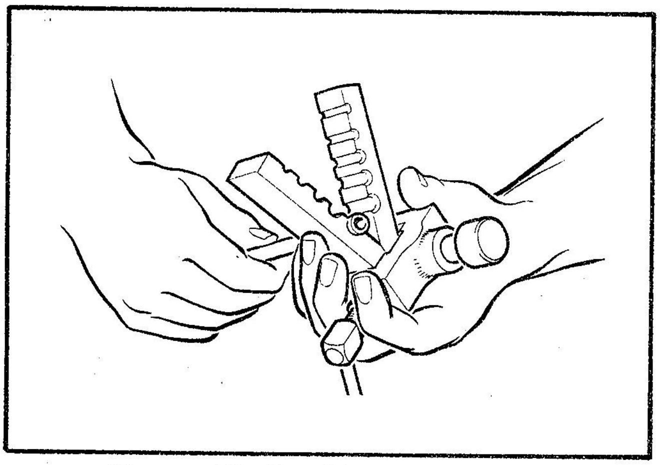


Figure 13 Combination Flaring Tool No. 410

hand and strike the pin sharply so that as few blows as possible will be required to obtain a completed flare.

SCREW PRESSURE FLARING

24 In this method the conical swaging tool, or flaring cone, is screwed down into the mouth of the tube to make the flare. The tube is supported by a flaring die block similar to that used in the hammer combination tool. Various improvements have been made in this tooling. In the tool illustrated, see Figure 14, rollers are set in the flaring cone, the size of the flare is preset, and the finished flare is burnished.

25 The operation is as follows:

(a) The correct spacer leg of the flare control gauge is pivoted into position and the cone feed screw is turned down until a shoulder contacts the gauge.

(b) The yoke is slipped over the flaring die block and tubing is inserted in the proper opening, using the flaring cone as a stop.

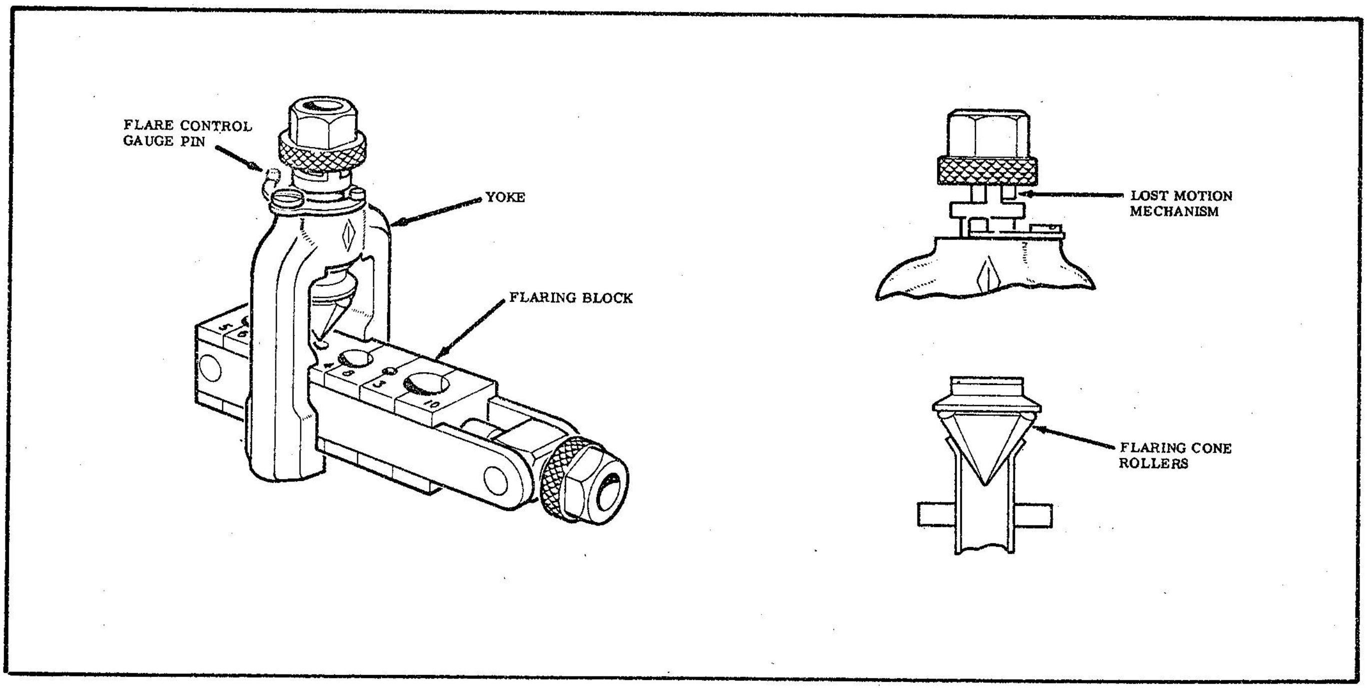


Figure 14 Roller Flaring Tool

(c) The flare control gauge is then pivoted to a neutral position and the compressor screw turned down as far as it will go. The flare is formed above the die block.

(d) When backing off flaring cone after flare is made, a lost-motion mechanism disengages the feed during the first revolution, causing the three rollers in the cone to burnish the flare.

DOUBLE FLARING

26 Double flaring is generally required in aluminum alloy tubing 1/4 to 3/8" outside diameter and is required on all diameters of aluminum alloy tubing used in oxygen systems. A double flaring operation by the screw pressure method as shown in Figure 15 is recommended for the double flaring of aluminum alloy only. To produce a double flare on stainless steel tubing it will require the use of a flaring machine as shown in Figure 16. EO 70-30HB-2 details the use of this flaring machine. To make a double flare on aluminum alloy tubing, proceed as follows.

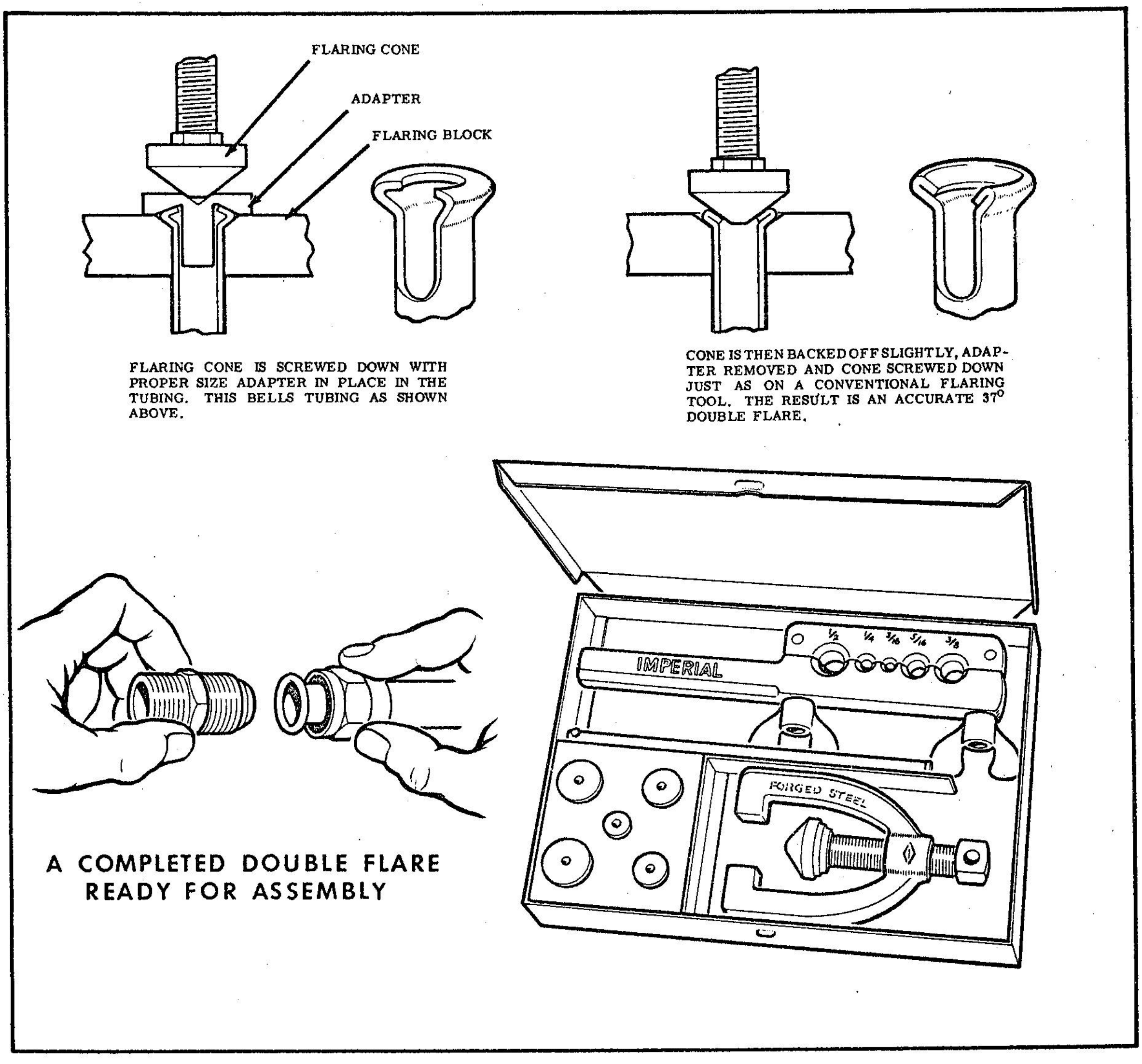


Figure 15 Double Flaring Tool Kit

(a) Prepare the tube as for a single flare.

(b) Make the initial flare. The size of the initial flare and the length that the tube must project from the die block (or flaring bar) is found by trial.

(c) Back off flaring cone, install correct adapter and bellmouth the tube.

(d) Remove adapter and complete flare with flaring cone. Flaring must conform to dimensions shown in Figure 10.

NOTE

Before flaring, make certain that the clamping surfaces are free from oil, grease or aluminum alloy particles. An occasional cleaning with a solvent (Item 1) and a stiff brush is recommended. A wire brush or steel wool should not be used. If the

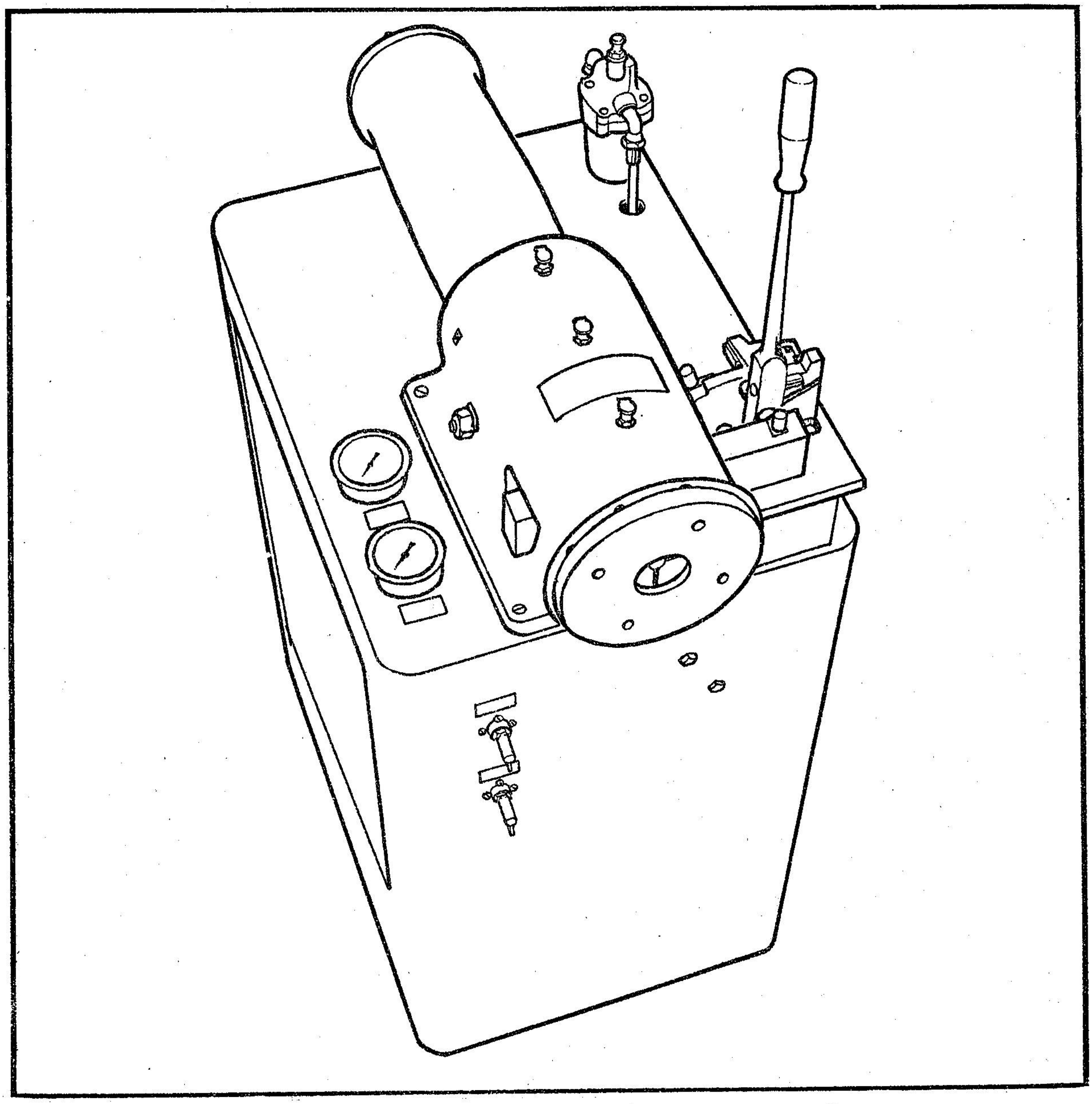


Figure 16 Double Flaring Machine

tubing slips in the tool and the cleaning procedure does not work, dip the clamping blocks in a 20% solution (by weight) of sodium hydroxide, (Item 2) or potassium hydroxide (Item 3) in water. This will remove aluminum alloy particles. Do not sandpaper, grind or refinish the inner surfaces of the tool as this will render the tool unsatisfactory for use.

27 Check the flare by placing a sleeve (Item 4) over the tube. The outside diameter of the flare should extend approximately 1/16 inch beyond the end of the sleeve, but should not be larger than the largest outside diameter of the sleeve.

FLARELESS FITTINGS

28 Description and assembly of flareless fittings are as follows:

(a) The flareless tube fitting (Item 3), like the AN-flared fitting, is designed to provide a tube connection, able to withstand high pressure and severe vibration. Flareless tube fittings provide an economical installation in terms of time and money saved, as no preparation of the tubing nor special tools are required for assembly in the field.

(1) A flareless tube fitting connection comprises a (male) connector, a sleeve, a nut and the tube. As the nut is tightened onto the connector during the first assembly or presetting of the fitting, it forces the sleeve forward into the 24 degree internal taper of the connector. During this operation, the pilot of the sleeve contracts, forcing the cutting edge of the sleeve to embed into the outer surface of the tube, making a tight joint. The sealing points of the

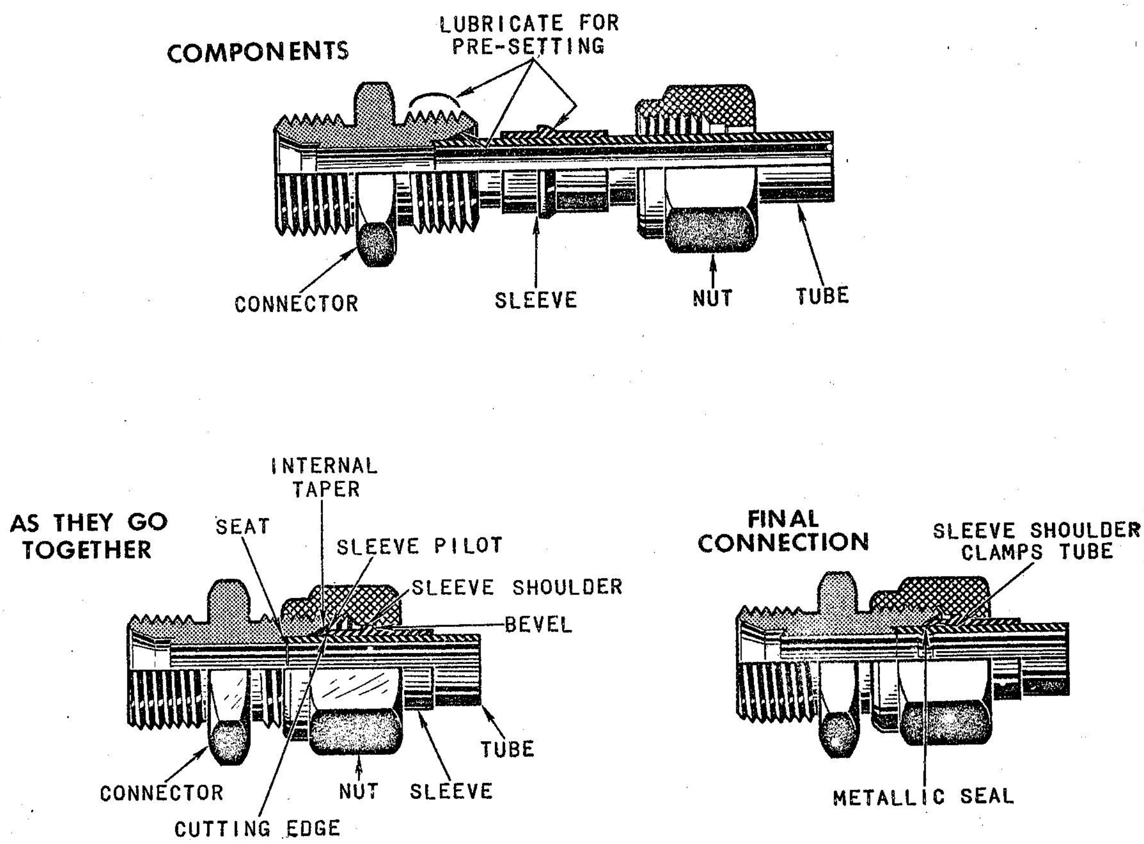


Figure 17 Flareless Tube Fitting Connection

assembled fitting are at the sleeve cut in the tube and at the point where the bowed sleeve barrel contacts the 24 degree tapered seat of the connector.

(2) The sleeve pilot guides the cutting edge and normally limits the depth of the cut in the tube. Bottoming of the end on the 15 degree reverse angle seat in the connector is not intended to provide a sealing surface, but rather is to provide a support for the tube end during the presetting of the fitting. It also aids in keeping the cutting edge of the sleeve firmly pressed into the cut, thus preventing seepage type leaks at low pressure. The nut presses against the bevel on the sleeve shoulder, causing this area of the sleeve to clamp tightly to the tube. Resistance to vibration is concentrated at this point rather than the sleeve cut.

(3) When the nut is fully tightened, the case-hardened sleeve is bowed slightly at the mid-section and acts as a spring. This spring action of the sleeve maintains a constant tension between the connector and the nut and thus prevents the nut from loosening. When the fitting is disconnected, some of the bow in the sleeve will disappear due to the spring-back action of the sleeve, but the bow is restored when the fitting is re-installed and tightened.

(4) After the first assembly, the sleeve is permanently attached (or pre-set) to the tube. Disassembly and re-assembly of the fitting can be carried out repeatedly without loss of strength or sealing qualities.

(b) Pre-Assembly (Pre-Setting) of Rigid Lines

(1) Pre-assembly of rigid lines, consisting of cutting the tubing and pre-setting the sleeves, must be carried out only as a fabrication operation, and must never be performed as part of the final installation on the aircraft. This prevents possible damage to fittings in the aircraft.

(c) Cutting Of Tubes

(1) Cut the tube to the correct length with the ends square.

(2) Deburr the ends of the tube, maintaining a chamfer of .002" to .006" and do not radius the tube ends.

(3) Carefully remove chips resulting from the deburring operation.

(d) Pre-Setting Tools

(1) The following two methods are used for the pre-setting of sleeves:-

a. Pre-setting machines are used, almost exclusively, by the aircraft manufacturers for quantity production purposes.

b. The recommended method of "bench" pre-setting sleeves in the field is accomplished with the aid of simple hand pre-setting tools. These hand tools are made from a high quality tool steel and consist of a block which incorporates the exact replica of a (male) connector. The block can be clamped in a vise where wrench torque can be applied to better advantage. When hand pre-setting tools are not available, any steel fitting can be used, to a maximum of five times, as a pre-setting tool. Aluminum alloy fittings may be used only once as a pre-setting tool.

(e) Pre-Setting

(1) Slide the nut and then the sleeve on the tube. The pilot on the sleeve must point towards the end of the tube.

TUBING		HAND PRE-SET TURNS	PROOF TEST PRESSURE psi
MATERIAL	SIZE INCHES		
AISI 304	1/4 - .020	1.1/6	6000
1/8 Hard	1/4 - .028	1.1/6	6000
Corrosion	1/4 - .035	1.1/6	6000
Resistant	3/8 - .028	1.0	6000
Steel	1/2 - .035	1.1/6	6000
MIL-T-6845	5/8 - .049	1.0	6000
AMS 5566	3/4 - .058	1.0	6000
AISI 321 or 347,			
Annealed			
Corrosion	1/4 - .028	1.1/6	5000
Resistant	1/4 - .035	1.1/6	5000
Steel	5/16 - .028	1.1/6	5000
MIL-T-8606	3/8 - .028	1.0	5000
AN-WW-T-858			
	1/4 - .020	1.0	2000
	1/4 - .028	1.1/6	2000
6061-T6	1/4 - .035	1.1/6	2000
Aluminum	5/16 - .028	1.1/6	2000
Alloy	3/8 - .035	1.1/6	2000
WW-T-789	3/8 - .049	1.0	2000
Temper T6	1/2 - .028	1.1/6	2000
MIL-T-7081	1/2 - .035	1.1/6	2000
Temper T6	1/2 - .049	1.0	2000
	5/8 - .049	1.1/6	2000
	5/8 - .065	1.1/6	2000
	3/4 - .049	1.1/6	2000
	1.0 - .049	1.1/6	2000
	1-1/2 - .058	1.1/6	1500
6061-0			
Aluminum	3/16 - .022	1.1/6	1000
Alloy	1/4 - .035	1.1/6	1000
WW-T-789			
Temper O	1.0 - .049	1.1/6	500
MIL-T-7081	1.0 - .065	1.1/6	500
Temper O	1-1/2 - .058	1.1/6	500

Figure 18 (Sheet 1 of 2) Pre-set and Proof Test Data

TUBING		HAND PRE-SET TURNS	PROOF-TEST PRESSURE psi
MATERIAL	SIZE INCHES		
5052-0 Aluminum Alloy WW-T-787 Temper O	1/4 - .022	1. 1/6	1000
	1/4 - .028	1. 1/6	1000
	1/4 - .035	1. 1/6	1000
	5/16 - .035	1. 1/6	1000
	3/8 - .038	1. 1/6	1000
	3/8 - .035	1. 1/6	1000
	1/2 - .035	1. 1/6	1000
	1/2 - .042	1. 1/6	1000
	5/8 - .042	1. 1/6	1000
	3/4 - .042	1. 1/6	1000
	1.0 - .035	1. 1/6	500
	1.0 - .049	1. 1/6	500
	1-1/4 - .049	1. 1/6	500
	1-1/2 - .035	1. 1/6	500
	1-1/2 - .049	1. 1/6	500

Figure 18 (Sheet 2 of 2) Pre-set and Proof Test Data

(2) Place the tool in a vise.

(3) Apply a thin coat of lubricant to the bevel on the sleeve shoulder, the internal taper of the tool and the external thread of the tool.

(4) Hold the tube bottomed firm and square on the seat of the tool and tighten the nut until the cutting edge of the sleeve just starts to grip the tube. This point is determined by turning the tube back and forth very lightly between the thumb and two fingers while tightening the nut. While rotating the tube, the first point of resistance will indicate that the nut is ready for final pre-setting.

(5) After the sleeve grips the tube, further tighten the nut exactly the number of turns shown in Figure 18. The wrench movement required can be judged by the hexagon of the nut (i.e each flat of the hexagon equals 1/6 of a turn).

CAUTION

Do not use these "bench" pre-setting values for final installation in the aircraft.

(6) The sleeve is now pre-set, and after backing off and removing the tool, the tube and sleeve are ready for inspection.

(f) Inspection

(1) The sleeve should be bowed slightly. This bowed (barrel) portion must be inspected for cracks and crazing. Cracks and/or crazing are causes for rejection of the individual assembly.

(2) The sealing surface of the pre-set sleeve, which contacts the internal taper of the connector must be smooth and free from nicks and scratches.

(3) The sleeve may rotate on the tube after pre-setting.

(4) A slight collapse of the inside wall of the tube opposite the cutting edge as a result of pre-setting is permissible.

(g) Proof Testing

(1) Proof testing should be carried out as a final check to determine that a line assembly has been properly pre-set. All line assemblies must be tested with a hand pump as a source of pressure using hydraulic fluid (MIL-O-5606) with the exception of oxygen lines, where water must be used. Testing should be accomplished as follows:-

a. Connect the assembly to the appropriate test stand in accordance with para. (j) following.

b. Pump fluid through the line assembly at low pressure. When the assembly is thoroughly bled (fluid flow free of air), blank off open end of line assembly, using appropriate blanking plug in accordance with EO 05-1-2AV.

c. Apply the proof pressure, quoted in Figure 18 applicable to the line assembly on test. Carefully check for leaks around the end fittings.

d. With pressure still applied, close the shut-off valve in the supply line to the line assembly on test. Check that there is no drop in pressure over a period of two minutes.

e. If leakage occurs during the test, release pressure and proceed with instructions as laid down in para. (j) following.

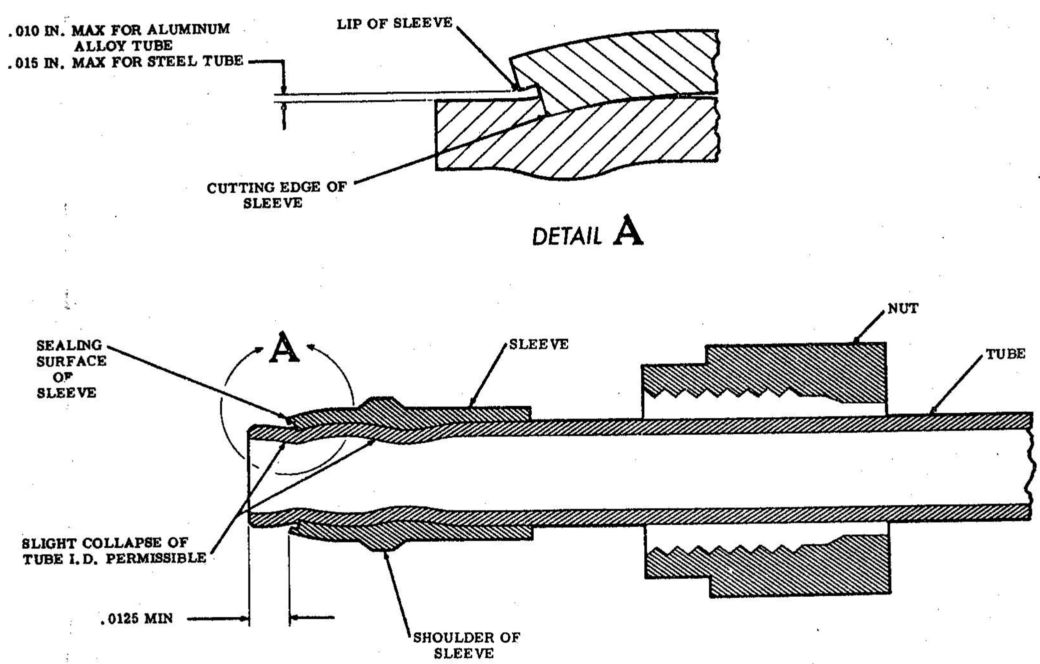


Figure 19 Flareless Fitting Assembly Dimensions

f. On completion of test, release pressure, disconnect line assembly from test stand and remove blanking plug. Check end fittings for signs of distortion, cracks or any other damage.

(h) Cleaning of Line Assemblies

(1) Oxygen lines will be cleaned in accordance with para. 91. All other lines will be cleaned in accordance with para. 90 following.

(j) Final Installation

(1) Apply a thin coat of lubricant, in accordance with Figure 20 following to the level on the sleeve shoulder and all but the first two threads on the male fitting.

(2) Place the line assembly with pre-set sleeve in the installed position, making certain that the sealing surfaces are not scratched during installation and that the sleeve meets the fitting squarely and fully. In order to obtain correct alignment of the line assembly, both tube ends must bottom freely on the reverse angle seats of their fittings, before either of the nuts is engaged. The line assembly should be supported while connecting as well as during subsequent tightening of the nuts. Clips, clamp block and adjacent structure must not restrict free movement of the line assembly, during these operations.

CAUTION

Never use the nut to draw the sleeve and tube into the fitting.

(3) Turn the nut onto the male fitting, using a wrench under very light pressure, until a sudden rise in resistance tends to bring the wrench to a stop, indicating that the nut has contacted the bevel on the sleeve shoulder. A second wrench should be used on the hexagon or flats on the male fitting to prevent the fitting from turning.

NOTE

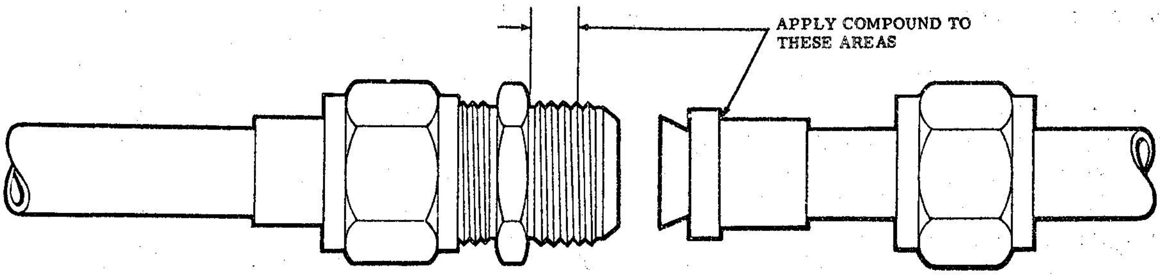
The nut must turn freely during the initial tightening. It is obvious that a nut, not contacting the bevel on the sleeve shoulder after initial tightening, will fail to properly bow the sleeve upon application of the recommended final tightening force. A false rise of resistance of the wrench during initial tightening of the nut, can occur from a nut jamming because of a nicked or dirty fitting, dirty nut threads or a cocked tube.

(4) From the point of sudden rise in resistance, turn the nut exactly 1/6 of a turn, using a wrench as before on both the nut and the male fitting. The wrench movement required can be judged by the hexagon of the nut.

CAUTION

Do not use these final installation values for the presetting of sleeves.

(5) If the connection leaks during pressure check, do not attempt to eliminate the leak by further tightening, but back-off the nut completely and inspect the components of the fittings as well as its matching connector for scores, cracks, presence of foreign material or damage from previous over-tightening. Then place the line assembly in the installed position, check for correct tube alignment and repeat the procedure of foregoing paragraphs (j) (3) and (4). If the connection still leaks, back off the nut completely, repeat the procedure of foregoing paragraph (j) (3), then from the point of sudden rise in resistance, tighten the nut exactly 1/3 of a turn.



Type of Installation		Thread Compound Specification	
		Straight Threads	Tapered Threads
Engine Fuel and Oil Pressure Instruments (Transmitter Type)	A-1 Type Transmitter	Gasoila Varnish	Gasoila Varnish
	Autosyn Type Transmitter	JAN-A-669	JAN-A-669
Fuel		JAN-A-669	Gasoila Varnish and JAN-A-669. Refer to Paragraph 36.
Hot Air		Wingo RBI	Wingo RB1
Hydraulic		AN-P-51 or MIL-O-5606	JAN-A-669
Pneumatic		MIL-L-4343	MIL-L-4343
Oxygen		MIL-T-5542 B	MIL-T-5542 B
All Other Systems Not Covered Above		JAN-A-669	JAN-A-669

NOTE

On threads in oxygen systems, the compounds specified are used only to prevent seizure and not for sealing.

Figure 20 Thread Compound Application

CAUTION

Do not over-tighten. In direct contrast to tightening a leaking AN-flared connection, over-tightening of a leaking flareless connection only aggravates the leak and can permanently damage the sleeve and tube. Never tighten the nut more than a total of 1/3 of a turn. If the connection still leaks at 1/3 of a turn, replace the complete line assembly. If the connection has been tightened more than a total of 1/3 of a turn, replace the complete line assembly whether leaking or not, and check the adjacent fittings for damage and distortion.

(6) The origin of a leak can be traced in the following manner:-

a. Leakage from under the skirt of the sleeve indicates a leakage path at the sleeve cut.

b. Leakage from the threads of the nut and the fitting indicates a leakage path at the 24 degree internal taper of the fitting.

ASSEMBLY OF FLARED FITTINGS

29 Rigid tubing assemblies having an fittings are to be assembled as follows:

(a) Immediately prior to installation, lubricate the male threads of fittings in accordance with paragraph 38, following:

(b) Place the assembly in the installed position, making certain that the tubing is not scratched during installation.

(c) Align the tubing, flares and fittings accurately, then press the flares and cones tightly together to make full contact.

(d) Using fingers only, start the nuts on the fittings and turn until the flares and sleeves are firmly seated. Ensure that the flares are snugly pressed against the cones by attempting to shake the tube. Do not use the nut to draw the flare onto the cone. Do not use a wrench until the nut is finger tight.

(e) When the nuts are finger tight (hand tight on oxygen lines), place a wrench on the hexagon or flat of the body of the fittings to prevent turning and use a torque wrench on the nuts to tighten the nuts to the torque values specified in EO 05-1-3/25.

30 When a straight threaded fitting is screwed into a component, such as a pump or filter, an O-ring or similar gasket is required. Frequently no recess is provided in the component and the O-ring is compressed between the component boss and the fitting hexagonal face.

31 With taper threads, no gasket is used. Thread compounds for both straight and taper threads are listed in Figure 20.

~~BULKHEAD FITTINGS USING O-RINGS~~

32 Install as follows:-

(a) Spin nut (Item 6), on fitting (Item 7) the waisted portion and on to second threads.

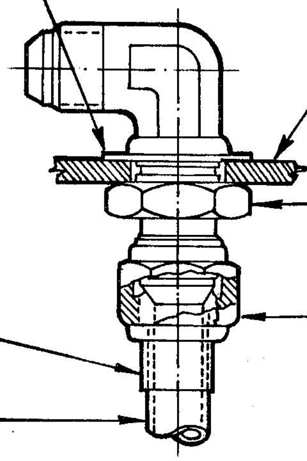
DELETED

(b) Lubricate threads with hydraulic fluid and work on ring (Item 8), until it touches the nut.

~~(c) Work on gasket until it is against the ring (Item 8).~~

USE WASHER AN960, 1/16 THICK FOR FITTINGS SIZE -6 OR SMALLER, AND 3/32 THICK FOR FITTINGS SIZE -8 OR LARGER WHEN BULKHEAD IS 3/16 THICK OR LESS. WHEN BULKHEAD IS THICKER THAN 3/16, WASHER IS NOT REQUIRED PROVIDED HOLE IN BULKHEAD IS EQUAL TO THE HOLE IN APPLICABLE AN960 WASHER. WASHER IS NOT REQUIRED WHERE FITTING END HAS HEX INSTEAD OF FLANGE SHOWN, PROVIDED HOLE IN BULKHEAD IS EQUAL TO HOLE SIZE IN APPLICABLE AN960 WASHER.

FITTING WITH BULKHEAD END IN SIZES -6 AND SMALLER, MAY BE USED THROUGH BULKHEADS UP TO 1/4 MAXIMUM THICKNESS. SIZES -8 AND LARGER AND ALL SIZES OF AN832 MAY BE USED THROUGH BULKHEADS UP TO 3/8 MAXIMUM THICKNESS.



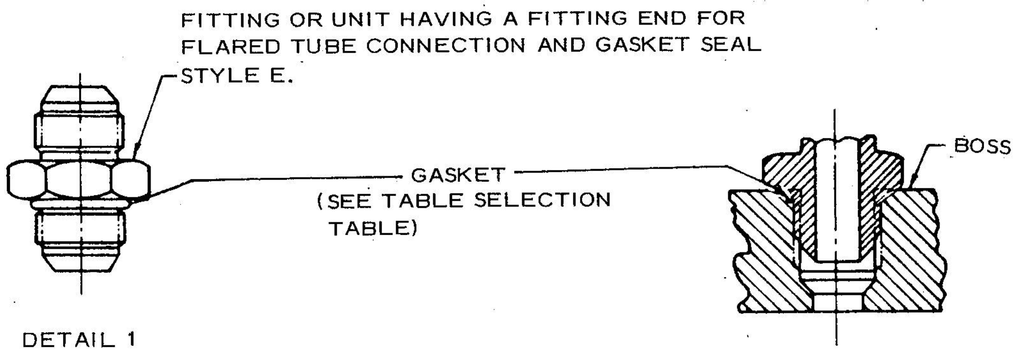
BULKHEAD AND FLARED TUBE INSTALLATION

DASH NOS. REF.	TUBING OD INCHES	WRENCH TORQUE FOR TIGHTENING AN818 NUT (POUND INCH)						HOSE END FITTINGS AND HOSE ASSEMBLIES (POUND INCH)	
		ALUMINUM-ALLOY TUBING FLARE		STEEL TUBING FLARE		ALUMINUM-ALLOY TUBING FLARE FOR USE ON OXYGEN LINES ONLY		MEDIUM & HIGH PRESSURE	
		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
	1/8	—	—	—	—	—	—	—	—
-3	3/16	—	—	90	100	—	—	70	100
-4	1/4	40	65	135	150	—	—	70	120
-5	5/16	60	80	180	200	100	125	85	180
-6	3/8	75	125	270	300	—	—	100	250
-8	1/2	150	250	450	500	—	—	210	420
-10	5/8	200	350	650	700	—	—	300	480
-12	3/4	300	500	900	1000	—	—	500	850
-16	1	500	700	1200	1400	—	—	700	1150
-20	1-1/4	600	900	—	—	—	—	—	—
-24	1-1/2	600	900	—	—	—	—	—	—
-28	1-3/4	—	—	—	—	—	—	—	—
-32	2	—	—	—	—	—	—	—	—

INSTALLATION OF FITTINGS HAVING THE CONNECTION END THROUGH BULKHEADS. WRENCH TORQUES FOR ASSEMBLING THE TUBING ARE THE SAME.

NOMINAL USE: AIRFRAME FLUID CONNECTIONS.

Figure 21(Sheet 1 of 4) Fittings - Installation of Flared Tube, Straight Threaded Connectors



DETAIL 1

DETAIL 2 TIGHTENED POSITION

NON-POSITIONING TYPE FITTING INSTALLATION SUITABLE FOR NOMINAL OPERATING PRESSURES UP TO AND INCLUDING 3000 PSI.

PROCEDURE FOR INSTALLATION OF FITTING END, STYLE E.

1. LUBRICATE THE GASKET IN APPROPRIATE LIQUID (SEE TABLE).
2. INSTALL GASKET ON THE FITTING AS SHOWN IN DETAIL 1.
3. SCREW THE FITTING ASSEMBLY INTO THE BOSS UNTIL IT BOTTOMS TIGHTLY ON THE BOSS AS SHOWN IN DETAIL 2.

GASKET SELECTION TABLE		
APPLICATION	MS NO.	APPROPRIATE LUBRICATING LIQUID
HYDRAULIC	MS28778	MIL-0-5606 OR PETROLATUM
ENGINE OIL	MS28778	ENGINE OIL
FUEL	MS29512	APPLICABLE FUEL
PNEUMATIC	MS28778	MIL-G-4343

Figure 21(Sheet 2 of 4) Fittings - Installation of Flared Tube, Straight Threaded Connectors

~~(d) Turn nut down against the back-up~~ ring (Item 8) until the back-up ring forces the gasket (Item 9) firmly against the threads.

(e) Install fitting (Item 7) in boss, letting the nut turn with fitting until the gasket contacts the face of the boss. This can be determined by a sudden increase in torque. With the fitting in this position, place a wrench on the nut to prevent it from turning and at the same time turn the fitting 1-1/2 turns.

(f) Position fitting by turning it not more than one additional turn.

BULKHEAD ASSEMBLY USING WASHER.

33 At least one washer is required between the web of the bulkhead and the bulkhead fitting nut. See Figure 21 for proper installation of AN elbows, tee fittings and adapters.

SEALING OF GASKETS

34 Gaskets (Item 11) used in fuel lines are ~~sealed on assembly with grease, (Item 10).~~

~~35 Install O-rings in fuel cell intercon-~~ nectors as follows:

(a) Prior to installations, examine the O-rings for imperfections such as tears, cracks and incomplete sections.

(b) Lubricate each O-ring with petrolatum (Item 12) and carefully slide into the groove.

(c) Apply petrolatum to the surface of the fuel line tube which contacts the O-ring and complete the installation.

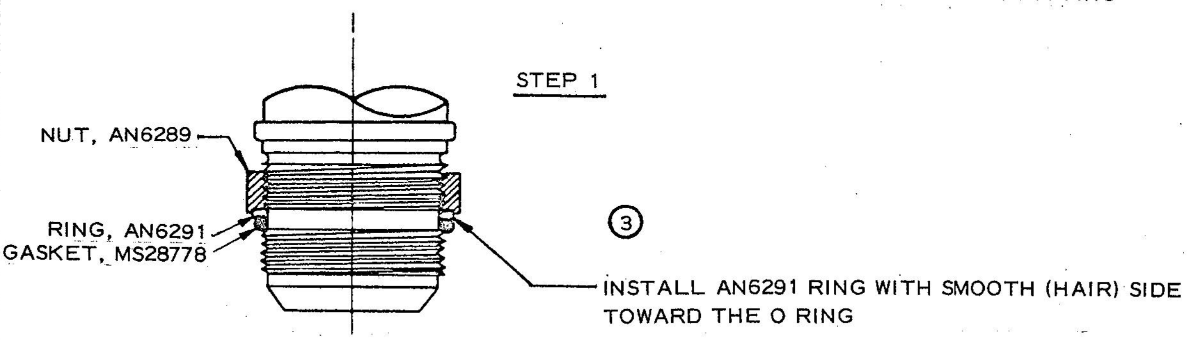
(d) Before using Lock-O-Seal washers in fuel cell installations, remove the O-ring portion of the washer, examine for imperfections and lubricate with petrolatum. Slide the O-ring onto the bolt and add the metal retaining washer, making sure the ring is well nested in the washer.

NOTE

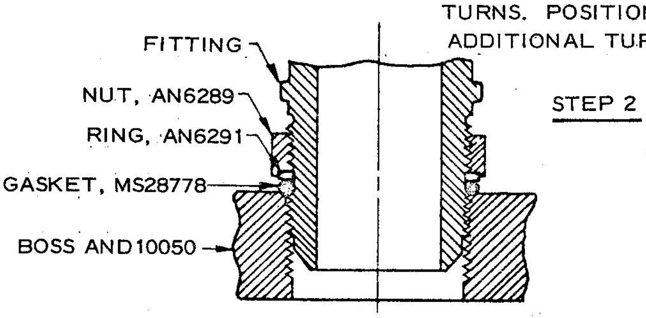
Lock-O-Seal washers must not be used in fuel systems, fuel cells or tanks, ~~unless used in original installation.~~

DELETED

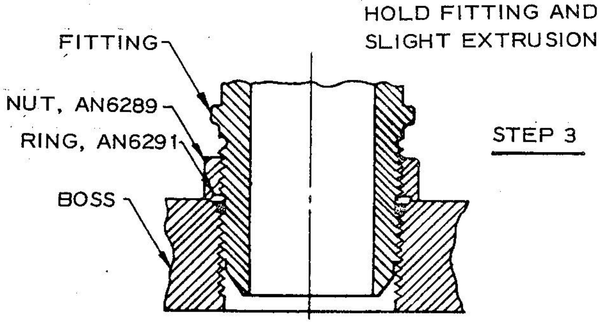
COAT MALE THREADS OF FITTING, RING, AN6291, AND GASKET, MS28778, SPARINGLY WITH PETROLATUM, SPECIFICATION AN-P-51 (VASELINE), OR HYDRAULIC FLUID AND ASSEMBLE AS SHOWN. WORK THE RING, AN6291, INTO THE COUNTERBORE OF THE NUT, AN6289; THEN TURN THE NUT, AN6289, DOWN UNTIL THE GASKET, MS28778 IS PUSHED FIRMLY AGAINST THE LOWER THREADED SECTION OF THE FITTING



INSTALL THE FITTING INTO THE BOSS, AND, AT THE SAME TIME, KEEP THE NUT, AN6289, TURNING WITH THE FITTING UNTIL THE GASKET, MS28778 CONTACTS THE BOSS. THIS POINT CAN BE DETERMINED BY A SUDDEN INCREASE IN TORQUE. WITH THE FITTING IN THIS POSITION, PUT A WRENCH ON THE NUT, AN6289, TO PREVENT ITS TURNING AND, AT THE SAME TIME, TURN THE FITTING IN 1-1/2 TURNS. POSITION FITTING BY TURNING IN NOT MORE THAN ONE ADDITIONAL TURN



HOLD FITTING AND TURN NUT, AN6289, DOWN TIGHTLY AGAINST BOSS, SLIGHT EXTRUSION OF THE RING, AN6291 IS NOT DETRIMENTAL.



POSITIONING TYPE UNIVERSAL FITTING INSTALLATION SUITABLE FOR NOMINAL OPERATING PRESSURES UP TO AND INCLUDING 3000 PSI IN HYDRAULIC AND PNEUMATIC SYSTEMS

Figure 21(Sheet 3 of 4) Fittings - Installation of Flared Tube, Straight Threaded Connectors

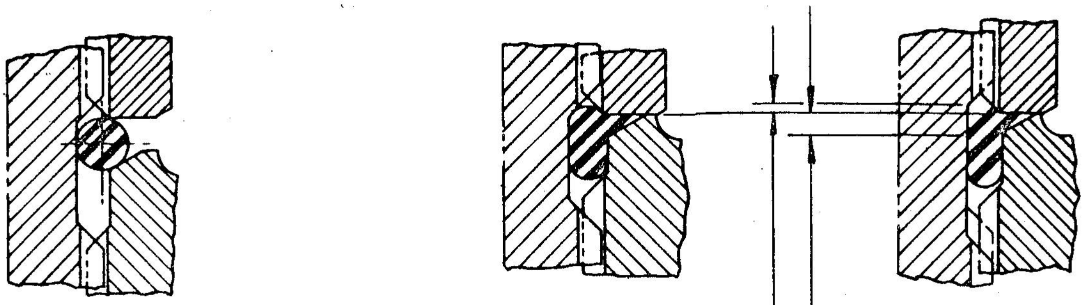
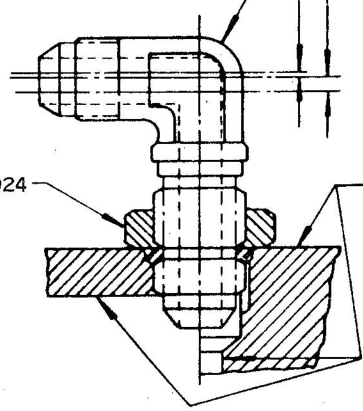
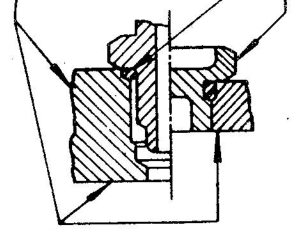


FIGURE I
DETAIL OF POSITIONING TYPE
NOMINAL CONTACT POSITION OF SEAL

FIGURE II
NUT CONTACTS BOSS

FIGURE III
POSITIONING OF FITTING





POSITIONING TYPE UNIVERSAL FITTING INSTALLATION

PROCEDURE FOR INSTALLATION

ASSEMBLE NUT AN924 ON FITTING END UNTIL WASHER FACE OF NUT LINES UP WITH UPPER CORNER OF SEAL GROOVE (FIG. 1). LUBRICATE SEAL SPARINGLY WITH WHITE PETROLATUM AND PLACE SEAL ON FITTING GROOVE SO IT CONTACTS NUT (FIG. 1). SCREW FITTING (AND NUT SIMULTANEOUSLY) INTO BOSS UNTIL SEAL CONTACTS BOSS CHAMFER (FIG. 1) AND UNTIL NUT CONTACTS BOSS (FIG. II). BEFORE TIGHTENING LOCKNUT AN924, POSITION FITTING DIRECTION BY EITHER TURNING IN AS MUCH AS 3/4 TURN (+270°) OR TURNING OUT AS MUCH AS 1/4 TURN (-90°) (FIG. III). ASSEMBLE FLUID LINE TO FITTING END. HOLDING THE FITTING STATIONARY IN SELECTED POSITION, TIGHTEN LOCKNUT.

NON-POSITIONING TYPE FITTING OR PLUG INSTALLATION

PROCEDURE FOR INSTALLATION

1. LUBRICATE SEAL SPARINGLY WITH WHITE PETROLATUM AND PLACE SEAL IN GROOVE.
2. SCREW FITTING OR PLUG INTO BOSS UNTIL CONTACT IS MADE WITH BOSS SURFACE.

NOMINAL USE: AIRCRAFT ENGINE FLUID CONNECTION.

Figure 21(Sheet 4 of 4) Fittings - Installation of Flared Tube, Straight Threaded Connectors

LUBRICATION OF TAPERED THREAD IN FUEL SYSTEM

36 To lubricate tapered threads in fuel systems, proceed as follows:

(a) Apply varnish (Item 14) sparingly and carefully to the male threads only, but not to the first two male threads to engage the female threads.

(b) Allow the sealing compound to dry,

(c) Apply a thin coat of anti-seize compound (Item 15) to all male threads including those threads already coated with sealing compound and the first two bare threads.

(d) Assemble the threaded fittings and torque. For torque tables, refer to EO 05-1-3/25.

(e) Pressure test all assemblies with aircraft fuel.

GALLING IN TAPERED THREADS OF SOFT ALUMINUM BOSSES.

37 Where galling is encountered on screwing fittings with tapered (pipe) threads into soft aluminum bosses, proceed as follows:-

(a) Apply petrolatum (Item 12), to the male threads in accordance with paragraph 36, preceding and secure the male fitting into the boss by hand.

(b) Back out the fitting and apply compound (Item 15), to the male threads in accordance with paragraph 36, preceding.

(c) Screw the fitting into the boss and tighten.

WARNING

This procedure must not be used in oxygen systems.

LUBRICATION OF THREADED TUBE CONNECTIONS

38 To lubricate threaded tube connections, proceed as follows:-

(a) Apply the selected compound sparingly and carefully to the male threads only, but not to the first two male threads to engage the female threads, see Figure 20.

(b) Where connections are of the type using a coupling sleeve (Item 17), or similar, apply a thin coat of the selected compound to the back of the shoulder of the sleeve, see Figure 20. Use a small stiff brush for this purpose.

NOTE

Do not apply or allow compound to remain on the end of a fitting where it may enter the system and cause contamination or malfunction. Do not apply compound to female threads.

SOLDERING PROCEDURE - HIGH P EN TUBING

GENE

DELETED

39 Soft solder (item 1 ...ng soldered joints on high pressure oxygen copper tubing for rep ... The solder is to be melted in a container sufficiently

HIGH PRESSURE OXYGEN COPPER LINE

WARNING

Copper tubing for high pressure Oxygen lines must not be flared. Solder type fittings only are to be used; for soldering procedure Refer to EO 55-65-2B.

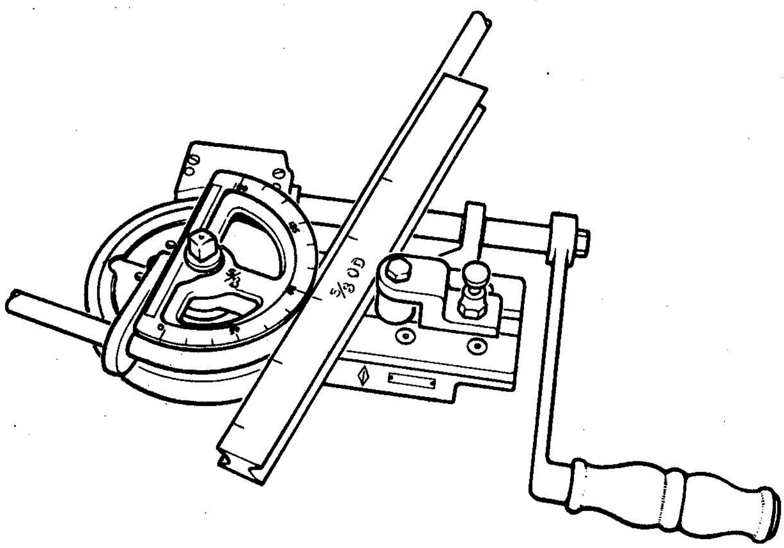


Figure 22 Hand Tube Bender

(Paragraphs 39 to 50 inclusive have been deleted by this Revision)

(c) Repeat the process outlined in Sub-paragraph

(d) Rinse the tubing and nipple with hot

(e) Dry the tubing thoroughly

(f) If pipes are not ... g, protect th
caps or bind up to ...

DELETED

DRYING

...rying and t... ...t must be
...apour, grea... ...y as possible.

DELETED

...pper tubing ... must not be flared. Solder type fittings
...to be used ...

49 ...g, refer to EO 05-1-3/20.

...ldered parts in a 10% sulphuric acid (Item 24) solution for 20
...ure. Rinse in hot water and dry with compressed air, or by placing
... than 250°F.

SOFT SOLDERING

51 Where requirements call for hydraulic parts to be joined and sealed by sweat soldering observe the following:

(a) Perform operations quickly to prevent corrosion on all unplated parts.

(b) Tin all surfaces to be joined prior to assembly.

(c) Where threaded areas or press fits are joined, preheat the parts to melt the solder on the tinned surfaces. Assemble the parts, tighten fully (threaded joints) and seal by the addition of sufficient solder to fill the joints. Do not add an excess. Apply torch heat during the above operations to keep the solder molten, but do not overheat.

(d) Flux the joint edge using paste flux to ensure perfect sealing.

(e) Allow the parts to cool and clean thoroughly.

52 For methods of cleaning, soft soldering and flux removal, refer to EO 05-1-3/20.

TUBE BENDING

GENERAL

53 Tube bending can be done with any one of a variety of hand bending tools, see Figure 22 or power bending tools. Avoid bending to smaller radii than the limits shown in EO 05-1-3/25, or forming flattened, kinked or wrinkled bends. Bending tube without the aid of tools can be accomplished by carefully forming the desired radius by hand, but this method should be used only in the absence of the proper tools. Flattened, wrinkled or irregular bends should not be installed. Wrinkled bends usually result from trying to bend thin-walled tubing without using a tube bender. Aluminum alloy tubing for oxygen systems should never be hand bent. To make

acceptable bends use the hand tube bender.

NOTE

Make certain that forming wheel and follow bar are of correct size.

PLASTIC TUBING

54 For bending of plastic tubing, refer to EO 05-1-3/13.

BEND LIMITATIONS

55 When bending tube, observe the following limitations:

(a) Minimum bend radii must conform to dimensions shown in EO 05-1-3/25.

(b) Bends must be uniform without kinks and the outside diameter of the tubing at the bend must not vary more than 5% from the outside diameter of the adjacent straight section.

(c) Embossed marks caused by pits and other minor imperfections in bend blocks are permissible in tubing used for conduit or air ducting, provided that the height of such defects does not exceed approximately 10% of the tubing wall thickness.

(d) Mandrel bumps, flat spots and dents without abrupt change in section are not cause for rejection provided that such defects do not increase nor decrease the nominal tube diameter by more than 5% or .030 inch, whichever is greater.

(e) Wrinkles are acceptable on the inside radius of a bent tube provided that the depths shown in EO 05-1-3/25, are not exceeded.

(f) On assemblies using sleeves, the minimum distance between the tube bend at the point of tangency and the sleeve end must not be less than that specified in EO 05-1-3/25, except where specifically approved by engineering authority.

(g) DELETED

USE OF FUSIBLE ALLOYS FOR BENDING TUBES

GENERAL

56 The use of fusible alloys (Item 25 and 26) is permitted as fillers to assist in the bending of tubes, with the exception of tubes to B.S.I. Specification T.2 (85-ton Nickel Chromium Steel Tubes), DTD.254 (75-ton Nickel Chromium Steel Tubes) and DTD.199 (50-ton High Chromium Non-corrodible Steel Tubes) and DTD.211 (50-ton Chromium Nickel Non-corrodible Steel Tubes)

PROCEDURE

57 Before using one of these alloys as a filler, the inside of the tube should be lightly oiled to minimize the risk of the alloy sticking to the walls of the tube and thus rendering complete removal doubtful.

58 Suitable alloys are those which melt at a temperature below 100 C (212°F). Loading and unloading can then be carried out by aid of boiling water. After the tube is oiled, plug one end and preheat the tube in boiling water. Tun in molten alloy and quench the filled tube in cold water, quickly but progressively, from the plugged end.

59 After bending, unload the tube by removing the plug and immersing tube in boiling water, thus allowing the molten alloy to run out.

CLEANING

60 Clean the tube internally to ensure the complete removal of any adherent alloy. Use a suitable brush of the pull-through or rotary type or blow through with wet steam.

61 Do not omit this cleaning process. Residual alloy in aluminum alloy tubes will cause early corrosion. In steel tubes which are subsequently heat treated, residual alloy would attack the steel and cause intergranular cracking.

ALUMINUM ALLOY TUBES

62 In the case of aluminum alloy tubes, the material of which may be susceptible to accelerated age-hardening, take the following precautions:

(a) Perform the filling and bending operations as soon as possible after normalizing.

(b) Immerse the tubes in boiling water for preheating before filling, only for such time as is necessary for the tubes to attain the temperature of the water. The bending operation should take place immediately after cooling the filled tube.

(c) During preheating or unloading the aluminum alloy tubes do not allow the temperature to exceed 100°C.

SPECIAL MANDRELS

63 Special mandrels to fit the inside or outside diameter of tubing have been produced and are available for use when bending pipes, The use of the inside mandrel is not recommended as this may mar the wall of soft tubing. The mandrel must be of the proper size to fit the tubing and tooling used.

TUBING REPAIR

GENERAL

64 With ordinary care, accidents such as nicking and scratching can be avoided, as a large part of such damage occurs from careless handling of tools.

MINOR REPAIRS

65 Any dent less than 20% of the tube diameter, by visual inspection, is not objectionable unless it is on the heel of a sharp bend radius. A nick no deeper than 10% of the wall thickness may be reworked by burnishing with hand tools. Since aluminum and its alloys or copper are the only materials easily worked, these alone are burnished. Severe die marks, seams or splits in the tube are cause for immediate rejection, as they cannot be repaired.

66 In the heel of bends, when the material has already been stretched thin in forming, burnishing is not allowed. Such a tube should be rejected if it is a medium or high pressure line. Where the tube is used for fluids at atmospheric pressure or less, the bursting strength of the tube is unimportant, but it must be leak-tight at all times.

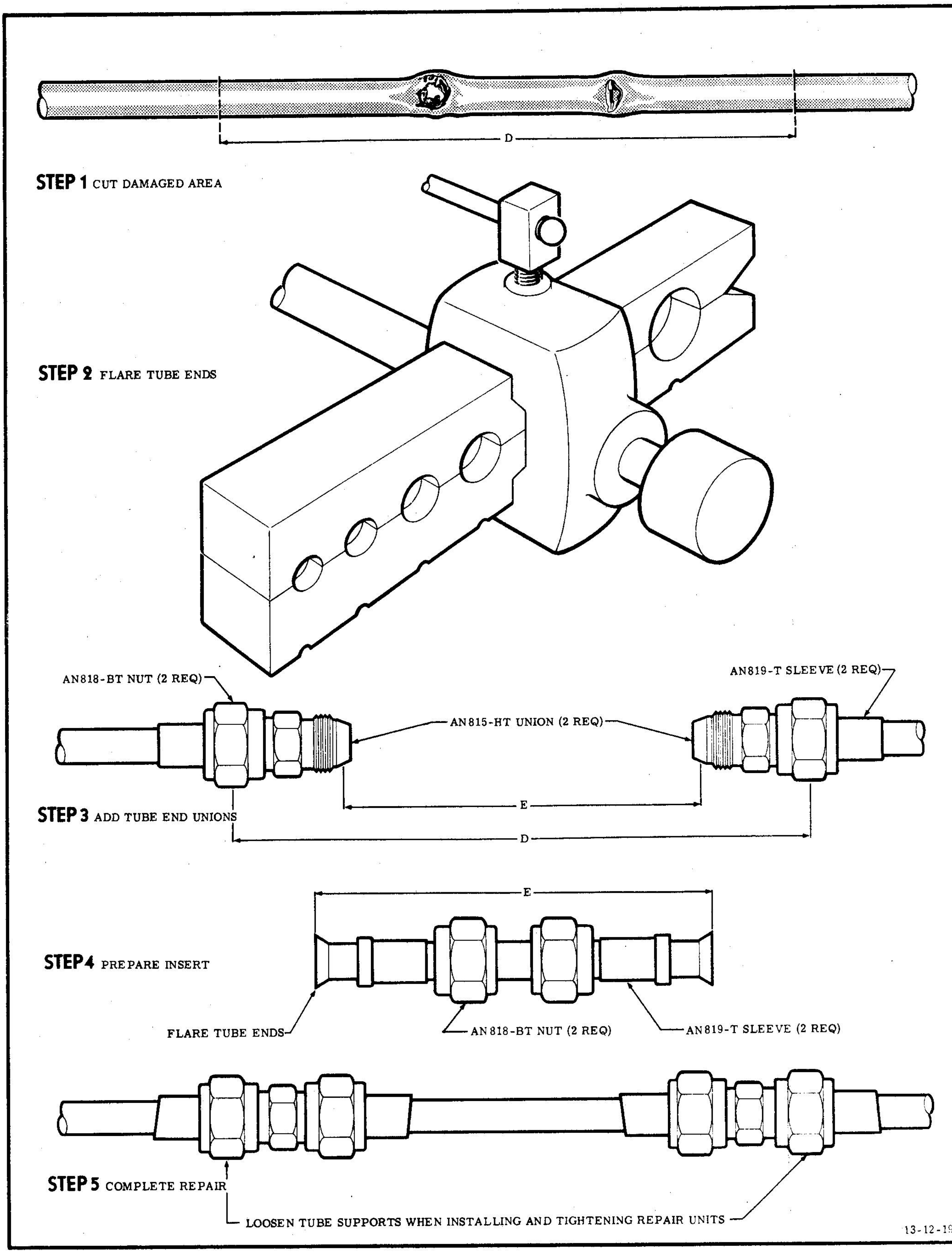


Figure 23 High-pressure Line Repairs

67 Dents can be removed from tubing by drawing a bullet, attached to a flexible cable, through the the tube. The diameter of the bullet must be equal to or slightly less than the internal diameter of the tube.

REPAIR OF LOW-PRESSURE LINES

68 To repair low-pressure lines, carry out the following procedure.

(a) Remove the damaged portion of the tube, deburr the remaining tube ends and remove cuttings from the tube interior.

(b) Bead the remaining tube ends.

(c) Cut a repair section 1/2 inch shorter than the length of the removed damaged portion. Burr the section, bead and clean the tube.

(d) Cut hose connections of proper length and diameter from synthetic rubber hose (item 27) and slip two hose clamps (Item 28) over the ends of each. Slip one hose connection well back over original tube before positioning repair insert.

NOTE

Exercise care in positioning of hose clamps in order to prevent band overhang or tightening screws from chafing or damaging neighbouring parts. Where the possibility exists, reposition the clamp.

(e) Slip hose connections midway over the junction formed by the original tube and the repair section. Glycerine (Item 29), applied to a metal pipe aids the sliding of the rubber hose.

(f) Tighten hose clamps, refer to EO 05-1-3/11.

NOTE

Two hose clamps on each end of a connection are normal on some beaded oil lines, as these lines maintain a relatively high pressure.

REPAIR OF HIGH-PRESSURE LINES

69 To repair high-pressure lines, carry out the following procedure, see Figure 23.

(a) Cut out and remove damaged portion of the tube. Remove the burr from the ends of undamaged tube portions and clean. Slip nut (Item 30) and sleeve (Item 4) of proper size and material onto the remaining tube ends. Flare the tube ends.

(b) Insert union coupling (Item 31) of proper diameter and material into the flared tube ends. Apply hydraulic oil (Item 32), to threads except when working with oxygen systems and slip sleeve down against flared tube end. Oxygen system tube assemblies must not be lubricated. Measure accurately the distance between the union faces. If the length of the damage is several inches or the damaged tubing is to be removed to the nearest fitting, a repair insert must be used. Cut a repair length of similar tubing, clean and remove the burr. Flare the tube ends as indicated in paragraph 21, preceding. The section of tubing into which the repair section is to be installed should be loosened in order to permit ease of alignment upon re-installation.

(c) Carry out a pressure test on all newly fabricated pressure lines used for replacement prior to assembly. Test the line in accordance with pressure shown in Figure 18 or three times the maximum operating pressure applicable to the particular installation, whichever is the higher.

(d) Place the repair section between the unions, thread on the two nuts and tighten. Use torque wrench so that no damage will result from tightening the nut. Refer to EO 05-1-3/25, for torque values.

(e) If the damaged portion of the line does not exceed the length of the union, a repair section is not needed. Cut out the damage so that after the tube ends are flared and a union is inserted, a leak-tight joint will result, see Figure 23.

ROUTING AND CLEARANCE OF LINES

70 Liquid and gas lines must be routed at least six inches away from electrical cable.

71 A minimum of 1/8 inch clearance is to be maintained between tubing or hose and the structure adjoining a supporting clamp, as shown in Figure 24.

72 Sufficient clearance must be provided between a tube or hose and a projection, such as a bolt or nut, to prevent contact in service. Where a tube or hose is supported close enough to such a projection that no relative motion will exist, a minimum clearance of 1/8 inch must be maintained. Where relative motion will exist, an initial clearance is to be allowed which will provide a minimum clearance of 1/8 inch under the relative motion, see Figure 25.

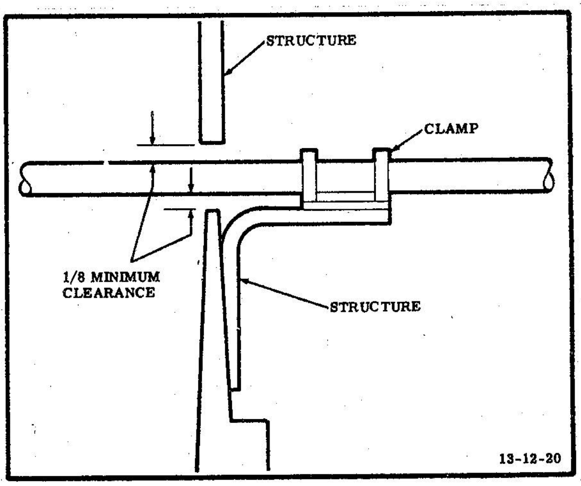


Figure 24 Tube or Hose Installation

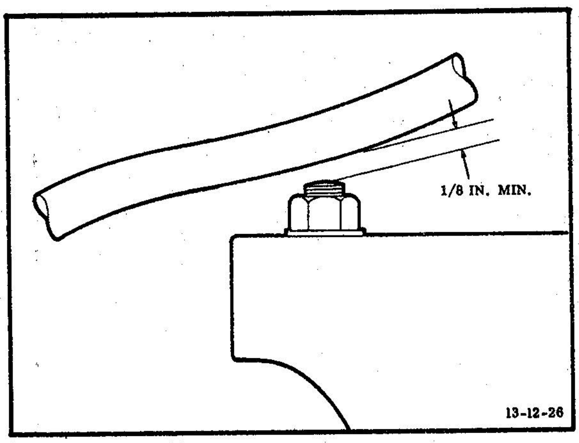


Figure 25 Tube or Hose Clearance

73 The clearance of 1/8 minimum specified in Figure 24 and in paragraphs 71 and 72, preceding, may be reduced as follows for rigid lines only.

Outer Diameter of Tubing	Recommended Maximum Support Spacing	
	For Aluminum Tubing	For Steel Tubing
1/4	15	18
5/16	15	18
3/8	15	18
1/2	22	25-1/2
5/8	22	25-1/2
3/4	22	25-1/2
1 and over	26-1/2	30

Figure 26 Table of Recommended Maximum Support Spacing

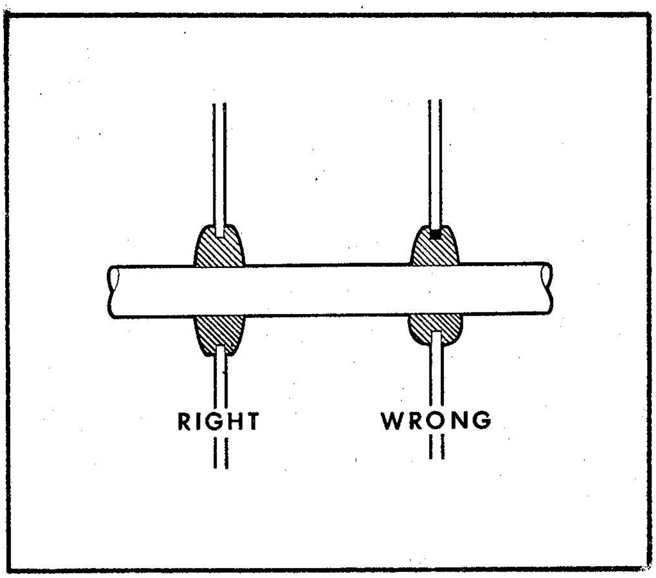


Figure 27 Tube and Grommet Installation

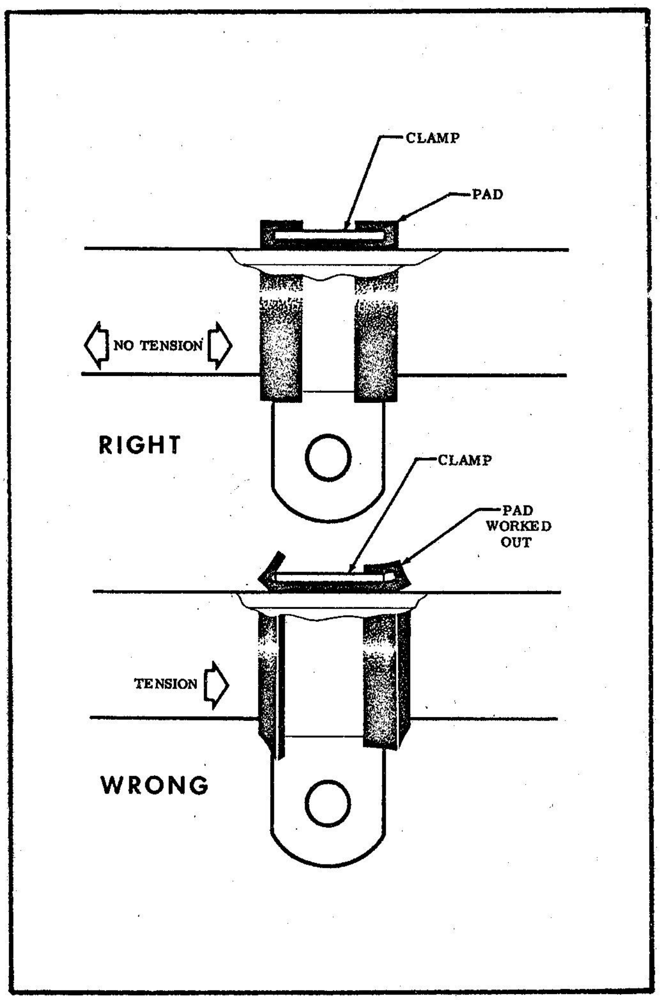


Figure 28 Tube or Hose Installation between Supports

(a) The clearance on short line assemblies may be cut down to 1/16 inch where space is not available to make 1/8 inch clearance practical. This applies mainly to closely spaced line groups and to bends close to end flares.

(b) Parallel runs of lines become more rigid when clipped together. In these cases the space, available, and more often the design of the clips, does not permit more than 1/16 inch spacing. This is acceptable.

(c) Lines clipped to flat panels free from adjacent rivet heads or stiffening angles are acceptable at 1/16 inch clearance, provided that the installation is rigidly clipped to prevent any possible line movement due to vibration and hydraulic loads.

74 Recommended maximum spacing between supports for rigid line assemblies is shown in Figure 26.

75 Where a tube passes through a grommet, the tube must not bear on the grommet in such a way as to cause cutting of the grommet in service, see Figure 27.

76 Tubing or flexible hose must be installed without tension between supports which might cause the pad of a clamp to work out as shown in Figure 28. On hose installations, clamps and supports must be so located that the hose will not be pulled or twisted in service, nor forced to bend sharper than the minimum allowable radius.

77 Lines running through cutouts should be installed with care so that the tube is not scarred in being worked through the hole. The edges of the cutout should be taped before the lines are installed, especially if the line assembly is long.

PIPE LINE IDENTIFICATION

78 Pipe line identification symbols are to be installed on all new and repaired systems in accordance with instructions contained in EO 05-1-2Y.

REPLACEMENT

79 Damaged tubing should be replaced with

new parts. If a line assembly is to be replaced, the fittings can be salvaged so that replacing the assembly usually amounts to tube replacement only. In replacing a damaged tube, select a tube of the same size and material, if possible. Cut the piece of tubing approximately 10% longer than the length of the tube to be replaced. After required bends have been made, the new tube may be 1/2 to 2 inches longer than the old tube. Allowances should be made for the flaring operation to follow. The amount of tubing in excess of these required dimensions should be cut off. Cracked fitting sleeves installed on hydraulic or pneumatic tubing subjected to pressures up to and including 3000 psi are not considered unsafe and do not need to be replaced unless a leak is present. If a leak is present, they must be replaced. An exception to this is that when a line is disconnected for any other reason all cracked fitting sleeves should be replaced with serviceable fitting sleeves. The above instructions also apply to cracked fitting sleeves on return, vent, and drain lines. The above statements are not to be interpreted to mean that a cracked fitting sleeve or sleeves cannot be replaced at the discretion of responsible personnel. Minor surface corrosion on sleeves and fittings, while not desirable, is acceptable. Whether or not corroded sleeves and fittings will be replaced is also at the discretion of responsible personnel.

TUBE TEMPLATE

80 If the old tube is intact and the bends have not been changed, use it as a template or pattern from which to bend a new tube. If re-routing is required and a new model or template must be made, select a soft iron wire and proceed as follows:

(a) Place a wire into one of the fittings where the tube is to be connected. Form the necessary bends. When the template is satisfactorily formed to span the area between the fittings, remove and use the pattern to bend the new tube.

(b) Select a path with the least total degrees of bend as this reduces the flow loss and simplifies bending.

(c) Use a path, if possible, with all bends in the same plane.

NOTE

Do not select a path that requires no bends. A tube cannot be cut or flared accurately enough so that it can be installed without bends and still avoid initial mechanical strain on the tube.

81 If the tubing is small in diameter (below 1/4 inch) and can be hand formed, casual bends may be made to allow for this. If the tube must be machine formed, definite bends must be made to avoid a perfectly straight assembly. This is not necessary if the replaced tube assembly is to be used to repair a damaged section of a continuous line. Care must also be taken to start all bends a reasonable distance from the end fittings, as the sleeves and nuts must be slipped back along the tube for inspection and to prevent binding of the tube against the coupling sleeve. (Refer to EO 05-1-3/25.) In all cases the new tube assembly should be so formed prior to installing that it is not necessary to pull the assembly into alignment by means of the coupling nuts.

REPLACEMENT MATERIAL

82 Tubing replacement should be made with tubing of the same material and heat treat, outside diameter and wall thickness. Replacement with another material cannot be made without approved engineering authority and after consideration of strength, vibration resistance, formability and, if of another size, flow and volume characteristics, bend radii and clearances.

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EXAMPLE

84 It is desired to determine the internal working pr... e diameter x .035 inch wall tubing of 57S-1/2H al... ...l working pressure of 1 inch ... DELETED ...-O alloy is 217 psi. The con- ... working pressure, then, of a 1 inch outside d... ...g of 57S-1/2H alloy is 3.2 x 217 psi or 694.4 psi.

CAUTI...

Figure ... DELETED ... plumbing requirements. Surge ... pressure system.

LAYOUT

85 Locate terminal points where the tube starts and ends to determine path of tubing. Check for vibration effects on layout. Avoid obstructions and possibility of abuse from other equipment. Establish supporting points with due regard to flexibility. Ensure that tubing does not obstruct or chafe on other equipment.

86 A tubing line may be installed by several different routes, but there is usually a preferred path. See Figure 31 for a sample installation giving alternate routes. The reason for using tube (B) as the preferred route is as follows:

(a) Tube (A) obstructs the access door.

(b) Tube (C) obstructs access to adjoining equipment.

(c) Tube (B) is the best direct path for this particular tubing layout.

Alloy and Temper	Conversion Factor
1S-1/2H	1.4
1S-H	
24S-O	
DELETED	
	2.9
	2.5
57S-1/2H	3.2
57S-H	3.4
65S-O	1.5
65S-W	3.0
65S-T	3.8

Figure 30 Conversion Factors of Typical Internal Working Pressures

DETERMINATION OF TUBING LENGTH

87 For determination of proper tubing length, dimensions should be taken as follows:

(a) From end to end or, for first bend, from end to centre line of tube.

(b) For succeeding bends, from centre line to centre line, see Figure 32.

88 On the Triple-lok type of fitting (Item 33), measure from base of machined flare. On Ferulok type (Item 34) measure to face of equipment, as indicated by dimension A, see Figure 32. Dimension B is clearance between face of equipment and centre line of tube. Then A + B dimension is measurement from end of tube to centre line of first bend. Dimension C is measurement between centre lines of first and second bends. This is obtained by measurement of dummy tubes supported at the points of the proposed layout.

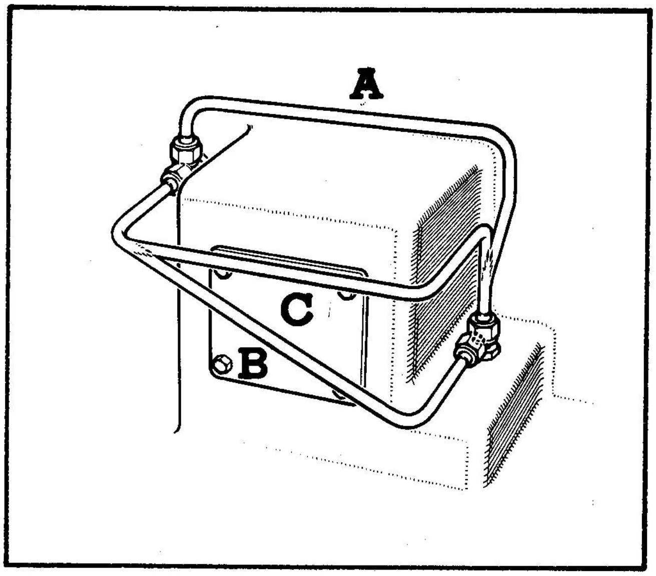

Figure 31 Routing of Tubing

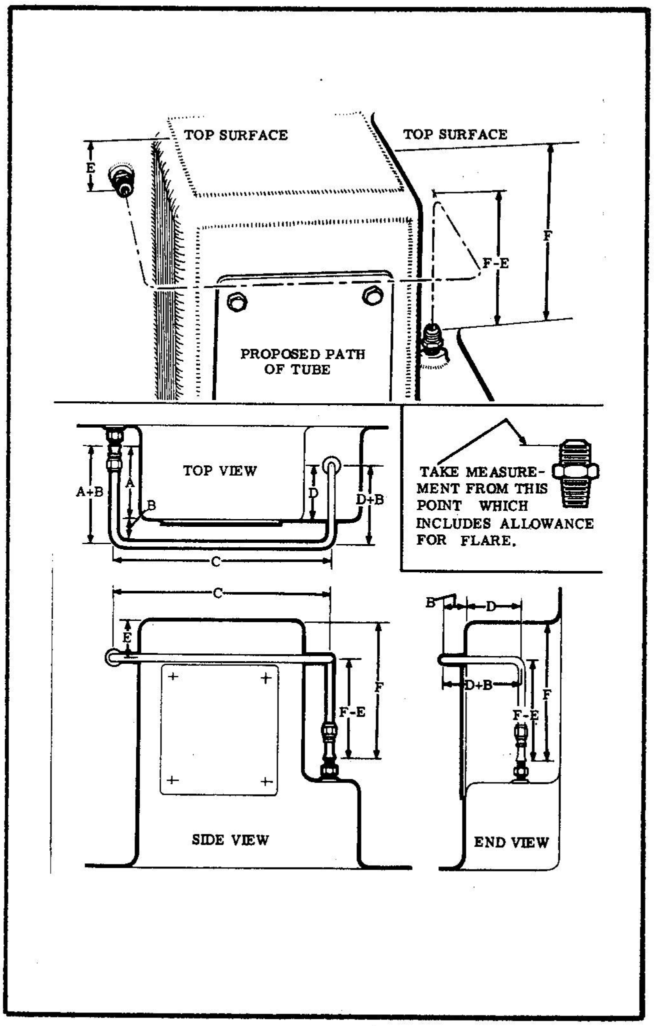

Figure 32 Measurement of Tubing for Layout

Dimension D is obtained from centre of terminal fitting to face of equipment. Then D + B is distance between second and third bends. To obtain elevation between terminals place straight edge across equipment. Measure dimension E to centre line of tubing and dimension F to end of terminal fitting. Then F - E = length of tubing from centre line of third bend to final terminal connection. Add these dimensions to obtain total length of tubing necessary and cut to length. Assemble nut and sleeve of flare fitting on tube and form flare on end of tube.

NOTE

If Ferulok type fittings are used, flaring is unnecessary.

TUBE BENDING BEFORE INSTALLATION

89 Mark dimension A + B on tube, using soft pencil. Place tube in bender, lining up pencil mark with outside edge of bender radius block. Use bender of correct radius and bend to required angle. To locate second bend transfer dimension C to tube. Bend in proper direction and transfer next dimension, D + B, Recheck layout and bend tube in proper direction. Complete flaring operation after assembling fittings to tube.

NOTE

It may be advantageous in some cases to leave extra material on both ends of tube until all bending is completed and then trim off to fit final connections.

CLEANING LINES

90 All tubing must be cleaned before installation. Clean lines and fittings, other than in the oxygen system, by blowing out with clean dry compressed air.

CLEANING OF OXYGEN LINES

91 Clean oxygen lines as follows:

(a) Flush the interior and exterior of all lines including sleeves and nuts with hot stabilized solvent (item 17).

(b) Drain tubing and blow out with nitrogen, oxygen or clean dry air, allowing the gas to flow until no odour or traces of solvent remain.

Item No.	Material	RCAF Ref.	Specification	Manufacturer
1	Trichloroethane	33C/774	31-GP-213	
2	Sodium Hydroxide	33CM/19	15-GP-7a	
3	Potassium Hydroxide			Technical grade
4	Sleeve	28/	MIL-F-5509	
5	Fitting, Flareless MS21921 & MS21922	28/	MIL-F-5509	
6	Nut	28/	MIL-F-5509	
7	Fitting	28/	MIL-F-5509	
8	Ring, gasket back-up AN6291	28/	AN-R-22	
9	Gasket AN6290	28/	MIL-G-5510	
10	Grease, General purpose	34A/178	3-GP-682	
11	Gasket	32E/	HH-P-96	
12	Petrolatum	34A/165	3-GP-665	
13	Washer, Lock-O-Seal	28NS/		Franklin C. Wolfe, 3644 Eastham Dr., Culver City, Calif.
14	Varnish, Gasoila	33G/		Federal Process Co. 2133 E 9th Street, Cleveland, Ohio.
15	Compound, Anti-seize	34A/164	3-GP-801	
16	Solder, Soft	30B/400 404	QQ-S-571B comp Sn50	
17	Trichloroethane	33C/774	31-GP-213	
18	Acid, Nitric	33C/2	O-C-303	
19	Flux, Soldering	32C/	MIL-F-12784A	
20	Flux, Soldering		DTD-81	
21	Ammonium Chloride	33C/107 14B/1695		

Figure 33 (Issue 1) (Sheet 1 of 2) Table of Material Specifications

Item No.	Material	RCAF Ref.	Specification	Manufacturer
22	Acid, Hydrochloric	33C/1		
23	Detergent	33CM/17	2-GP-20P	
24	Acid, Sulphuric	33C/4	15-GP-8a	
25	Wood's Metal			
26	Cerrobend			
27	Hose, Rubber, Synthetic	32C/	MIL-H-6000	
28	Clamp, Hose AGS605	28/		
29	Glycerine	14B/43		
30	Nut AN818	28/	MIL-F-5509	
31	Union	28/	MIL-F-5509	
32	Oil, Hydraulic	34A/100	3-GP-26a	
33	Fitting, Triple-lock	28NS/		Parker Appliance Co. 17325 Euclid Ave., Cleveland
34	Fitting, Ferulok	28NS/		Parker Appliance Co. 17325 Euclide Ave., Cleveland
35	Nitrogen		MIL-N-6011	

Figure 33 (Issue 1) (Sheet 2 of 2) Table of Material Specifications

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TUBING		HAND PRE-SET TURNS	PRO[illegible] T
MATERIAL	SIZE INCHES		
	1/4 - .022		
	1/4 - .028		
	1/4 - .035		1000
	5/16 -		1000
5052-0	[illegible]	DELETED	1000
Aluminum		[illegible]	1000
Alloy		1.1/6	1000
[illegible]		1.1/6	1000
		1.1/6	1000
	[illegible]	1.1/6	1000
	[illegible] - .035	1.1/6	500
	1.0 - .049	1.1/6	500
	1-1/4 - .049	1.1/6	500
	1-1/2 - .035	1.1/6	500
	1-1/2 - .049	1.1/6	500

Figure 34 (Sheet 2 of 2) Pre-set and Proof Test Data

(c) After flushing, drain the lines thoroughly and bake in an oven at a temperature of 250 to 300°F for approximately two hours.

(d) Allow to cool from the baking operation and blow out each line with nitrogen (Item 35). Allow the nitrogen to flow through the line for about five seconds to remove all traces of solvent or other vapours.

(e) Inspect the tubing and fittings and repeat cleaning operations, paragraphs (a), (b), (c) and (d) if necessary.

SEALING OF LINES

92 Between each of the above cleaning operations and immediately after the final operation, all lines must be sealed. Any line left open at any time except during actual cleaning operations is to be recleaned and resealed, using an approved cap in accordance with EO 05-1-2AV. Caps must not be removed until immediately prior to final installation.

93 Completed lines and fittings for the oxygen system must not be placed nor stored near machinery or in any other location where they may become contaminated with oil, grease, water or other foreign substances.

INSPECTION OF HYDRAULIC LINES AND INSTALLATIONS

GENERAL

94 A detailed inspection during periodic maintenance is recommended as the most satisfactory method of obtaining trouble-free operation. Particular attention should be paid to congested areas, especially in the engine bay and nose wheel wells.

INSPECTION

95 Inspect line routing and clearances as follows:

(a) All lines must clear adjacent structure and other installations by at least 1/8". Refer to paragraphs 70 to 77 inclusive, preceding.

(b) Flexing of hydraulic lines and aircraft structure may reduce clearances. Broken clamps or damaged attaching points usually indicate improper routing and inadequate allowance for flexing.

NOTE

A practical check for line chafing due to improper routing or inadequate clearances consists of setting the system relief valve slightly above system pressure to promote line chatter and indicate abnormal conditions.

96 Check connecting fittings as follows:-

(a) Check base of flare for cracks and distortion.

(b) Flared ends of line must seat freely and squarely on connecting flare.

(c) Line must be concentric with sleeves.

(d) Bulkhead fittings must be properly positioned in bulkhead without causing local distortion of the web of the bulkhead. Extra washers may be used on either side of the bulkhead to compensate for variations in line length.

MATERIAL SPECIFICATIONS

97 For table showing item numbers, materials, specifications and manufacturers, see Figure 33.