

 **BOEING**
COMPONENT
MAINTENANCE MANUAL

TO: ALL HOLDERS OF REPAIR OF ALUMINUM FUEL TUBES COMPONENT
MAINTENANCE MANUAL 28-00-10

REVISION NO. 4 DATED NOV 01/04

HIGHLIGHTS

Pages which have been added or revised are outlined below together with the highlights of the revision. Remove and insert the affected pages as listed and enter Revision No. and date on the Record of Revision Sheet.

CHAPTER/SECTION

AND PAGE NO.

DESCRIPTION OF CHANGE

CONTENTS

Added REPAIR 4-1.

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REPAIR 4-1
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REPAIR 2-2
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Changed radiographic inspect specification.

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Realigned steps for coupling installation procedures.

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Added the note to the hydrostatic test step.

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HIGHLIGHTS

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REPAIR OF ALUMINUM FUEL TUBES

NO ASSIGNED PART NUMBER

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TITLE PAGE

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REVISION RECORD

- Retain this record in front of manual. On receipt of revision, insert revised pages in the manual, and enter revision number, date inserted and initial.

REVISION NUMBER	REVISION DATE	DATE FILED	BY	REVISION NUMBER	REVISION DATE	DATE FILED	BY

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REVISION RECORD

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TEMPORARY REVISION AND SERVICE BULLETIN RECORD

BOEING SERVICE BULLETIN	BOEING TEMPORARY REVISION	OTHER DIRECTIVE	DATE OF INCORPORATION INTO MANUAL

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TR & SB RECORD

01

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TABLE OF CONTENTS

NOTE: This manual contains Boeing recommended procedures for repair of aluminum tubing used in airplane fuel systems. Repairs included range from a temporary method acceptable for small defects, to permanent methods involving replacement of tube sections in case of more extensive damage.

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INTRODUCTION

The instructions in this manual provide the information necessary to perform shop-type repair of aluminum fuel tubes.

This manual is divided into separate sections:

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|--|----------------------------|
| 1. Title Page | 4. List of Effective Pages |
| 2. Record of Revisions | 5. Table of Contents |
| 3. Temporary Revision &
Service Bulletin Record | 6. Introduction |
| | 7. Procedures |

Refer to the Table of Contents for the page location of applicable sections.

The beginning of the REPAIR section includes a list of applicable standard Boeing practices and Process Specifications.

All measurements used in the manual are in English units, unless otherwise stated. When metric equivalents are given they will be in parentheses following the English units.

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INTRODUCTION

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REPAIR – GENERAL

1. General

- A. For small damaged areas, permanent repair of aluminum fuel tubing can be accomplished by removing short sections of tubing and installing a rigid tube coupling. For larger areas of tube damage, which exceed the limit of tube section cutout required for installation of a single tube coupling, a longer section of the tube must be cut away and replaced with a new section of tube connected by two rigid couplings. Alternatively, some repairs may be accomplished more economically by replacing the entire end of a tube using a rigid tube coupling. All fuel tube repair work must conform to the applicable standard practices and references listed below:

NOTE: Acceptability of tube wear limits must be reviewed on an individual basis.

- B. A temporary repair method for aluminum fuel tubing involves the weld repair of small punctures, cracks, and wear-through. Since this method can cause hard spots and stress concentrations, the repaired tube is limited for flight hour service use. A permanent weld repair method involves removal of the damaged section of tubing and replacing it by welding in a new section.
- C. If possible, determine and correct cause of tube failure.

2. Standard Practices and References

- A. Refer to the following standard practices as applicable, for details of procedures in individual repairs.

20-11-03 Repair of Electrical Terminations and Electrical Bonding Areas
20-20-02 Penetrant Methods of Inspection
20-30-02 Stripping of Protective Finishes
20-30-03 General Cleaning Procedures
20-30-80 Solvents for General Cleaning of Metal
20-30-88 Solvents for Final Cleaning of Metal Before Non-Structural Bonding
20-50-02 Installation of Safetying Devices
20-50-10 Application of Stencils, Insignia, Silk Screen, Part Numbering and Identification Markings
20-60-01 Cleaning Materials

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- B. Additional information may be obtained by reference to the following Boeing Process Specifications and Documents:

BAC 5001-1 Tube Cut-Off, Tube End Forming
BAC 5001-2 Pressure Testing
BAC 5001-3 Tube Bending
BAC 5001-5 Roller Swaged Tube End Fabrication
BAC 5001-6 Installation of Tube Assemblies and Components
BAC 5719 Alodizing
BAC 5748 Abrasive Cleaning, Deburring and Finishing
BAC 5765 Cleaning and Deoxidizing Aluminum Alloys
BSS 7041 Radiographic Inspection
BAC 5975 Fusion Welding of Metals
BAC D-2042 Tube Bend Radii (Document)

3. Materials

NOTE: Equivalent substitutes may be used.

- A. Solvent -- Series 80 (Ref 20-30-80)
B. Solvent -- Series 88 (Ref 20-30-88)
C. Lockwire -- MS20995C32

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COUPLING METHOD – REPAIR 1-1

NOTE: Refer to REPAIR-GEN for list of applicable standard practices and references.

1. General

A. The coupling method of tube repair is approved on aluminum fuel tubing when an installation clearance of approximately 0.25 inches is available between the coupling nut and adjacent structure or components, and only if the coupling can be installed on a straight section of tube.

CAUTION: INCORRECT TUBE LENGTH AND/OR MISALIGNMENT CAN INDUCE STRESSES IN TUBE ASSEMBLY, WHICH MAY LEAD TO COUPLING LEAKAGE, BLOWOFF, OR OTHER FAILURE.

B. When replacing sections of bent tubing, ensure that tube length is correct and that proper alignment is obtained on installation. Cutout of bent tube sections should include adequate straight sections on each end to allow for swaging tool clearance (Ref BAC 5001-1).

C. Repair is accomplished with tubing removed from airplane.

D. All repaired tube sections must be electrically bonded per Repair 3-1.

2. Approved Rigid Couplings for Tube Repair

A. Coupling standards approved for fuel tubing repair are presented in Fig. 601.

PART NAME	BOEING SERIES	HYDRAFLOW SERIES	WIGGINS SERIES	MS PART NO.
Body	BACC42T-	TC001-	S83051-	--
Ferrule	BACF32F-	TC010-	S83052-	--
Nut	BACN10KP-	TC002-	S8305-	--
Ring	BACR12BR-	TC001-	8395-	--
O-Ring	--	--	--	MS29513 *[1]

*[1] Standard O-ring sizes as defined by MS33666. O-ring material to be selected on the basis of fluid compatability.

Approved Rigid Couplings
Figure 601

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- B. Use of flexible and semi-flexible couplings may be approved on an individual basis when it can be shown that the tube is adequately supported and the flexibility is desired.

3. Coupling Installation Procedures

- A. Determine length T of tube section cutout required to accommodate coupling fittings (Fig. 602).
- B. Cut out damaged tube section per BAC 5001-1.
- C. Fabricate replacement tube section in accordance with drawing specifications for original tube.
- D. Swage coupling fittings onto tube ends per BAC 5001-5.
- E. Assemble coupling per Fig. 603 and install lockwire per 20-20-02, double-twist method.
- F. Install bonding jumper between tube sections per 20-11-03 and Repair 3-1.

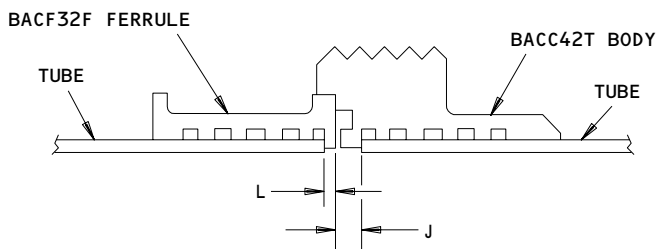
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$T = L + J$

WHERE: T = REQUIRED TUBE SECTION CUTOUT FOR COUPLING INSTALLATION
L = TUBE SETBACK FOR COUPLING FERRULE
J = TUBE SETBACK FOR COUPLING BODY

TUBE NUMBER	TUBE SIZE	L	J	T
4	1/4	0.035	0.09	0.125
5	5/16			
6	3/8			
8	1/2			
10	5/8	0.035	0.10	0.135
12	3/4			
14	7/8			
16	1			
20	1 1/4			
24	1 1/2			
28	1 3/4			
32	2	0.035	0.105	0.140
36	2 1/4		0.110	
40	2 1/2			
48	3	0.060	0.095	0.095
56	3 1/2			
64	4	0.035	0.100	0.135
72	4 1/2	0.080		0.180
80	5			
88	5 1/2		0.130	0.210

NOTE: ALL DIMENSIONS ARE IN INCHES

Tube Section Cutout to Accomodate Coupling
Figure 602

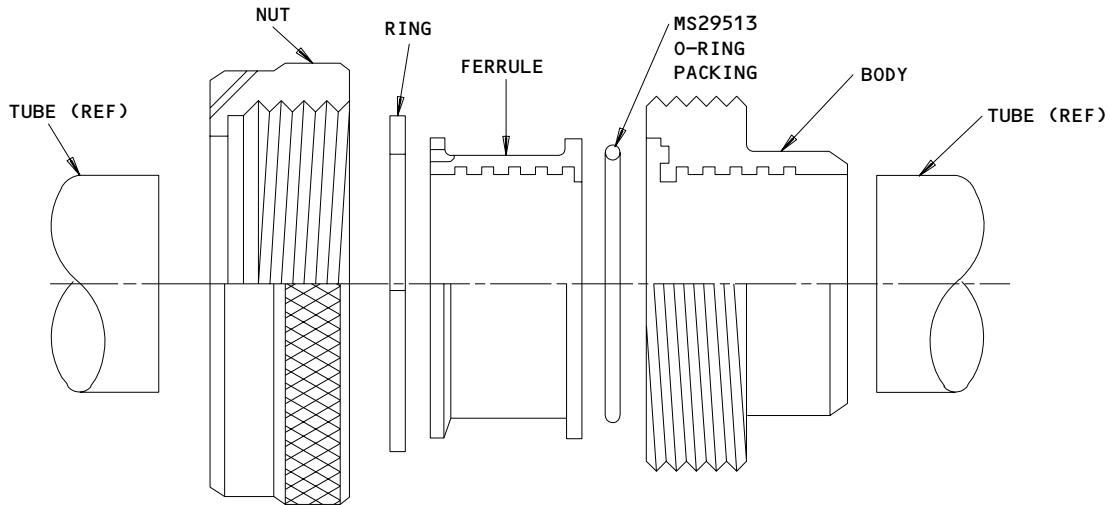
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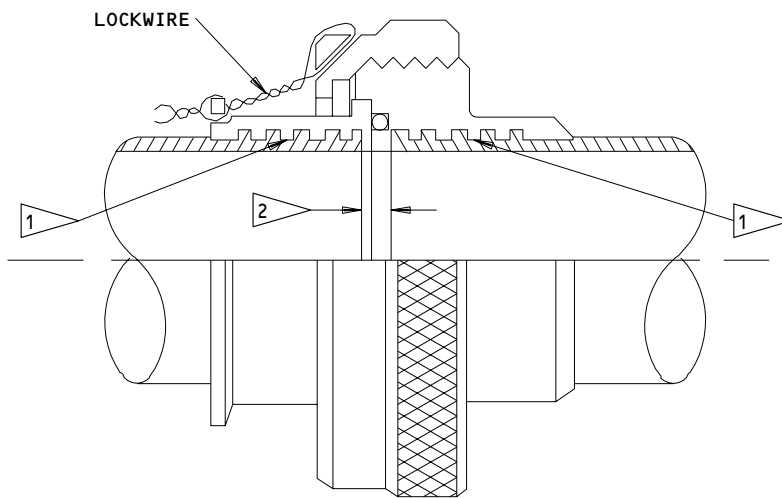
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EXPLODED VIEW



ASSEMBLED VIEW

PART NAME	PART NUMBER	
	BOEING STD.	AEROSPACE STD.
BODY	BACC42T	AS1732
NUT	BACN10KP	AS1734
RING	BACR12BR	AS1736
FERRULE	BACF32F	AS1737

CONVERSION FROM SUPERSEDED BOEING STANDARD TO SUPERSEDING AEROSPACE STANDARD

- 1 COUPLING FITTINGS SWAGED ONTO CUT TUBE ENDS PER BAC 5001-5
- 2 TUBE SECTION CUTOUT "T" PER FIG. 602

Rigid Tube Coupling Installation
 Figure 603

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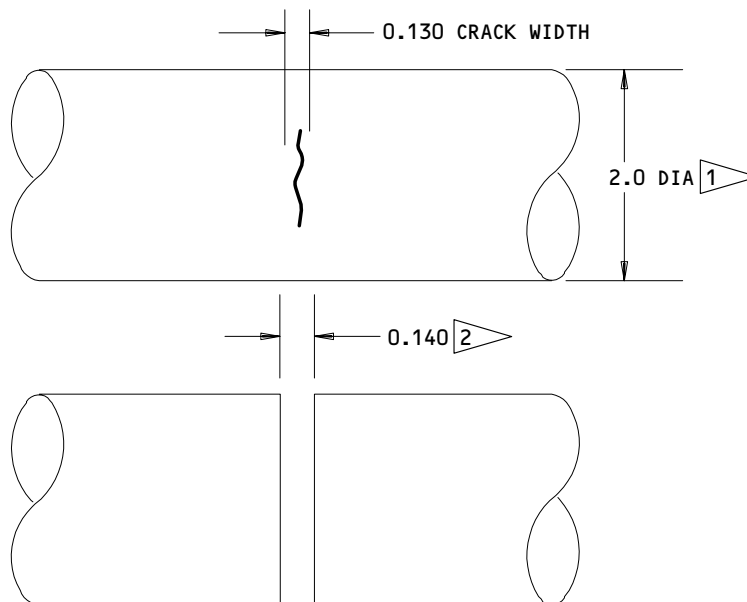
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4. Coupling Repair Examples

- A. A typical repair for a tube with a crack running circumferentially on a fuel tube is shown in Fig. 604. Since the width of the damaged area is less than the section cutout required to install the coupling (Fig. 602), the single coupling repair method is acceptable.



1 NO. 32 TUBE

2 REQUIRED TUBE SECTION CUTOUT PER FIG. 602

Example of Single Coupling Repair
Figure 604

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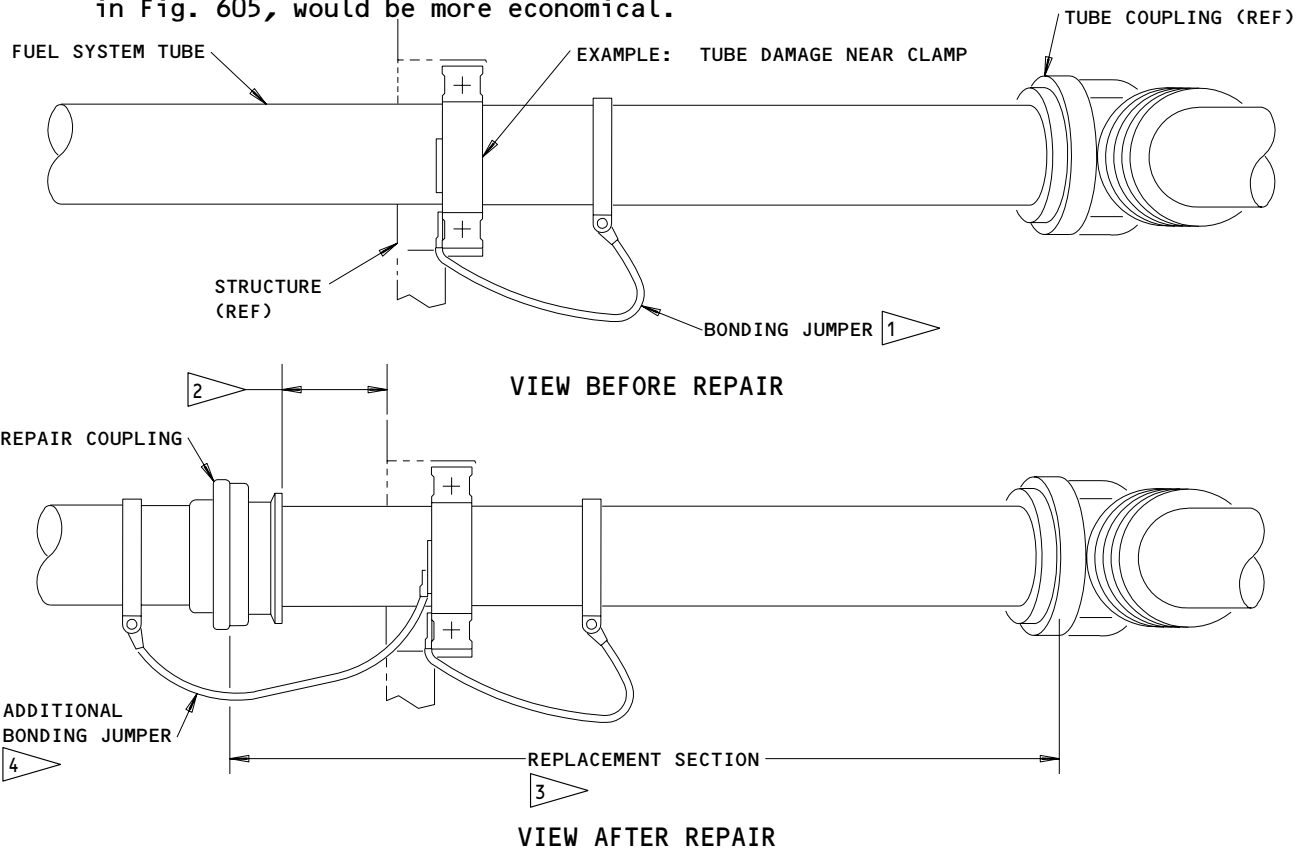
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B. In certain situations, such as a crack close to supports, structure, or the end of a tube section, replacement of the tube end section, as shown in Fig. 605, would be more economical.



- 1 INSTALLATION PART
- 2 LOCATE COUPLING AS REQUIRED TO CLEAR DAMAGED AREA AND TO PROVIDE ADEQUATE CLEARANCE BETWEEN COUPLING AND STRUCTURE
- 3 FABRICATE REPLACEMENT SECTION PER CONTROLLING BOEING PROCESS SPECIFICATIONS LISTED IN REPAIR-GENERAL
- 4 INSTALL PER REPAIR 3-1

NOTE: REPAIR OF STRAIGHT TUBE SECTION SHOWN. REPAIR OF RADIUS BENT TUBING SIMILAR.

Replacement of Tube End Section
 Figure 605

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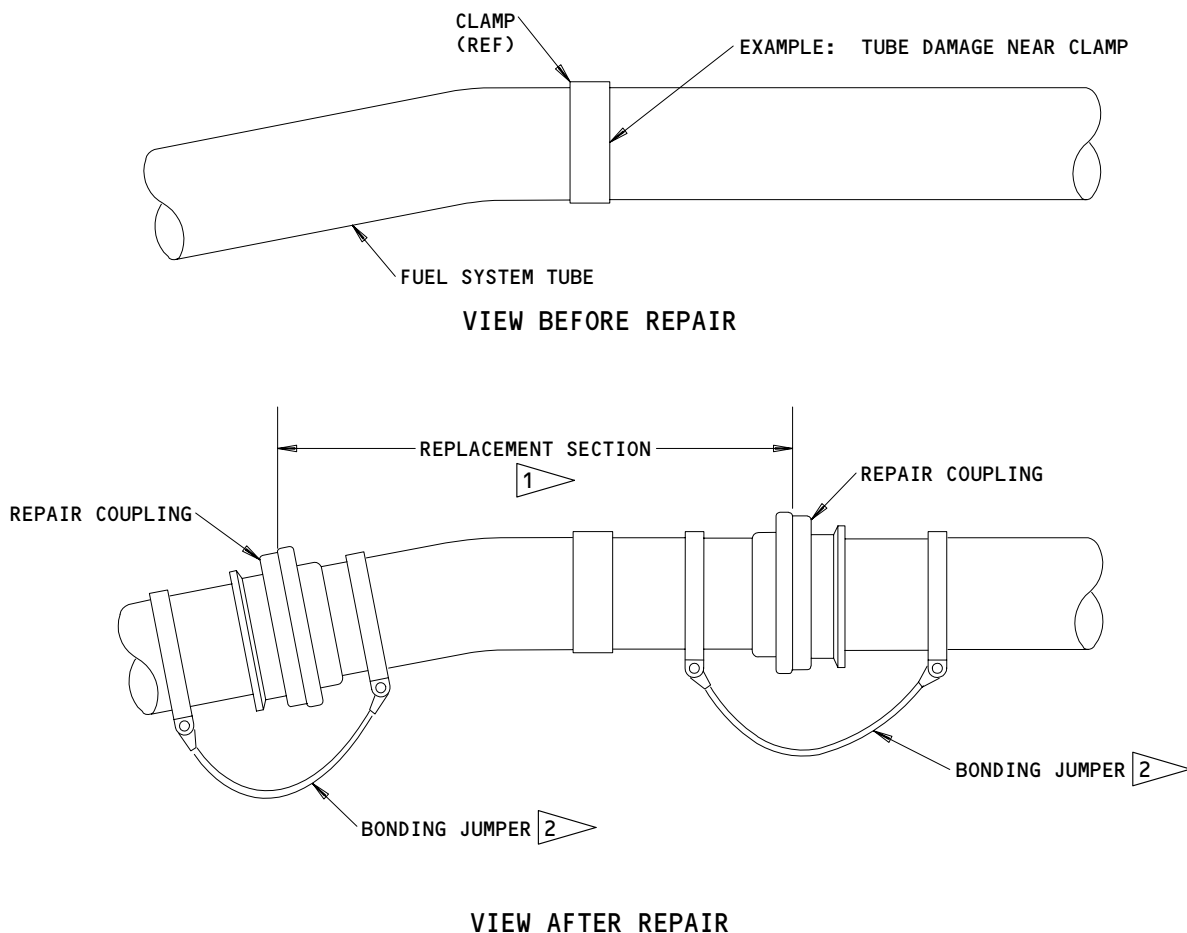
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C. When length of damaged tubing exceeds amount of section cutout required to install a single coupling, longer sections of tubing may be removed and replaced using two coupling joints as shown in Fig. 606.



- 1 FABRICATE REPLACEMENT SECTION PER CONTROLLING BOEING
PROCESS SPECIFICATIONS LISTED IN REPAIR-GENERAL
- 2 INSTALL PER REPAIR 3-1

Section Replacement Using Two Coupling Joints
Figure 606

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TEMPORARY WELD REPAIR METHOD – REPAIR 2-1

NOTE: Refer to REPAIR-GEN for list of applicable standard practices and references.

1. General

CAUTION: A TEMPORARILY REPAIRED TUBE MUST BE REPLACED WITH A NEW SECTION OF TUBE WITHIN A MAXIMUM OF 250 FLIGHT HOURS.

- A. This is a temporary repair method approved for 6061 and 5052 aluminum fuel system tubing, and is applicable only to tubes with wear-through damage, cracks, or punctures.
- B. Repair is accomplished with tubing removed from airplane.

2. Repair Procedures

CAUTION: FAILURE TO CLEAN TUBING MAY RESULT IN CONTAMINATION OF THE WELD, THEREBY AFFECTING WELD QUALITY.

- A. Completely clean inner and outer surfaces of entire tube section with solvent, Series 80 (Ref 20-30-80), per 20-30-03.
- B. If tubing is cracked, drill 3/32-inch stop holes at each end of crack.
- C. Clean tubing per BAC 5765, Method 3, or use wire brush to descale and remove all protective coatings and oxides from area to be welded, per BAC 5748.

NOTE: Wire brushes used for descaling must have bristles of austenitic corrosion-resistant steel or nickel-silver.

- D. Remove all residue by wiping or rinsing with solvent, Series 88 (Ref 20-30-88).

CAUTION: EXCESSIVE PRESSURE WITHIN TUBE DURING WELDING MAY ADVERSELY AFFECT WELD BEAD CONFIGURATION.

- E. Fusion weld damaged area by gas tungsten arc process per BAC 5975, Class A, using 4043 filler rod.

3. Inspection and Testing

- A. Penetrant check welded area per 20-20-02.
- B. Rinse with solvent, Series 88 (Ref 20-30-88).

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C. Hydrostatically test repaired tube to 240 psig per BAC 5001-2. There shall be no leakage.

NOTE: Use the pressure test value shown on the engineering drawing to hydrostatic test fuel vent or drain tubes. Contact Boeing if a pressure test value is not shown on the drawing.

4. Refinish

A. Finish repaired area with appropriate protective coatings as required to meet original tube finish requirements.

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PERMANENT WELD REPAIR METHOD – REPAIR 2-2

NOTE: Refer to REPAIR-GEN for list of applicable standard practices and references.

1. General

CAUTION: PATCH REPAIR OF TUBING IS NOT APPROVED.

- A. An acceptable method of permanent weld repair for 6061 and 5052 aluminum tubing is to cut out a length of tube as required to remove the damaged area. The removed section is replaced by square butt welding a tube fabricated to the original tube material specifications.
- B. Repair is accomplished with tubing removed from airplane.

2. Repair Procedures

CAUTION: FAILURE TO CLEAN TUBING MAY RESULT IN CONTAMINATION OF THE WELD, THEREBY AFFECTING WELD QUALITY.

- A. Completely clean inner and outer surfaces of entire tube section with solvent, Series 80 (Ref 20-30-80), per 20-30-03.
- B. Secure tube in a jig with adequate clamping to prevent tube misalignment during welding.

NOTE: Tube ends should be indexed to ensure that repaired tube is of correct length and in proper alignment for reinstallation.

CAUTION: REPLACEMENT OF SHORT SECTIONS OF TUBE WITHIN A RADIUS BEND IS NOT APPROVED.

- C. Cut out length of tube as required to remove entire damaged section. Tube section cutout should be at least one inch long to allow for adequate bead separation and bead uniformity. If damage occurs on a radius bend of tubing, replace entire section of tubing between radius bend tangents, plus an additional 0.25 inches, minimum, at each tangent.
- D. Cut a replacement section of tubing to length, from stock made to original tube specifications, or equivalent.
- E. Completely clean inner and outer surfaces of replacement tube section with solvent, Series 80 (Ref 20-30-80) per 20-30-03.

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- F. Clean ends of tubing to be welded per BAC 5765, Method 3, or use wire brush to descale and remove all protective coatings and oxides from area to be welded, per BAC 5748.

NOTE: Wire brushes used for descaling must have bristles of austenitic corrosion-resistant steel or nickel-silver.

- G. Remove all residue by wiping or rinsing with solvent, Series 88 (Ref 20-30-88).

CAUTION: EXCESSIVE PRESSURE WITHIN TUBE DURING WELDING MAY ADVERSELY AFFECT WELD BEAD CONFIGURATION.

- H. Purge inside of tube with argon gas and keep filled with flowing (low volume) argon gas during welding.

- I. Fusion weld (square butt) replacement tube section in place by gas tungsten arc process per BAC 5975, Class A, using 4043 filler rod.

3. Inspection and Testing

- A. Penetrant check welded area per 20-20-02.

- B. Radiographic inspect per BSS 7041, optional for the fuel vent or drain tubes unless required by the engineering drawing.

- C. Rinse with solvent, Series 88 (Ref 20-30-88).

- D. Hydrostatically test repaired tube to 240 psig per BAC 5001-2. There shall be no leakage.

NOTE: Use the pressure test value shown on the engineering drawing to hydrostatic test fuel vent or drain tubes. Contact Boeing if a pressure test value is not shown on the drawing.

4. Refinish

- A. Finish repaired tube section with appropriate protective coatings as required to meet original tube finish requirements.

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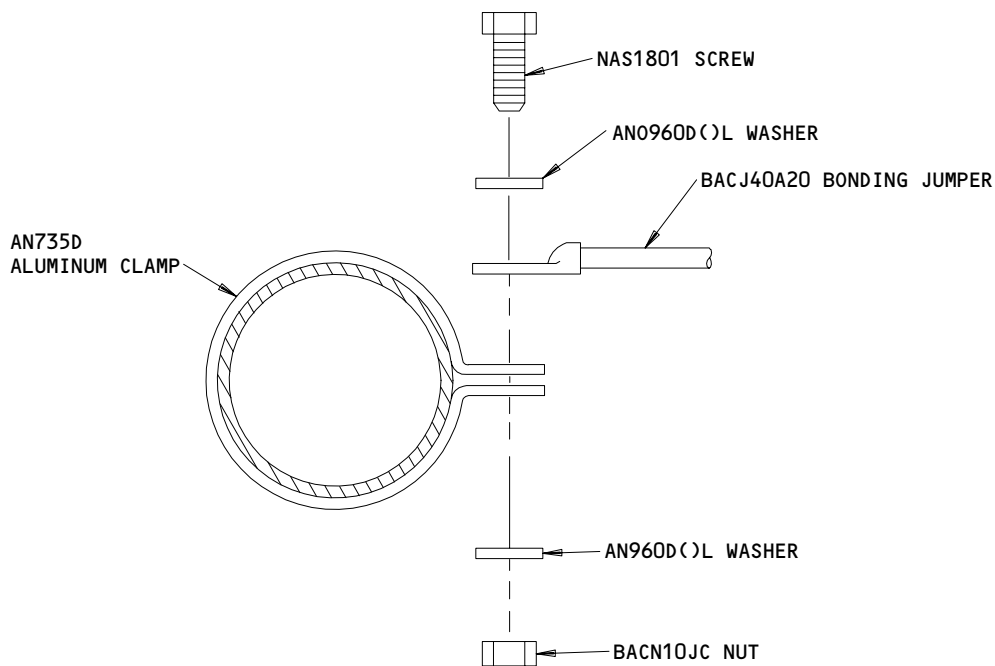
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ELECTRICAL BONDING OF FUEL TUBES – REPAIR 3-1

NOTE: Refer to REPAIR-GEN for list of applicable standard practices and references.

1. Attach bonding jumper per Fig. 601 to connect old and new sections of tube.

NOTE: All repaired tubing must be electrically bonded after reinstallation on the airplane, as specified in applicable Maintenance Manual procedures.



Typical Bonding Jumper Installation
Figure 601

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DENT/WRINKLE REPAIR PROCEDURE – REPAIR 4-1

1. General

- A. This repair procedure to remove wrinkles and dents is for aluminum vent or drain tubes with a low system operating pressures.
- B. The repair is accomplished with the tube removed from the airplane.
- C. All the repaired tube sections must be electrically bonded (REPAIR 4-1).
- D. Refer to the Standard Overhaul Practices Manual (SOPM) for the SOPM chapters identified in this procedure.

2. Tube Repair Procedure

A. Consumable Material

- (1) B01000 Solvent – Series 80 (SOPM 20-30-80)
- (2) B01008 Solvent – Series 88 (SOPM 20-30-88)

B. References

- (1) BAC 5001-2, Pressure Testing and Autofrettage of Tube Assemblies
- (2) BAC 5001-10, Tube Assemblies, Installation and Clamping
- (3) BAC 5001-12, Forming and Straightening of Ducts
- (4) BSS 7041, Radiographic Inspection
- (5) SOPM 20-20-02, Penetrant Method of Inspection
- (6) SOPM 20-30-02, Stripping of Finishes
- (7) SOPM 20-30-03, General Cleaning Procedures
- (8) SOPM 20-30-80, General Cleaning of Metal
- (9) SOPM 20-30-88, Solvents for Final Cleaning of Metal Before Non-Structural Bonding

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C. Procedure

CAUTION: USE NON-METALLIC TOOLS. METALLIC TOOLS ARE ONLY ALLOWED FOR INTERNAL MANDRELS OR ANVILS IF NECESSARY TO REMOVE WRINKLES.

(1) Tube Repair

- (a) Fully clean the inner and outer surfaces of the tube section with a series 80 solvent (SOPM 20-30-80) per (SOPM 20-30-03).
- (b) Secure the tube in an adequate fixture to prevent movement if necessary.
- (c) Remove wrinkles and/or dents as specified in the (BAC 5001-12). Reworked areas must meet the specifications of (BAC 5001-10).
- (d) Wipe or rinse with a series 88 solvent (SOPM 20-30-88) to remove all residue.

D. Inspection and Testing

- (1) Penetrant inspect reworked areas as specified in the (SOPM 20-20-02).
- (2) Radiographic inspect (BSS 7041), optional unless required by the engineering drawing.
- (3) Do a hydrostatic test of the repaired fuel vent or drain tube as specified in the (BAC 5001-2), there must be no leakage. Refer to the engineering drawing for the required pressure test value. Contact Boeing if a pressure test value is not on the drawing.

E. Refinish

- (1) Apply the applicable protective finish to the repaired area as shown on the design data.

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