



AIRCRAFT
MAINTENANCE MANUAL

TUBING - REPAIR

EFFECTIVITY: ALL

1. General

- A. This section gives the approved repair procedures for the tubing of the different aircraft systems.
- B. The procedures in this section are given in the sequence below. The tasks identified with (♦) are part of the Scheduled Maintenance Requirements Document (SMRD).

TASK NUMBER	DESCRIPTION	EFFECTIVITY
20-10-03-300-801-A	TUBING - REPAIR	ALL

TASK 20-10-03-300-801-A

EFFECTIVITY: ALL

2. TUBING - REPAIR

A. General

- (1) This procedure gives the instructions to repair tubing.

CAUTION: • DO NOT USE TITANIUM FITTINGS IN REPAIRS IN THE OXYGEN SYSTEM TUBING.

- HYDRAULIC TUBES INSTALLED BETWEEN THE FRONT AND REAR PRESSURE BULKHEADS MUST BE REPAIRED WITH NO SEPARABLE FITTINGS ONLY.
- DO NOT USE FITTING NUTS TO PULL THE FITTINGS INTO ALIGNMENT. STRESSES APPLIED TO FITTINGS WILL CAUSE LEAKAGE, BLOWOFF, AND OTHER FAILURES.

(2) When you form-repair sections, get the correct alignment of tubing and fittings to make the fittings stay against the two ends of the repair section.

(3) Tubing can be reworked if the procedures written in this section are obeyed. A damaged tubing can be replaced or repaired. The repair can be made with a tube splice or with a fitting, if the damaged area is sufficiently small. For tubing repair, these instructions must be obeyed:

- (a) At the tube removal, it is most important not to change the tubing bends because this can change the bend ovality and cause cracking in the tube.
- (b) If the tubing must be bent, the bending is to be done in the ovality limits, recommended radius, wrinkle depth, and scratch depth, as shown in [Figure 801](#), [Figure 802](#), and [Figure 803](#).
- (c) Dents or chafed areas must not be reworked. The tube or section must be replaced if the defect depth is more than the values given in [Figure 804](#). For tubes with defects below these values, rework or replacement is not necessary. Times between inspections must be as recommended in the Scheduled Maintenance Requirements Document (SMRD).

(4) Tubing repairs are made with the replacement of a damaged tube section. The damaged section is cut out and replaced with a pre-assembled fitting/tube assembly or a union fitting.

(5) Tubing repairs must be made with tube sections of the same tubing material and gauge as specified in [Figure 805](#). Splice repairs can be made as shown in [Figure 806](#).

- (a) In the fuselage interior, use only no separable fittings.
- (b) In the landing gear compartment, do not use aluminum tubes.

(6) The aircraft is factory-equipped with flareless tubes TI-3AL-2.5V, 21-6-9, and 6061T6, Permaswage fittings, and Sierracin sleeves.

- (a) When a repair is made, tubes TI-3AL-2.5V may possibly be replaced with tubes CRES 304 annealed or 304 1/8 HARD or 21-6-9.

- (b) Sierracin sleeves can be replaced with sleeves MS21922, Permaswage, or Rynlok sleeves, and repair "H" fittings, when the sleeve or fitting agrees with the tube, as specified in [Figure 805](#) and [Figure 806](#).
- (7) Tube section repairs are of three categories, which are related to the location and the length of damage:
 - (a) Replacement of a tube end-section with a flareless end-fitting than can be moved apart by the installation of a pre-assembled fitting assembly. Refer to [Figure 807](#).
 - (b) Replacement of a tube center section with a short damage segment, which can be repaired by the installation of a single union. Refer to [Figure 808](#).
 - (c) Replacement of a tube center section with large damage by the installation of a pre assembled fitting assembly. Refer to [Figure 809](#).
- (8) Refer to AMM MPP 06-41-01/100, AMM MPP 06-41-02/100, AMM MPP 06-42-00/100, [AMM MPP 06-43-00/100](#), and [AMM MPP 06-44-00/100](#) for the access to the tubing.

B. References

<i>REFERENCE</i>	<i>DESIGNATION</i>
AMM MPP 06-41-01/100	-
AMM MPP 06-41-02/100	-
AMM MPP 06-42-00/100	-
AMM MPP 06-43-00/100	- COMPONENT LOCATION
AMM MPP 06-44-00/100	- COMPONENT LOCATION
AMM TASK 20-10-03-400-801-A/400	TUBING - INSTALLATION
AMM TASK 29-10-00-860-803-A/200	HYDRAULIC SYSTEM - BLEED OF AIR
AMM TASK 32-00-01-910-801-A/200	LG SAFETY PIN - INSTALLATION AND REMOVAL

C. Zones and Accesses

Not Applicable

D. Tools and Equipment

<i>ITEM</i>	<i>DESCRIPTION</i>	<i>PURPOSE</i>	<i>QTY</i>
GSE 015	Permaswage complete kit (manual pump included)	For tubing repair	
GSE 014	Permaswage pneumatic pump (optional pump of GSE 015)	For tubing repair	
GSE 396	Rynlok complete kit	For tubing repair	

E. Auxiliary Items

Not Applicable



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F. Consumable Materials

SPECIFICATION (BRAND)	DESCRIPTION	QTY
ASTM-D740	Methyl Ethyl Ketone (MEK)	AR
Commercially available	Scotch Brite sponge	AR
MIL-C-5541	Chemical-Conversion Compound, Alodyne 1200S	AR
MEP 10-063	Corrosion-Inhibiting Compound (Dinitrol AV- 8) AR	AR

G. Expandable Parts

Not Applicable

H. Persons Recommended

QTY	FUNCTION	PLACE
1	Does the task	On damaged tubing

I. Preparation

SUBTASK 841-002-A

- (1) On the circuit breaker panel, open the applicable system circuit breaker, and attach a DO-NOT-CLOSE tag to it.
- (2) Make sure that the pressure in the related system is fully released.
- (3) Make sure that the safety pins of the landing gears are installed, if you must do the removal procedure near them ([AMM TASK 32-00-01-910-801-A/200](#)).

J. Repair of Tubing

SUBTASK 360-002-A

- (1) Tube repair section fabrication - General Instructions.
 - (a) Select the applicable type of repair. Refer to [Figure 805](#).
 - (b) For repair of tube made of aluminum only (return lines), do as follows:
 - 1 Clean with MEK the tube that you will examine
NOTE: Make sure that dirt and grease are removed before you start the visual inspection
 - 2 Do a visual inspection for signs of chemical attack and/or light corrosion. If you find signs of chemical attack and/or light corrosion, do as follows:
 - a Lightly abrade the chemical attack/corrosion spots with Scotch Brite brush, make sure that they are removed from the surface of the tube.
NOTE: The defect depth limit is 0.005 in. Refer to [Figure 804](#).
 - b Clean with MEK the tube that you will inspect

- c Apply type I, class 1 chemical conversion coating Alodyne to the abraded areas and also Dinitrol AV8 or equivalent
 - (c) For repair of small damage, find the tube cutout length for replacement of the damaged tube area. Refer to [Figure 808](#).
 - (d) For repair of a tube with damaged end or center section, with a pre-assembled tube and fitting assembly, find the cutout length as follows:

NOTE: For the Rynglok fitting, obey the manufacturer's instructions to find the cutout length.

 - 1 Find the total length (C1) of the repair section necessary to replace the damaged tube. Refer to [Figure 807](#) and [Figure 809](#).
 - 2 Cut the repair tube.

NOTE: To cut the tube, obey the fitting manufacturer's instructions.
 - 3 If applicable, assemble the associated nut(s).
 - 4 Swage the necessary sleeve to the repair tube.

NOTE: To swage the fitting, obey the fitting manufacturer's instructions.
 - 5 Measure the correct total pre-assembled tube length (C1).
 - 6 Find the necessary cutout length (C2) as shown in [Figure 807](#) and [Figure 809](#) by the method given in [Figure 810](#) and [Figure 811](#).
 - (e) Release the pressure from the applicable system where repair is to be made. Refer to the Maintenance Manual Instructions.
 - (f) Cut out the damaged tube (C2), trim the tube end(s), and install the applicable fitting(s).

NOTE: Obey the fitting manufacturer's instructions to cut out the damaged tube.
 - (g) Install the prefabricated repair section and, if applicable, tighten the nuts ([AMM TASK 20-10-03-400-801-A/400](#)).

NOTE: When you replace a tube bend section, the tube end minimum straight length requirements for all fitting must be kept.
- (2) Harrison Elastomer Swaging Method
- (a) This method is recommended for the installation of 35235VN flareless sleeves on 6061-T6 and 50-52-0 tubes, and 35235VN or 35235V flareless sleeves on 304ANN, 304 1/8 H, and 21-6-9 tubes.
 - (b) For the use of this method, obey the recommendation given in this section and the instructions written in the swaging kit.
- (3) Harrison Roller Swaging Method

- (a) This method is recommended for 35235V flareless sleeve installation on 21- 6-9 and TI-3AL-2.5V tubes. Refer to [Figure 805](#).
 - (b) For the use of this method, obey the recommendation given in this section and the instructions written in the swaging kit.
- (4) Permaswage and Rynghlok Methods

CAUTION: • PERMASWAGE FITTINGS MUST NOT BE USED ON OXYGEN SYSTEM LINES.

• RYNGLOK FITTINGS MUST BE USED ON HYDRAULIC SYSTEM LINES ONLY.

- (a) These methods are recommended for aluminum permanent unions on 6061-T6 tubing, and steel unions on 6061-T6, 21-6-09, TI-3AL2.5V, and 304 1/8 H tubing. Refer to [Figure 805](#).
- (b) For the use of these methods, obey the fitting manufacturer's instructions.

NOTE: • If you have leakage at the Permaswage fitting, you can swage it one more time only.

• For the Permaswage fitting re-swaging, if possible, put the tool in the 45° position to the first swage marking.

- (5) "H" Fitting

CAUTION: "H" FITTINGS MUST NOT BE USED ON OXYGEN SYSTEM LINE.

- (a) This fitting is an approved method for permanent repair of hydraulic lines for which no special tooling is necessary. Usual tool boxes contain all that is necessary for tube preparation and fitting assembly. The repair "H" fitting was approved for use on aluminum and stainless (low and high strength) tubing 21-6-9 cres, 304 1/8 hard cres, 304 annealed cres, and 6061-T6 aluminum.

NOTE: The maximum gap between tube ends for the installation of "H" fitting is 0.250 inch.

K. Follow-on

SUBTASK 842-002-A

- (1) Remove from the work area all tools, materials, and equipment that you used.
- (2) Make sure that the area is clean.
- (3) On the circuit breaker panel, close the applicable system circuit breaker and remove the DO-NOT-CLOSE tag from it.
- (4) Pressurize the related system and obey the applicable procedures to do a check for leaks.

NOTE: Most of the hydraulic lines can be pressurized on ground by pressurizing the related hydraulic system (1 or 2). Guidance in the AMM Part I and/or SSM can be used for more determination on the pressurization requirements for the



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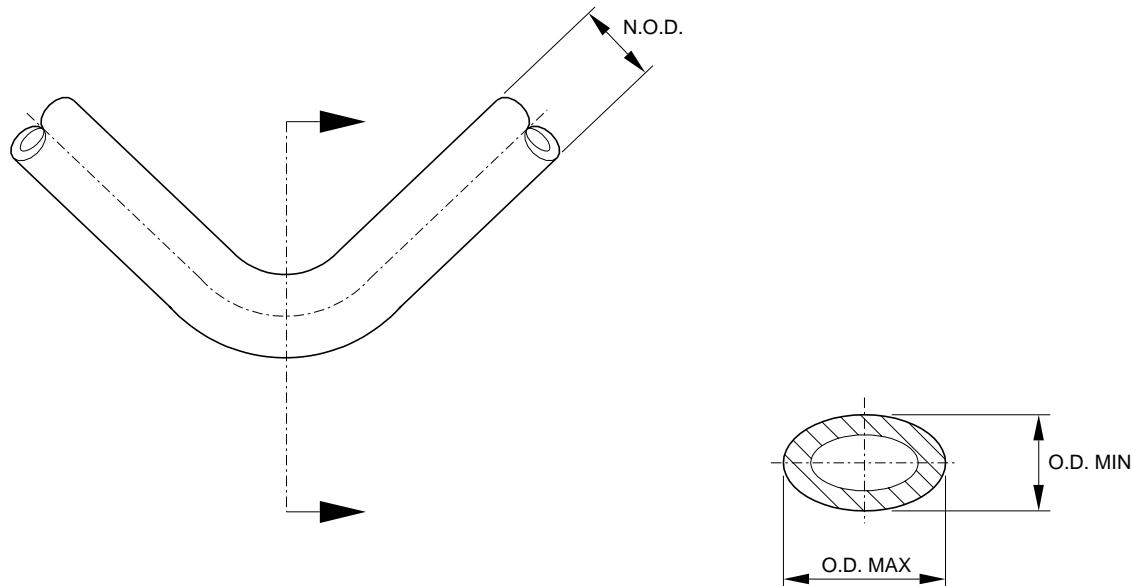
related line. All the safety and preparation procedures must be followed as given in the AMM before you apply the pressurization procedures.

- (5) Do the bleed of the air from the related hydraulic system ([AMM TASK 29-10-00-860-803-A/200](#).

EFFECTIVITY: ALL

Maximum Permitted Ovality in Tube Bends

Figure 801



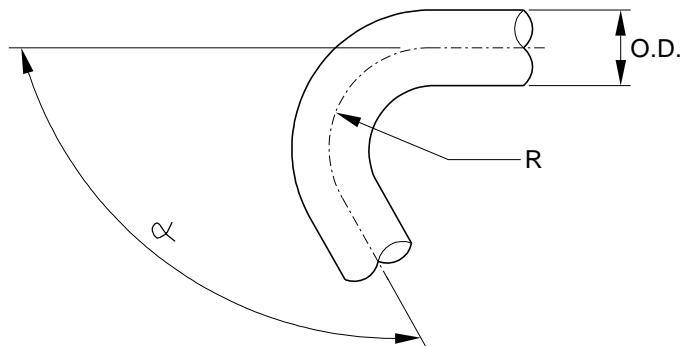
OPERATING PRESSURE	TUBE O.D.	TUBE MATERIAL	ALLOWABLE OVALITY (PERCENT OF * NOMINAL O.D.)
0 TO 1500 PSI LINES	ALL SIZES	21-6-9 6061-T6 5052-0	10
1500 PSI TO 3000 PSI LINES	ALL SIZES	TI-3AL-2.5V CRES 21-6-9 304 ANNEALED 304 1/8 HARD	3

$$\text{Percent (Ovality)} = \frac{\text{O.D. MAX} - \text{O.D. MIN}}{\text{O.D. NOMINAL}} \times 100$$

* NOMINAL DIAMETER = DRAWING SPECIFIED TUBE DIAMETER

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EFFECTIVITY: ALL

 Recommended Radius for Tubing Bending
 Figure 802


TUBE O.D. INCHES (MM)	WALL THICKNESS (dimension in INCHES)			MINIMUM BEND RADIUS INCHES (MM)
	6061-T6 (WW-T-700/6) (MIL-T-7081)	21-6-9 (AMS5561)	TI-3AL-2.5V (AMS4944)	
1/4 (6.35)	0.028	0.016	0.016	1 (25.4)
5/16 (7.94)	0.028	0.016	0.016	1 1/4 (31.8)
3/8 (9.52)	0.028	0.020	0.020	1 1/2 (38.1)
1/2 (12.70)	0.028	0.026	0.026	2 (50.8)
5/8 (15.88)	–	0.016	–	2 1/2 (63.5)

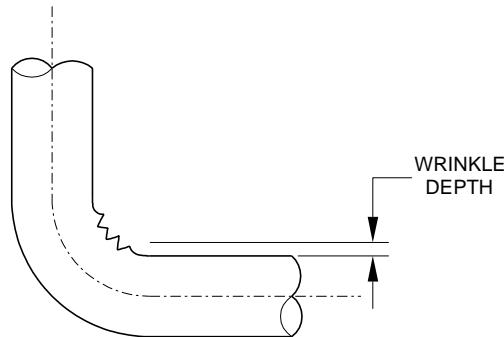
TUBE O.D. INCHES (MM)	WALL THICKNESS (dimension in INCHES)			MINIMUM BEND RADIUS INCHES (MM)
	304 ANNEALED (AMS 5567)	304 1/8 HARD (MIL-T-6845)	5052-0 (WW-T-700/4)	
1/4 (6.35)	0.035	0.035	0.035	3/4 (19.05)
5/16 (7.94)	0.035	0.035	0.035	1 5/16 (23.81)
3/8 (9.52)	0.035	0.035	0.035	1 1/8 (28.57)
1/2 (12.70)	0.035	0.035	0.035	1 1/2 (38.1)

NOTES

- Recommended angle of bending, α must not exceed 120°.
- 304 steel and AL5052-0 tubes are easier to bend.
- May be used in replacement of aircraft original tubes provided that the compatibility between tube and fitting (Figure 803) is met.
- For bending 21-6-9 and TI 3AL-2.5V tubes, an appropriate internal mandrel shall be provided to restrict availability to limits shown in Figure 801.

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EFFECTIVITY: ALL
 Wrinkles and Scratch Depths
 Figure 803



SYSTEM PRESSURE	TUBE MATERIAL	WRINKLE MAXIMUM	SCRATCH MAXIMUM DEPTH
		DEPTH O.D. %	TUBE WALL %
BELOW 500 PSI	ALL	2%	10%
ABOVE 500 PSI	21-6-9 (AMS 5561)	1%	3%
	6061-T6 (WM-T-700/6)		
	304 ANNEALED (AMS 5567)		
	304 1/8 HARD (MIL-T-6845)		
	5052-0 (WW-T-700/4)		
	TI-3AL-2.5V (AMS 4944)	SHOULD NOT HAVE VISIBLE WRINKLES	5%

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EFFECTIVITY: ALL

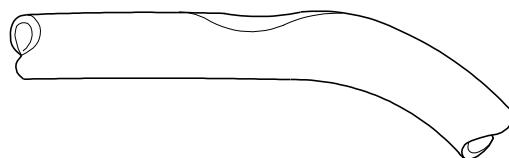
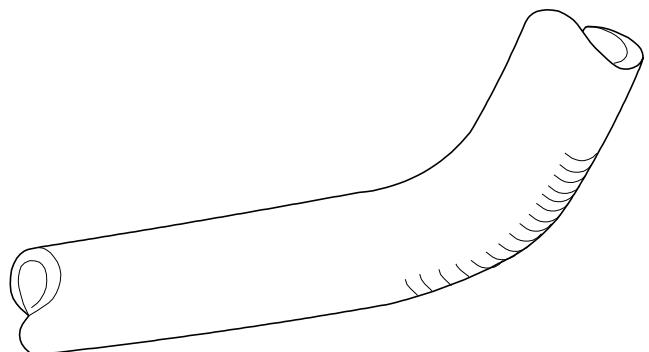
Permitted Tube Defect Depth

Figure 804

TUBE MATERIAL (PRESSURE)	DEFECT TYPE	TUBE OUTSIDE DIAMETER (O.D.)				
		1/4	5/16	3/8	1/2	5/8
TI-3AL-2.5V (3000 PSI)	CHAFED	0.006	0.006	0.007	0.008	-
	DENTED	0.005	0.006	0.007	0.016	-
21-6-9 (3000 PSI)	CHAFED	0.006	0.006	0.007	0.008	0.005
	DENTED	0.005	0.006	0.007	0.010	0.006
6061-T6 (1500 PSI)	CHAFED	0.012	0.012	0.012	0.008	-
	DENTED	0.012	0.012	0.012	0.008	-

NOTE

- All dimensions are in inches.
- The above values were established based in standards, with no laboratory test data.
- For tubes CRES 304 Annealed, 304 1/8 HARD and AL5052-0, the defect depth limit, such as notches, pits, dents, nicks, chafings, scores and galling were defined in 0.005 in.



145AMM200031.MCE A

EFFECTIVITY: ALL
Tube Material and Fittings Selection Chart
Figure 805

REPAIR METHOD	TUBE JOINTING		TUBE MATERIAL	APPROVED SIZES	TOOL REQUIRED	ASSOCIATED NUT	
	Type and Part Number	Illustration					
RECONNECTABLE WITH FLARELESS FITTING SLEEVES	SIERRACIN/ HARRISON SLEEVES 35235	ELASTOMER SWAGE	AL5052-0 AL6061-T6 CRES 304ANN	1/4, 5/16, 3/8, 1/2	A	MS21921	
			CRES 304 1/8H	1/4, 5/16, 3/8, 1/2			
			CRES 21-6-9	1/4, 5/16, 3/8, 1/2, 5/8			
	SLEEVE MS21922 BYTE-TYPE		TI-3AL-2.5V	1/4, 5/16, 3/8, 1/2	B		
			CRES 21-6-9	1/4, 5/16, 3/8, 1/2, 5/8			
	SLEEVE D10609 PERMASWAGE		AL5052-0	1/4, 5/16, 3/8, 1/2	D, E		
			CRES 304 1/8H CRES 304ANN	1/4, 5/16, 3/8, 1/2			
	SLEEVE D10007 PERMASWAGE		AL6061-T6	1/4, 3/8	C	D10600W PERMASWAGE	
			TI-3AL-2-5V	1/4, 5/16, 3/8, 1/2	C	D10006 PERMASWAGE	
			CRES 304 1/8H	1/4, 5/16, 3/8, 1/2			
			CRES 21-6-9	1/4, 5/16, 3/8, 1/2, 5/8			
RECONNECTABLE WITH FLARED FITTING SLEEVES	SLEEVE R82101T RYNGLOK		AL6061-T6	1/4, 1/2, 5/8	G	NOT REQUIRED	
			TI-3AL-2-5V	1/4, 5/16, 3/8, 1/2			
			CRES 304 1/8H	1/4, 5/16, 3/8, 1/2			
			CRES 21-6-9	1/4, 5/16, 3/8, 1/2, 5/8			
	SLEEVE D10610 PERMASWAGE		AL6061-T6	1/4	C	D10600W PERMASWAGE	
			AL6061-T6	1/4	G	NOT REQUIRED	
			AL6061-T6	1/4			
			AL6061-T6	1/4, 3/8, 1/2, 5/8			
PERMANENT UNIONS TUBE-TO-TUBE	UNION D10036 PERMASWAGE		AL6061-T6 TI-3AL-2-5V	1/4, 5/16, 3/8, 1/2	C	NOT REQUIRED	
			CRES 304 1/8H	1/4, 5/16, 3/8, 1/2			
			CRES 21-6-9	1/4, 5/16, 3/8, 1/2, 5/8			
	SLEEVE R80101T RYNGLOK		AL6061-T6 TI-3AL-2-5V	1/4, 5/16, 3/8, 1/2	G		
			CRES 304 1/8H	1/4, 5/16, 3/8, 1/2			
			CRES 21-6-9	1/4, 5/16, 3/8, 1/2, 5/8			
	REPAIR "H" FITTING 36011V		AL6061-T6 CRES 304ANN TI-3AL-2-5V	1/4, 5/16, 3/8, 1/2	F		
			CRES-304 1/8H	1/4, 5/16, 3/8, 1/2			
			CRES 21-6-9	1/4, 5/16, 3/8, 1/2, 5/8			

Dimensions in inches

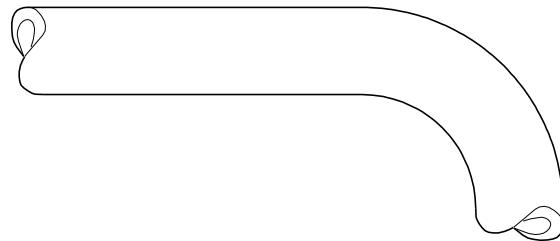
- A - SIERRACIN/HARRISON (ELASTOMER)
B - SIERRACIN/HARRISON ROLLER SWAGE TOOL KIT
C - GSE 015
D - PRESSURE PRESETTING TOOL

- E - HAND PRESETTING TOOL
F - SPECIAL TOOL NOT REQUIRED - HAND TOOL ONLY
G - GSE 396

145AMM200032.MCE E

EFFECTIVITY: ALL

Approved Fitting/Tube Material Combinations for Repair
Figure 806



PERMASWAGE FITTING MATERIAL	FOR USE WITH TUBE MATERIAL	SIERRACIN/ HARRISON SLEEVE	COMPATIBLE TUBE MATERIAL
21-6-9 CRES	304 1/8 HARD CRES (MIL-T-6845)	CADMIUM PLATED (35235VN) (ELASTOMER SWAGE ONLY)	5052-0 6061-T6 21-6-9 304 ANN 304 1/8 H
	21-6-9 CRES (AMS 5561)	PASSIVATED (35235V)	TI-3AL-2.5V 21-6-9 304 ANN 304 1/8H
	TI-3AL-2.5V (AMS 4944)		
	6061-T6 AL (WW-T-700/6)		
6061-T6 AL	6061-T6 AL (WW-T-700/6)		

NOTE:

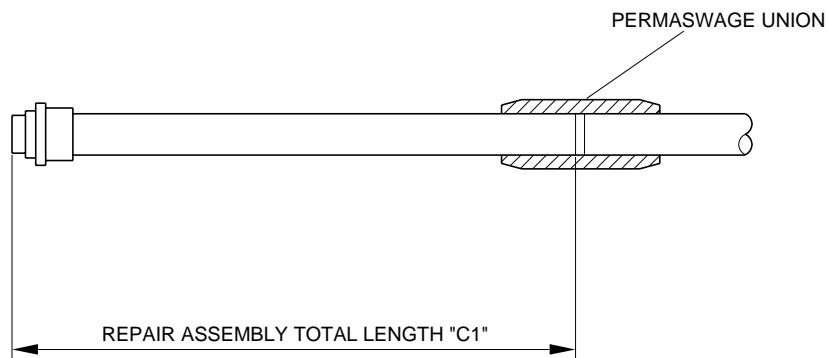
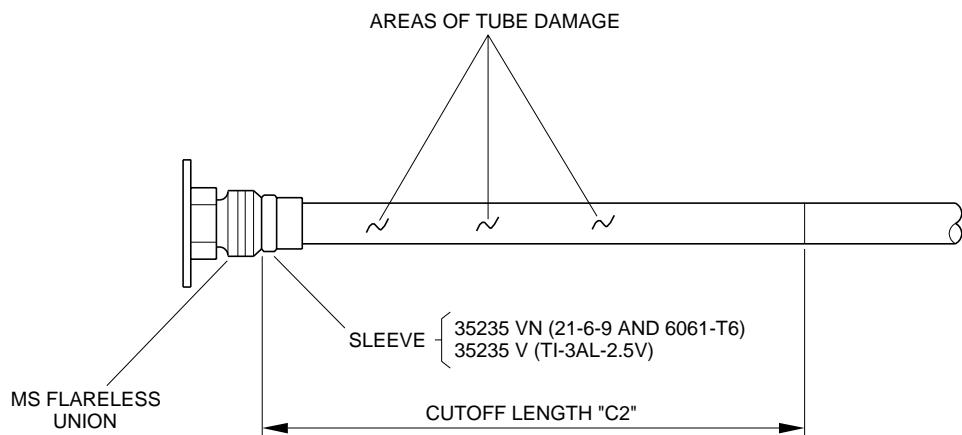
Aluminum permaswage unions that do not have all grooves filled with the silicone sealant are not approved for use on EMBRAER aircraft.

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EFFECTIVITY: ALL

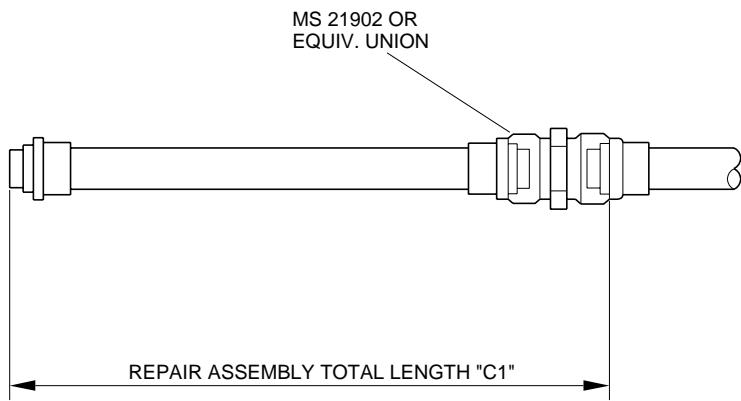
Tubing Repair by End Replacement

Figure 807



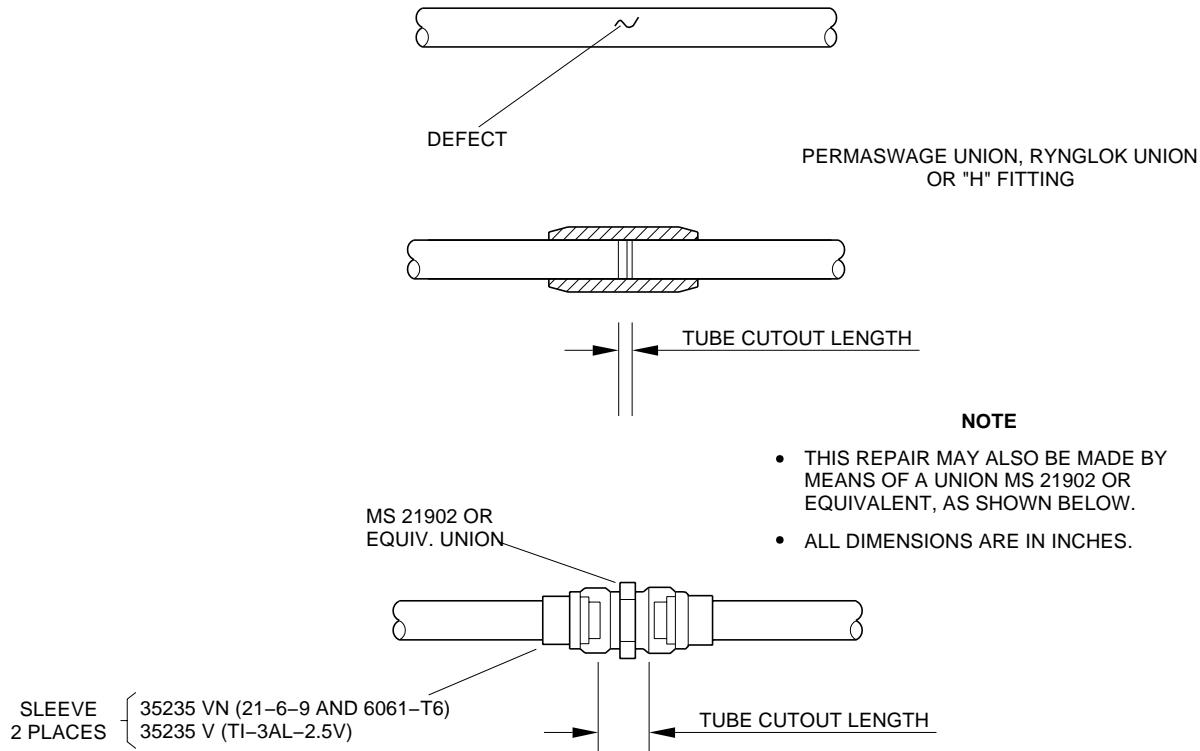
NOTE

THIS REPAIR MAY ALSO BE MADE BY
MEANS OF A UNION MS 21902 OR
EQUIVALENT, AS SHOWN BELOW.



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EFFECTIVITY: ALL

 Tubing Repair with Unions - Small Damage
 Figure 808


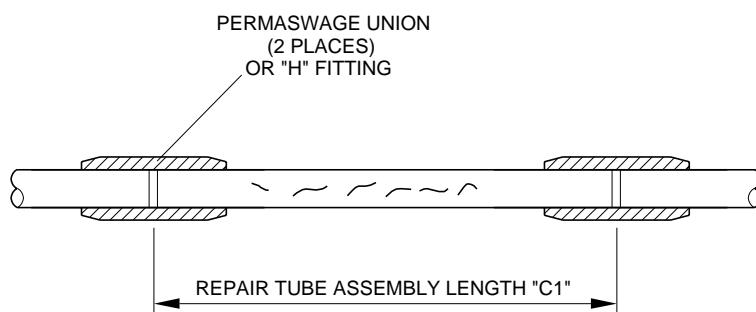
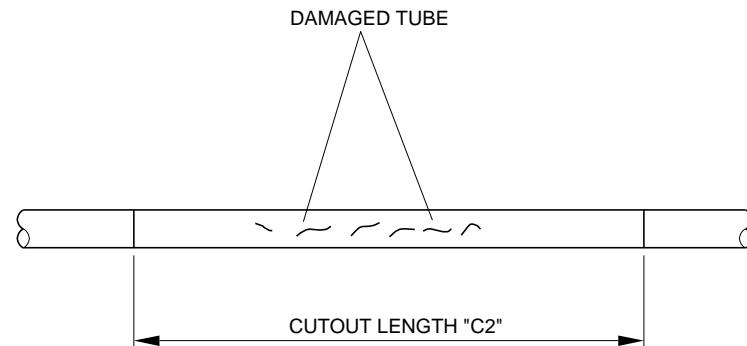
TUBE SIZE		1/4	5/16	3/8	1/2	5/8		
UNION	SLEEVE							
MS21902 OR EQUIVALENT	35235V 35235VN (ELASTOMER)	0.63	0.60	0.72	0.80	0.90		
	35235V (ROLLER SWAGE)	0.82	-	0.95	1.03	1.21		
RYNGLOK	NONE REQ'D	0.300 INCH MAXIMUM (GAP)			0.350 INCH MAXIMUM (GAP)			
PERMASWAGE	NONE REQ'D	0.150 INCH MAXIMUM (GAP)						
"H" FITTING	NONE REQ'D	0.250 INCH MAXIMUM (GAP)						

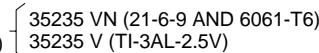
145AMM200035.MCE B

EFFECTIVITY: ALL

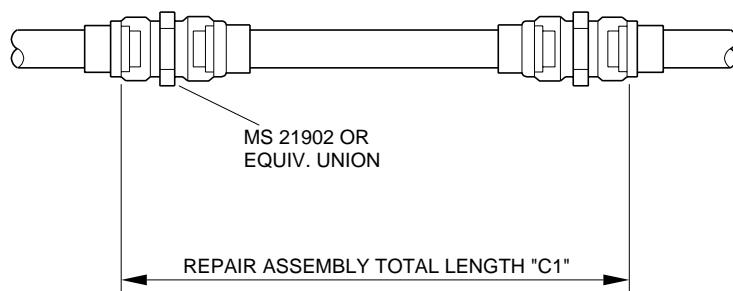
Tubing Repair by Replacement with Straight or Bent Tube - Large Damage

Figure 809



SLEEVE
(4 PLACES) 
35235 VN (21-6-9 AND 6061-T6)
35235 V (Ti-3AL-2.5V)

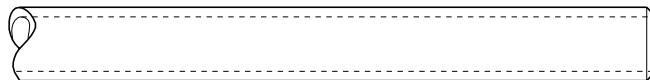
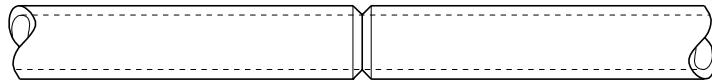
NOTE
THIS REPAIR MAY ALSO BE MADE BY
MEANS OF A UNION MS 21902 OR
EQUIVALENT, AS SHOWN BELOW.



145AMM200036A.MCE A

EFFECTIVITY: ALL

Method to Find Tube Cutout Length C2
Figure 810



FITTINGS USED FOR REPAIR OF TUBE ASSEMBLY			C2 CUT OUT LENGTH FORMULA	
FLARELESS SLEEVE		UNION	FOR TUBE END SECTION	FOR TUBE CENTER SECTION
PART No.	METHOD			
35235VN	HARRISON ELASTOMER SWAGE	MS21902 OR EQUIVALENT	C1 minus "2B"	C1 minus "2B"
35235VN 35235V	HARRISON ROLLER SWAGE		C1 minus "2A"	C1 minus "2A"
35235VN	HARRISON ELASTOMER SWAGE	PERMASWAGE	C1 minus (B + 0.10)	-
35235VN 35235V	HARRISON ROLLER SWAGE	-	C1 minus (A + 0.10)	-
-	-	PERMASWAGE	-	C1 minus 0.20

NOTE: ALL DIMENSIONS ARE IN INCHES

Example: It has been determined that tube damage will be repaired by removing a tube end section and replacing it with a prefabricated tube assembly as shown on figure 805. The repair tube end section has been fabricated by roller swaging 35235 VN or 35235V flareless sleeves to the tube ends and tightening to a MS21902 flareless union on one end.

STEP 1: Measure repair tube assembly total length C1 (figure 805).

STEP 2: Observe cutout length C2 formula (C1 minus 2A) in table above.

STEP 3: Determine "A" value for tube size in figure 811.

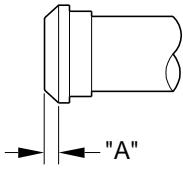
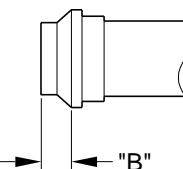
STEP 4: Subtract ("A" times 2) from measuring C1 for cutout length C2.

145AMM200037.MCE B

EFFECTIVITY: ALL

Flareless Sleeve Tube End "A" and "B" Values

Figure 811

FLARELESS JOINT TYPE	TUBE SIZE				
	1/4	5/16	3/8	1/2	5/8
ROLLER SWAGE 35235V 35235VN	0.140	-	0.137	0.190	0.195
					
ELASTOMER SWAGED 35235VN	0.214	0.230	0.230	0.285	0.330
					

NOTE: ALL DIMENSIONS ARE IN INCHES

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