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AEROSPACE STANDARD

SAE AS1650

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Submitted for recognition as an American National Standard

COUPLING ASSEMBLY, THREADLESS, FLEXIBLE, FIXED CAVITY, SELF-BONDING

1. SCOPE:

This document defines the requirements for a threadless, flexible, self-bonding coupling assembly, which, when installed on machined fixed cavity ferrules, provides a flexible connection for joining tubing and components in aircraft fuel, vent, or other systems. This assembled coupling, hereafter referred to as the assembly, is designed for use from -65 to 400 °F and at 125 psi operating pressure.

1.1 Product Classification:

The coupling assemblies shall be of the integral electrical bonding type.

2. REFERENCES:

2.1 Applicable Documents:

The following documents of the issue in effect on date of invitation for bids or request for proposals, form a part of this document to the extent specified herein unless otherwise specified.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS568	Aerospace Size Standard for O-Rings
AS1055	Fire Testing of Flexible Hose, Tube Assemblies, Coils, Fittings and Similar System Components
AS1651	Assembled Coupling, Threadless - Flexible, Fixed Cavity, Self-Bonding, Envelope Dimensions
AS1652	Coupling Assembly, Threadless - Fixed Cavity Ferrule Type, Self-Bonding
AS1653	Ferrule, Threadless Coupling - Fixed Cavity Swaged
AS1654	Sleeve, Threadless Coupling - Fixed Cavity Ferrule Type
AS1655	Coupling, Threadless - Fixed Cavity Ferrule Type, Self-Bonding

2.1.1 (Continued):

AS1656 Fitting End, Threadless Coupling - Ferrule or Sleeve, Design Standard
AS4734 Ferrule, Threadless Coupling - Fixed Cavity, Butt Welded

2.1.2 U.S. Government Publications: Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

PPP-T-60	Tape, Packaging, Waterproof
PPP-B-566	Boxes, Folding Paperboard
PPP-B-576	Box, Wood, Cleated, Veneer, Paper Overlaid
PPP-B-585	Boxes, Wood Wirebound
PPP-B-591	Boxes, Shipping Fiberboard, Wood-Cleated
PPP-B-601	Boxes, Wood, Cleated-Plywood
PPP-B-636	Boxes, Shipping Fiberboard
PPP-B-665	Boxes, Paperboard, Metal-Edged and Components
PPP-B-676	Boxes, Set-Up
VV-P-236	Petrolatum, Technical
WW-T-700	Tube, Aluminum Alloy, Drawn, Seamless, 6061
TT-S-735	Standard Test Fluids; Hydrocarbon
MIL-P-116	Preservation - Packaging, Methods of
MIL-B-5087	Bonding, Electrical and Lightning Protection
MIL-C-7024	Calibrating Fluid, Aircraft Fuel System Components
MIL-L-10547	Liners, Case and Sheet, Overwrap; Water-Vaporproof or Waterproof, Flexible
MIL-R-25988	Rubber, Fluorosilicone Elastomer, Oil & Fuel Resistant, Sheets, Strips, Molded Parts, & Extruded Shapes.
MIL-STD-105	Sampling Procedure and Tables for Inspection by Attributes
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-810	Environmental Test Methods
MIL-STD-831	Test Reports, Preparation of
MIL-STD-889	Dissimilar Metals

2.1.3 National Aerospace Standards: Available from Aerospace Industries Association, 1250 Eye Street NW, Washington, DC 20005.

NAS1787 Clamp, Tube Mounting

2.1.4 Uniform Classification Committee Publications: Available from The Uniform Classification Committee, 202 Chicago Union Station, Chicago, IL 60606.

Uniform Classification Committee
Uniform Freight Classification Rules

2.2 Definitions:

ASSEMBLED COUPLING: The completed coupled connection utilizing a coupling assembly to connect two ferrules, which are attached to tube ends.

COUPLING ASSEMBLY: The connecting device, which constrains the ferrules and provides a pressure seal and electrical continuity across the ferrules.

3. TECHNICAL REQUIREMENTS:

3.1 Qualification:

Assemblies furnished under this document shall be products which are qualified by meeting all of the requirements covered by this document. Manufacturers choosing to produce only a part or parts of the assembled coupling shall qualify the part or parts by complying with the requirements and performing all tests of this document. The test specimens for qualification of a part or parts shall be tested with a qualified part or parts made by other qualified manufacturers whenever possible.

3.2 Materials and Finishes:

Materials and finishes for the components shall be those designated on the applicable AS standard drawing. The assembly materials and finish shall be uniform in quality, free from defects, suitable for service, consistent with good manufacturing practice, and in conformance with the applicable specifications and requirements stated herein.

3.2.1 Dissimilar Materials: Materials shall possess adequate corrosion-resistance characteristics or shall be suitably protected by the use of finishes to resist corrosion, which may result from such conditions as dissimilar metal combinations, moisture, salt spray, and high-temperature deterioration. Dissimilar materials are defined by MIL-STD-889.

3.3 Design and Fabrication:

The assembly shall be a lightweight flexible connection for fuel, vent, and other system lines using the basic principles of O-ring sealing. It shall be capable of operating at 125 psig operating pressure at temperatures from -65 to +200 °F in aluminum and -65 to +400 °F in CRES. The assembly shall function at a maximum misalignment of 4° or maximum gap of .250 in or, in combination, a minimum gap of .063 in at 3° misalignment. If a component uses a sleeve end (AS1656-2-SIZE), the maximum misalignment is 2° or a maximum gap of .250 in.

3.3.1 Assembled Coupling Components: The assembled coupling shall consist of ferrules, O-ring seals and a coupling assembly, as specified in the following standards (see Reference AS1651):

a. Two ferrules: AS1653 or AS4734
b. Two O-ring seals: User defined
c. One coupling assembly: AS1652

3.3.2 Ferrule: Ferrules shall contain the fixed O-ring cavity. The design of the O-ring groove shall be for standard sizes as specified in Table 1. Attachment of the ferrule to the tubing shall be by mechanical roller swaging or welding. Ferrule material shall be compatible with the tubing to which it is attached and shall comply with MIL-STD-889.

3.3.3 Coupling Assembly: Coupling assemblies (AS1652) are provided to simplify drawing callouts. Ferrules are not considered integral to the coupling assembly because they are usually installed on tubing fabrication drawing and vary according to the attachment method.

3.3.3.1 Sleeve: The sleeve shall conform to AS1654 which is designed to carry only hoop stresses and to affect sealing. A portion of the sleeve outside surfaces shall be circumferentially grooved or knurled to facilitate installation and removal.

3.3.3.2 Coupling: The coupling shall lock when manually closed and shall be structurally capable of withstanding both the axial and bending moment loads transmitted by the system tubing when the tubing wall thickness is as specified in Table 2. The closure shall have clear indication of a locked condition both visually and by feel. Quick connect or disconnect action of the latch shall be utilized to allow assembly and removal with one hand. The coupling assembly shall provide a bonding means which meets the Class "S" electrical bonding requirements of MIL-B-5087.

3.3.4 Seals: O-rings are not considered a part of this document except for coupling qualification test requirements. O-ring sizes for the couplings are given in Table 1.

TABLE 1 - Physical Requirements

Coupling Size (Ref)	Tube Size (Ref)	Operating Pressure Min Neg (-) in Hg	Operating Pressure Min Pos (+) psig	Proof Pressure Min Neg (-) in Hg	Proof Pressure Min Pos (+) psig	Burst Pressure (Min)	AS568 O-ring Dash No. (Ref)
08	.500	24	125	28	250	375	-015
10	.625	24	125	28	250	375	-017
12	.750	24	125	28	250	375	-117
16	1.000	24	125	28	250	375	-214
20	1.250	24	125	28	250	375	-218
24	1.500	24	125	28	250	375	-222
28	1.750	24	125	28	250	375	-224
32	2.000	24	125	28	250	375	-226
36	2.250	10	125	12	250	375	-228
40	2.500	10	125	12	250	375	-230
48	3.000	10	125	12	250	375	-234
56	3.500	10	125	12	250	375	-238
64	4.000	10	125	12	250	375	-242

3.3.5 Dimensions: The assembly envelope dimensions shall be as specified in AS1651. Part dimensions shall be as specified in applicable AS part standards.

3.3.6 Weights: The individual components of the coupling shall not exceed the maximum weights listed on the applicable AS part standards.

3.4 Performance:

The assembled coupling shall meet the following performance requirements.

3.4.1 Proof Pressure: The assembled coupling shall meet the negative and positive proof pressures listed in Table 1 without leakage as specified or evidence of other malfunction. Testing is specified in 4.6.2.

3.4.1.1 Positive Pneumatic Leakage: The assembled coupling shall withstand pneumatic pressure equal to the proof pressure for 3 min at room temperature without any visible bubbles starting after 1 min at pressure or other malfunction that would affect assembly or disassembly.

3.4.1.2 Negative Pneumatic Leakage: The assembled coupling shall not exhibit a decrease in negative pressure exceeding 5 in Hg within a period of 5 min, when subjected to the negative proof pressure.

3.4.1.3 Liquid Leakage: The assembled coupling shall withstand liquid pressure equal to the proof pressure for 3 min at room temperature without allowing the escape of liquid or external wetting from any point of the assembly.

3.4.2 Fuel Resistance (Aging): The assembled coupling shall not show evidence of malfunction or leakage in excess of 3.4.1.3 when subjected to high temperature fuel aging, 200 °F, low temperature fuel aging, -65 °F, and air dry out, 200 °F. Testing is specified in 4.6.3.

3.4.3 Vibration: The assembled coupling shall show no evidence of malfunction or structural failure and no leakage in excess of 3.4.1.3 after exposure to vibration levels in accordance with 4.6.4. The resistance across the coupling shall not exceed 1 Ω.

3.4.4 Repeated Assembly: There shall be no evidence of deformation, damage, or degradation in latching ability to the assembled coupling and it shall not leak in excess of 3.4.1.3 when subjected to the burst pressure requirements of 3.4.9, after 100 repeated assembly operations. The resistance across the coupling shall not exceed 1 Ω. Testing is specified in 4.6.5.

3.4.5 Salt Fog: The assembled coupling shall show no evidence of leakage in excess of 3.4.1.3 when subjected to the Table 1 proof and burst pressures and shall show no evidence of excessive corrosion, peeling, chipping, or blistering of the finish nor exposure of base metal under plated surfaces after being subjected to salt fog. The resistance across the coupling shall not exceed 1 Ω. Testing is specified in 4.6.6.

3.4.6 Dust: The assembled coupling shall show no damage such as fouling of parts and no evidence of malfunction and shall be capable of withstanding Table 1 proof pressures without evidence of leakage in excess of 3.4.1.3 after being subjected to the dust test. The resistance across the coupling shall not exceed 1 Ω. Testing is specified in 4.6.7.

3.4.7 Flexure: The assembled coupling shall withstand Table 1 burst pressure without evidence of leakage in excess of 3.4.1.3 with no binding or galling of parts after being subjected to 28 800 flexure cycles with the coupling at an offset of 3°. Testing is specified in 4.6.8.

3.4.8 Pressure Impulse: The assembled coupling shall withstand 100 000 pressure impulse cycles as defined in Figure 5 without evidence of malfunction or leakage in excess of 3.4.1.3. Testing is specified in 4.6.9.

3.4.9 Burst: The assembled coupling shall not rupture nor show evidence of leakage in excess of 3.4.1.3 at any pressure up to the Table 1 burst pressures. Testing is specified in 4.6.10.

3.4.10 Electrical Bonding: The electrical resistance of the assembled coupling, when measured from tube to tube, shall not exceed 1 Ω at any time. Testing is specified in 4.6.11.

3.5 Identification of Product:

Coupling assembly parts and ferrules shall be marked for identification in accordance with MIL-STD-130 as specified on the applicable AS standard or drawing.

3.6 Workmanship:

Coupling components shall be manufactured and finished in accordance with commercially accepted practices and processes.

3.7 Cleaning:

The coupling components as supplied shall be free of oil, grease, dirt, or any other foreign material both internally and externally.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection and test requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the procuring activity for the performance of the inspection and test requirements. The procuring activity reserves the right to perform any of the inspections and tests set forth in the specification, where such inspections and tests are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of Inspections:

The examining and testing of assemblies shall be classified as:

a. Qualification inspections (4.3)
b. Quality conformance inspections (4.4)

4.3 Qualification Inspections:

4.3.1 Qualification Test Specimens: Aluminum alloy test specimens in accordance with Figure 1A or 1B and Table 3 shall be used for all tests specified herein. The number of specimens are specified in 4.3.2. Tubing for fabrication of test specimens shall be 6061-T6 in accordance with WW-T-700/6 with dimensions as shown in Table 2. Attachment of ferrules to tubing shall be in accordance with user specifications.

Qualification of CRES and titanium couplings shall be by similarity, subject to approval by the user.

TABLE 2 - Tube Size and Wall Thickness

Coupling Size (Ref)	Tube Size In (Ref) /1/	Tube Wall Thickness /2/
08	.500	.035
10	.625	.035
12	.750	.035
16	1.000	.035
20	1.250	.035
24	1.500	.035
28	1.750	.045
32	2.000	.035
36	2.250	.042
40	2.500	.042
48	3.000	.042
56	3.500	.049
64	4.000	.049

/1/ All sizes listed are not required for qualification testing but are included in the event that the user specifies additional testing.

/2/ Aluminum drawn tubing, 6061-T6 in accordance with WW-T-700/6.

4.3.2 Test Schedule and Sequence: Seven test specimens each for coupling sizes 08, 16, 24, 32, and 40 and six test specimens each for coupling sizes 48 and 64 shall be subjected to qualification tests in the order indicated in Table 3. MIL-R-25988/1A O-rings shall be used for all test specimens. Sizes other than those listed and smaller than size 64 are considered qualified by design similarity.

TABLE 3 - Test Schedule and Sequence

Specimen Numbers	1	2	3	4	5	6	/3/ 7
Applicable Tests	4.6.1 4.6.2 4.6.11 4.6.3 4.6.4 /1/ 4.6.2 4.6.11 4.6.10	4.6.1 4.6.2 4.6.11 4.6.3 4.6.4 /1/ 4.6.2 4.6.11	4.6.1 4.6.2 4.6.11 4.6.7 4.6.11 4.6.8 4.6.2 4.6.11 4.6.10	4.6.1 4.6.2 4.6.11 4.6.7 4.6.11 4.6.8 4.6.2 4.6.11	4.6.1 4.6.2 4.6.11 4.6.5 4.6.6 4.6.9 4.6.2 4.6.11 4.6.10	4.6.1 4.6.2 4.6.11 4.6.5 4.6.6 4.6.9 4.6 2 4.6.11	4.6.1 4.6.2 4.6.11 4.6.4 4.6.2 4.6.11

/1/ Specimens 1 and 2 will not be subjected to the vibration tests of 4.6.4 in sizes -08, -16, -24, -32, and -40. All other tests are applicable. Specimen 7 will be used for vibration testing of these sizes. Specimens 1 and 2 in sizes -48 and -64 will be subjected to the vibration tests of 4.6.4.

4.3.3 Test Report, Test Samples, and Data for the Procuring Activity: When the tests are conducted at a location other than the laboratory of the procuring activity:

a. Test Report: A minimum of three copies of a test report in accordance with MIL-STD-831, which shall include a report of all tests and an outline description of the tests and conditions.

b. Test Sample: The sample which was tested, when requested by the procuring activity.

c. Test Data: A minimum of three sets of engineering data in the form of assembly drawings. The assembly drawings shall have a cut-away section showing all details in their normal assembled position and shall carry part numbers of all details and subassemblies.

NOTE: Log sheets, containing required test data, shall remain on file at the suppliers test facility and shall be made available upon request.

4.3.4 Qualification Inspection Methods: Qualification inspection methods shall consist of all the examinations and tests specified in 4.6.

4.4 Quality Conformance Inspections:

Each coupling component shall be subjected to examination of product as specified in 4.6.1.

4.4.1 Quality Conformance Inspection Sampling: If sampling is used to determine compliance, the sample size shall be in accordance with MIL-STD-105. Recommended classes, AQLS, and defect characteristics referred to in MIL-STD-105 are presented in 6.2.

4.4.2 Rejection and Retest: Where one or more items selected from a lot fails to meet the specification, all items in the lot shall be inspected for the particular characteristic that failed.

4.4.2.1 Resubmitted Lots: Once a lot (or part of a lot) has been rejected by a procuring activity (Government or Industrial), before it can be resubmitted for tests, full particulars concerning the cause of previous rejection and the action taken to correct the defects in the lot shall be furnished, in writing, by the manufacturer to the procuring activity.

4.5 Test Conditions:

4.5.1 Assembly of Test Specimens: O-rings shall be lubricated with VV-P-236 Petrolatum, or equivalent.

4.5.2 Test Fluids: Test fluids shall be Type I or Type III, in accordance with TT-S-735 or as specified for each test.

4.5.3 Pressure Measurements: Unless otherwise specified, positive pressure measurements shall have a tolerance of ±10 psi. Negative pressures shall be equal to or greater than the specified value.

4.5.4 Temperature Measurements: Unless otherwise specified, the test specimens and fluid shall be maintained within ±5 °F. Ambient temperature measurements shall be taken within 6 in of the specimen.

4.6 Inspection Methods:

4.6.1 Examination of Product: Each assembly or part shall be visually and dimensionally inspected to determine compliance with this document and the applicable standard or drawing with respect to material, size, workmanship, and AQL level as specified in Table 12.

4.6.2 Proof Pressure: Test specimens shall be installed as shown in Figure 2 and subjected to Table 1 positive and negative proof pressures in conjunction with and as specified in other tests.

4.6.2.1 Negative Pneumatic Proof Pressure: Test specimens shall be dry and free of fuel or test fluid vapors. The connection between the test specimen and vacuum pump shall be 1/2 in nominal hose or tube size minimum and shall not exceed a length of 10 ft. A stop valve shall be installed between the test specimen and the vacuum pump. Pressure shall be measured within 6 in of the test specimen. A negative proof pressure equal to or greater than the Table 1 specified pressure shall be maintained for 15 min. The stop valve shall then be closed and the pressure shall be monitored for 5 min.

4.6.2.2 Positive Pneumatic Proof Pressure: Test specimens shall be immersed in water and proof pressure tested to the Table 1 positive value for a minimum of 3 min. Measurements shall begin after a 1 min stabilization period. The test fluid shall be dry compressed air or nitrogen.

4.6.2.3 Positive Liquid Proof Pressure: Test specimens shall be wiped dry and proof pressure tested to the Table 1 positive value for not less than 3 min and not more than 5 min. The test fluid shall be as specified in other tests or may be water.

4.6.3 Fuel Resistance: Test specimens 1 and 2, as specified in Figure 1, shall be mounted on a test fixture, as shown in Figure 2, with 3° misalignment between tube centerlines for each size coupling to be qualified. Tube end (L2) shall be rigidly clamped and tube end (L1) shall be clamped with clearance to allow axial movement of the tube until it is restrained by the coupling. Clamp blocks adjacent to the coupling shall be spaced 20 in apart. The coupling shall be centered between clamp blocks. The measured resistance across the coupling shall be measured before and after each step of the fuel resistance test per 4.6.11.

4.6.3.1 High Temperature Aging: Proof pressure test the test specimens in accordance with 4.6.2.3 and Table 1 positive proof pressure using TT-S-735, Type III test fluid. The pressure shall then be reduced to 125 psi and ambient and fluid temperatures shall be increased to 200 °F. After temperature stabilization, the test shall be continued for a minimum of 72 h maintaining a fluid and ambient temperature of 200 °F. Upon completion and while at 200 °F, the specimens shall be subjected to a positive proof pressure test in accordance with 4.6.2.3. The ambient and fluid temperatures shall then be reduced to room temperature condition.

4.6.3.2 Low Temperature Aging: The TT-S-735 Type III test fluid shall be removed from the test specimens and the specimens filled with TT-S-735 Type I test fluid. The test specimens shall be proof pressure tested in accordance with 4.6.2.3. The pressure shall then be reduced to 125 psi and ambient and fluid temperatures shall be lowered and stabilized at -65 °F.

The test shall be continued for a minimum of 72 h maintaining a fluid and ambient temperature of -65 °F. Upon completion and while at -65 °F, the specimens shall be subjected to a positive proof pressure test in accordance with 4.6.2.3. The ambient and fluid temperatures shall then be increased to room temperature conditions, the test fluid drained, and the specimens dried without disassembly or removal from test fixture.

4.6.3.3 High Temperature Drying: The test specimens while vented to the atmosphere shall be maintained for 168 h at 200 °F. Upon completion, the specimens shall be filled with TT-S-735 Type I test fluid and the low temperature test in accordance with 4.6.3.2 shall be repeated one additional time except upon completion the test fluid will not be drained. Resistance across the coupling shall then be measured in accordance with 4.6.11. Without disassembly of the couplings or removal from the test fixture, the couplings shall be subjected to vibration testing in accordance with 4.6.4.

4.6.4 Vibration:

4.6.4.1 Line Sizes -48 through -64: At the completion of the fuel resistance test in accordance with 4.6.3, and without disassembly or removal from the test fixture, test specimens 1 and 2 shall be subjected to vibration testing at room temperature. The vibration time shall be divided equally between the specimen pressurized with TT-S-735, Type I test fluid at 125 psi and at the Table 1 negative operating pressure while empty. The resistance across the coupling shall be periodically measured in accordance with 4.6.11.

a. Input: Plots of the actual vibration input spectra for each axis and test level.

b. Response: Frequency response plots of transmissibility (response/input) versus frequency for the equipment response points. Frequencies associated with minimum performance or other frequencies selected for resonance dwell points shall be identified on response points.

c. Chronological Log: The log shall contain clear description of test being performed and shall include all pertinent information concerning conduct of test, equipment performance, identification and description of failures, and/or degradations during the vibration testing shall be fully documented as well as the remedial action taken.

4.6.4.1.1 Resonance Survey: A sinusoidal resonance survey shall be made in each orthogonal axis noted in Figure 2. The frequency sweep shall be made slowly from 5 to 2000 Hz at .024 in double amplitude, or ±2 g, whichever is less. Resonance points shall be noted and resonance recorded and the modes of each resonance described. Resonant points used for resonance vibration shall be determined by input versus output levels as obtained per 4.6.4.1 (b). A resonance is defined as a magnification of output to input level by a factor of two or more.

4.6.4.1.2 Sinusoidal Vibration Test: The test specimens shall be vibrated in each orthogonal axis, as shown on Figure 7A, with up to two resonance dwells in the 5 to 2000 Hz range, for test times specified in Table 5.

If more than two resonance frequencies are noted, only the most severe points shall be used for resonance dwell. The double amplitudes or acceleration levels shall be in accordance with Table 4.

TABLE 4 - Vibration Levels (Sinusoidal)

Frequency	Amplitude or Acceleration Level
5 - 18 Hz	.10 in Double Amplitude
18 - 24 Hz	±1.5 g
24 - 50 Hz	.036 in Double Amplitude
50 - 1000 Hz	±5 g

TABLE 5 - Vibration Test Times

Number of Resonances	0	1	2
Total dwell times at resonance points (minutes)	0	30	60
Total cycling time (minutes)	90	60	30

4.6.4.2 Line Sizes -08 thru -40: (Specimen No. 7 Only)

4.6.4.2.1 General: All vibration testing shall be performed using the test fixturing of Figure 6. Accelerometers rigidly mounted on the fixture shall be used to control input acceleration forces. Response accelerometers rigidly mounted on each of the test specimens shall be used to monitor acceleration output forces on each of the test specimens. Each test specimen shall be mounted to the vibration fixture at a minimum angular displacement of 3° between tube centerline and shall be free to move axially to accommodate end loads to internal pressure prior to tightening. The distance between the inboard tube supports with the coupling mounted in the center shall be 20 in for all sizes. The distance between inboard and outboard tube supports shall be 4.5 in. Tube supports shall be NAS 1787 or equivalent. The test setup shall be photographed showing test specimens installed on test fixture locating input and response accelerometers and direction of test axes.

Resonant modes shall be monitored aurally and visually by comparison of input versus output level and by waveform shape change. Input vibration spectrum shall be within the tolerance of +3/-1.5 dB below 500 Hz and within ±3 dB between 500 and 2000 Hz except that ±6 dB are permissible over a cumulative bandwidth of 200 Hz maximum between 500 and 2000 Hz. Vibration frequency tolerance shall be ±2% or ±1/2 Hz below 25 Hz. Vibration amplitude tolerance shall be ±10% as used in sinusoidal vibration. A detailed chronological test log shall be maintained to verify conformance with test requirements.

The outboard end of each tube shall be suitably plugged and ported to provide for test fluid filling and pressurization. Test fluid shall be Stoddard Solvent per MIL-C-7024C pressurized to 125 psig ± 10 for all testing. The x- and y-axis of vibration shall be performed horizontally with the fixture rigidly mounted to a slip plate. The x-axis vibration shall be along the axial centerline of the tube assemblies. (Disregarding the 1-1/2° per tube offset). The y-axis shall be perpendicular to the tube centerline. The z-axis shall be perpendicular to the tube centerline but mutually perpendicular to the x- and y-axes. See Figure 7B.

All vibration testing shall be performed at room temperature. Electrical bond testing per 4.6.11 shall be conducted periodically.

4.6.4.2.2 Nongunfire Vibration:

4.6.4.2.2.1 Sinusoidal Vibration:

4.6.4.2.2.1.1 Resonance Survey: A sinusoidal resonance survey shall be made in each orthogonal axis noted in Figure 7B. The frequency sweep shall be made slowly from 5 to 2000 Hz at .024 in double amplitude, or ±2 g, whichever is less. Resonance points shall be noted and resonance recorded and the modes of each resonance described. Resonant points used for resonance vibration shall be determined by input versus output response levels.

4.6.4.2.2.1.2 Frequency Cycling and Resonance Dwell: Test specimens shall be vibrated in each orthogonal axis as shown on Figure 7B, with up to two resonance dwells in the 5 to 50 Hz range, for test times specified in Table 5. If more than two resonant frequencies are noted, only the most severe points shall be used for resonance dwell. The double amplitude and acceleration levels shall be in accordance with Table 6.

TABLE 6 - Vibration Levels (Nongunfire)

Frequency	Acceleration or Double Amplitude
5 - 9	.20 in Double Amplitude
9 - 17	.10 in Double Amplitude
17 - 29	±1.5 g
29 - 50	.036 in Double Amplitude

Logarithmic cycling sweep periods shall be 7.5 min per 5-50-5 Hz cycle. The actual input and response accelerations shall be plotted for one partial cycle, 5 to 50 Hz and selection of resonances from 4.6.4.2.2.1.1 shall be confirmed. If more than two resonances are encountered, the two most severe shall be utilized as evidenced by output versus input acceleration level. Double amplitudes and acceleration level shall be per 4.6.4.2.2.1.2. The test specimens shall not exhibit leakage during or subsequent to test. At each resonance, retuning shall be performed as necessary to maximize the response. Amplitude, response and frequency at the beginning and end of each dwell period shall be recorded.

4.6.4.2.2.2 Random Vibration: Prior to the test on each of the three orthogonal axes, the fixture with specimens shall be equalized to provide conformance with the vibration levels below.

The fixture with specimens shall be subjected to 3 h on each axis of vibration testing utilizing the acceleration levels of Table 7.

The actual control input response levels shall be plotted from 50 to 2000 Hz as G^2/Hz versus frequency and the overall gravity root/mean square at start, .5, 1.5, and 3 h into test shall be recorded.

TABLE 7 - Acceleration Levels (Nongunfire)

Frequency (Hz)	Power Spectral Density G^2/Hz
50 - 300	Beginning at .04 increasing at approximately +5 dB/Octave to .75 at 300 Hz
300 - 1000	Flat at .75
1000 - 2000	Beginning at .36 decreasing -6 dB/Octave to .09 at 2000 Hz
	(Overall +28.1 G rms)

4.6.4.2.3 Gunfire Vibration:

4.6.4.2.3.1 Sinusoidal Vibration:

4.6.4.2.3.1.1 Resonance Survey: The data obtained in 4.6.4.2.2.1.1 shall be used to the extent applicable to conduct gunfire vibration testing.

4.6.4.2.3.1.2 Frequency Cycling and Resonance Dwell: Utilizing any resonance frequencies encountered in 4.6.4.2.2.1.1, resonance dwell times and cycling times in minutes on each orthogonal axis shall be per Table 9. Double amplitudes or accelerations shall be in accordance with Table 8.

TABLE 8 - Vibration Levels (Gunfire)

Frequency (Hz)	Double Amplitude or Acceleration
50 - 81	.036 in Double Amplitude
81 - 210	±12 G
210 - 297	.00532 in Double Amplitude
297 - 500	±24 G

Logarithmic cycling time from 50-500-50 Hz shall be 7.5 min.

The actual control input and response accelerations for one partial sweep from 50 to 500 Hz shall be plotted and selection of equipment resonances from 4.6.4.2.2.1.1 shall be confirmed.

The fixed narrow band dwells shall be performed by sweeping the frequency about ±5% of the specified center frequency. For example, the 100 Hz dwell shall be performed from 95 to 105 Hz. The sweep rate shall be approximately the same as that used for the sweep testing in the same frequency range.

TABLE 9 - Vibration Test Times (Gunfire)

Number of resonances	0	1	2	3
Sweep time	30.0	22.5	15.0	7.5
Resonance dwell time	--	7.50	15.00	22.50
Fixed dwell at the following center frequencies:				
F_D = 67 Hz	7.50	7.50	7.50	7.50
100 Hz	7.50	7.50	7.50	7.50
135 Hz	7.50	7.50	7.50	7.50
200 Hz	15.00	15.00	15.00	15.00
267 Hz	7.50	7.50	7.50	7.50
300 Hz	7.50	7.50	7.50	7.50
335 Hz	7.50	7.50	7.50	7.50
400 Hz	15.00	15.00	15.00	15.00
467 Hz	7.50	7.50	7.50	7.50
500 Hz	7.50	7.50	7.50	7.50
Total time each axis	120.00	120.00	120.00	120.00

4.6.4.2.3.1.3 Selection of Resonance Dwells Bordering Fixed Dwells: When equipment resonance occurs within ±5% of a fixed dwell frequency, the fixed dwell period shall be omitted and only the resonance dwell performed. The omitted fixed dwell time shall then be added to the sweep time. Retuning shall be performed as necessary to maximize response at each equipment resonance.

4.6.4.2.3.2 Random Vibration: Prior to the test on each of the three orthogonal axes, the fixture with specimens shall be equalized to provide conformance with the vibration levels below.

The fixture with specimens shall be subjected to 30 min on each axis of vibration testing utilizing the acceleration levels of Table 10.

The actual control input and response levels from 500 to 2000 Hz shall be plotted as G^2/Hz versus frequency and overall G rms at start and end of test shall be recorded.

TABLE 10

Frequency (Hz)	Power Spectral Density G^2/Hz
500 - 1000	2.9
1000 - 2000	Decreasing -9 dB/Octave
(Overall = 50.4 G rms)	

4.6.5 Repeated Assembly: Test specimens 5 and 6 shall be mounted as specified in Figure 3 with a misalignment of 3° between tube centerlines. The coupling of each test assembly shall be unlatched, removed from the ferrules and sleeve, reinstalled, and latched 100 times. The ferrules and sleeve shall not be separated during this test. After completion of the test, the assemblies shall be proof pressure tested in accordance with 4.6.2.3 using TT-S-735, Type III, test fluid. The resistance across the coupling shall be measured in accordance with 4.6.11.

4.6.6 Salt Fog: Test specimens 5 and 6 as shown in Figure 1 shall be mounted in a suitable chamber and exposed to salt fog for 168 h in accordance with MIL-STD-810, Method 509.3. The test specimens shall then be subjected to the proof pressure test of 4.6.2.3 except that the pressures of 5 and 250 psi shall be held for a period of 1 min each. The resistance across the assembled coupling shall be measured in accordance with 4.6.11.

4.6.7 Dust: Test specimens 3 and 4 as shown in Figure 2 shall be mounted in a suitable dust chamber and tested in accordance with MIL-STD-810, Method 510.3. After the dust test, a proof pressure test shall be performed using TT-S-735, Type III, test fluid in accordance with 4.6.2.3 except hold pressures of 1, 5, 25, 50, and 125 psi for 1 min. The resistance across the coupling assembly shall be measured in accordance with 4.6.11.

4.6.8 Assembly Flexure: Test specimens 3 and 4 as shown in Figure 1 shall be mounted in the flexure test setup as illustrated by Figure 3. The 12 in tube shall be rigidly fixed and the 20 in tube shall be initially misaligned 3° between the tube centerlines. Axial movement of the 20 in tube shall be constrained only by the coupling assembly. The test setup shall provide for rotary or planar flexure of the 20 in tube. Tube displacement during flexure shall be equivalent to ±.5° movement in each direction from the initial 3° misalignment of the tube. Flexure shall be conducted at 60 cpm ± 5 and the test fluid shall be TT-S-735, Type I. Each test specimen shall be subjected to the following test sequence.

a. Prior to flexure and at room temperature, the assembly shall be proof pressure tested in accordance with 4.6.2.3 for a minimum of 5 min.

b. The test specimen shall then be depressurized and soaked while full of test fluid, at a temperature of 200 °F for a minimum of 1 h.

c. While at 200 °F and misaligned, the test specimen shall be proof pressure tested in accordance with 4.6.2.3 for a minimum of 5 min.

d. The pressure shall then be reduced to Table 1 operating pressure, the test specimen shall be flexure tested for a minimum of 4 h at 200 °F (14 400 total cycles).

e. While at 200 °F and misaligned, the test specimen shall be proof pressure tested in accordance with 4.6.2.3 for a minimum of 5 min.

f. The test specimen shall then be depressurized and soaked while full of test fluid, at -65 °F for a minimum of 1 h.

4.6.8 (Continued):

g. While at -65 °F, the pressure shall be increased to Table 1 operating pressure, and the test specimen flexure tested for a minimum of 4 h (14 400 total cycles).

h. While at -65 °F and misaligned, the test specimen shall be proof pressure tested in accordance with 4.6.2.3 for a minimum of 5 min.

4.6.9 Pressure Impulse: Test specimens 5 and 6 as shown in Figure 1A shall be installed in test fixture in accordance with the requirements of Figure 4. The specimens shall be proof pressure tested in accordance with 4.6.2.3. Pressure surges at 0 to 180 to 0 psi (±30 psi) shall be applied at a rate of 20 to 60 cpm with pressure traces conforming to Figure 5. Test sequence shall be as follows:

a. 50 000 pressure surge cycles at room temperature
b. 1 h soak at 200 °F.
c. 50 000 pressure surge cycles at 200 °F
d. Proof pressure test at 200 °F in accordance with 4.6.2.3

The electrical continuity shall be monitored periodically during this test in accordance with 4.6.11.

4.6.10 Burst: Test specimen numbers 1, 3, and 5 in accordance with Figure 1A shall be mounted as specified in Figure 2. The specimens shall be pressurized to the Table 1 burst pressure at room temperature for 2 min. The pressure shall be increased until failure occurs and the failure mode shall be recorded. Test fluid may be water.

4.6.11 Electrical Bonding: The electrical resistance shall be measured from tube to tube across the assembled coupling per Figure 1, using a suitable instrument to verify compliance with the requirements of MIL-B-5087, Class S bonding.

5. PREPARATION FOR DELIVERY:

5.1 Preservation and Packaging:

5.1.1 Level A: The parts specified herein shall be preserved in accordance with Method III of MIL-P-116 and unit package in containers conforming to PPP-B-566, PPP-B-665, or PPP-B-676. The gross weight of the boxes shall not exceed the weight limitations of the applicable container specification.

5.1.2 Level C: The parts specified herein shall be preserved and packaged in accordance with the manufacturer's commercial practice.

5.2 Packing:

Packing shall be level A, B, or C as specified (see 6.2).

5.2.1 Level A: The parts specified herein shall be preserved and packaged to meet 5.1.1 shall be packed in exterior type shipping containers conforming to PPP-B-585, PPP-B-591, PPP-B-601, PPP-B-636, or PPP-B-576. Insofar as practical, exterior containers shall be of uniform shape and size, of minimum cube and tare consistent with the protection required and shall contain identical quantities. The gross weight of each pack shall be limited to approximately 200 lb. Containers shall be closed and strapped in accordance with the applicable container specification or appendix thereto. Containers shall be provided with a case liner conforming to MIL-L-10547 and shall be sealed in accordance with the appendix thereto. The case liner shall not be required when the unit, intermediate or exterior container, conforms to PPP-B-636 and is sealed at all joints and seams, including manufacturer's joint, with tape conforming to PPP-T-60.

5.2.2 Level B: The parts specified herein shall be preserved and packaged to 5.1.1 shall be packed in domestic-type exterior containers conforming to PPP-B-585, PPP-B-591, PPP-B-601, PPP-B-636, or PPP-B-576. Exterior containers shall be of minimum cube and tare consistent with the protection required. Insofar as practicable, exterior containers shall be of uniform size and shape, and shall contain identical quantities. The gross weight of each pack shall be limited to approximately 200 lb. Containers shall be closed and strapped in accordance with the applicable container specification or appendix thereto. When fiberboard containers are used, the fiberboard shall conform to the special requirements of PPP-B-636.

5.2.3 Level C: Packages which require overpacking for acceptance by the carrier, shall be packed in exterior-type shipping containers in a manner that will ensure safe transportation at the lowest rate to the point of delivery. Containers shall meet uniform freight classification rules or regulations of other common carriers, as applicable to the mode of transportation.

5.3 Marking:

Interior and exterior containers shall be marked in accordance with MIL-STD-129.

5.3.1 Packing Date: The date of packing shall be marked on all interior and exterior containers.

6. NOTES:

6.1 Intended Use:

The parts are intended for joining tubing in aircraft fuel, vent, or other systems where the designed operating pressure, temperature, and electrical resistance of the coupling assemblies are within the requirements of this document. Installations in which the limits specified herein are exceeded, or in which the application is not covered specifically by this document will be subject to the approval of the user.

6.1 (Continued):

CRES coupling assemblies and ferrules are intended for use with CRES tubing systems in fire zones or in temperatures up to 400 °F maximum (within seal limitations).

Titanium ferrules and sleeves are intended for use in titanium tubing systems.

6.1.1 Fire Resistance: When fireproofing or fire resistance is a requirement, the test shall be conducted to the procedures and requirements specified in AS1055.

6.2 Recommended Sampling Criteria:

Recommended defect classification and characterization are shown in Tables 11 and 12.

TABLE 11 - Defect Characteristics

Class	AQL	Characteristic
Critical	100%	Likely to result in hazardous or unsafe conditions
Major	1.0%	Likely to cause malfunction, or reducing usability of the part
Minor A	4.0%	May have a slight effect on usability
Minor B	6.5%	Essentially no effect on usability

TABLE 12 - Classification of Defects

Part or Std.	Class	Characteristic
Ferrule, Swaged AS1653	Major 1.0% AQL	AS1656-1-( ) End, D Dia.
	Minor A 4.0% AQL	B & C Dim.
	Minor B 6.5% AQL	Remainder
Sleeve AS1654	Major 1.0% AQL	A Dia., B Dim.
	Minor A 4.0% AQL	C Dia.
	Minor B 6.5% AQL	Remainder
Coupling AS1655	Major 1.0% AQL	E Dia., C Dim.
	Minor A 4.0% AQL	D Dia.
	Minor B 6.5% AQL	Remainder

TABLE 12 (Continued)

Part or Std.	Class	Characteristic
Fitting End AS1656-1-( )	Major 1.0% AQL	A, B, F, G, Dia.
	Minor A 4.0% AQL	D & E Dim.
	Minor B 6.5% AQL	Remainder
Fitting End AS1656-2-( )	Major 1.0% AQL	L, M Dia., K Dim.
	Minor A 4.0% AQL	H Dia.
	Minor B 6.5% AQL	Remainder
Ferrule, Welded AS4734	Major 1.0% AQL	AS1656-1-( ) End, A Dia.
	Minor A 4.0% AQL	B & C Dia., .035 Dim.
	Minor B 6.5% AQL	Remainder

6.3 Ordering Data:

The procurement documents should specify:

a. The title, number, and date of this document.

b. The applicable "AS" part number and drawing number.

c. The size or special features desired.

d. The data requirements (see 4.3.2).

e. The applicable levels of preservation, packaging, and packing (see 5.1, and 5.2).

f. The samples subject to destructive testing are not to be considered or shipped as part of the contract or order.

PREPARED BY SAE SUBCOMMITTEE G-3A,
AEROSPACE COUPLINGS OF COMMITTEE G-3,
AEROSPACE COUPLINGS, FITTINGS, HOSE, AND TUBING ASSEMBLIES

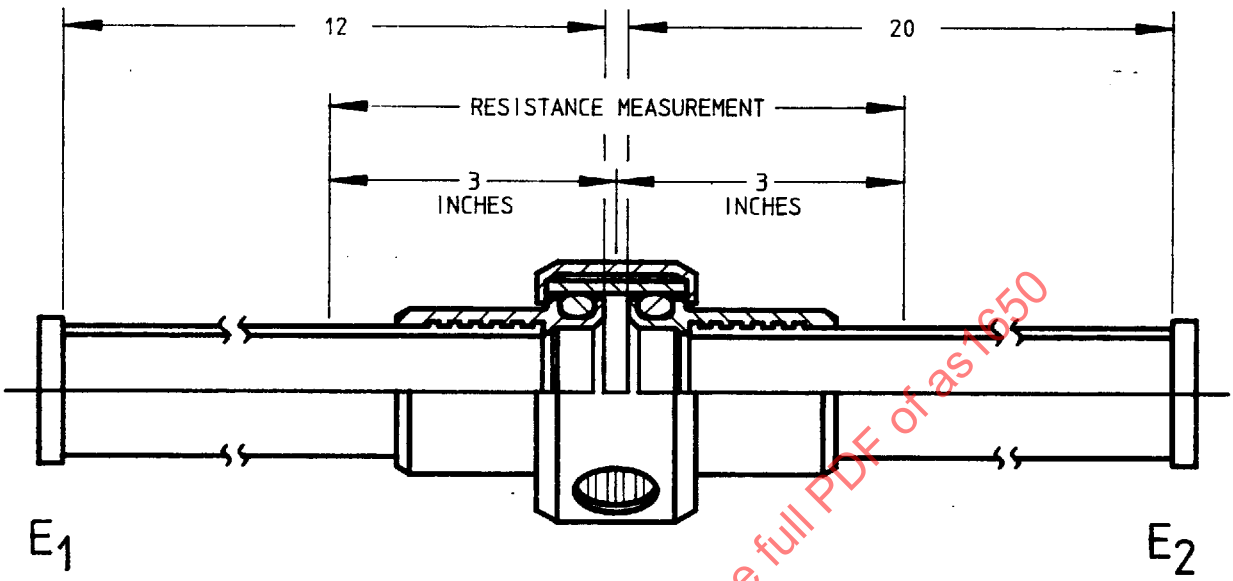

FIGURE 1A - Test Specimens 1 Through 6

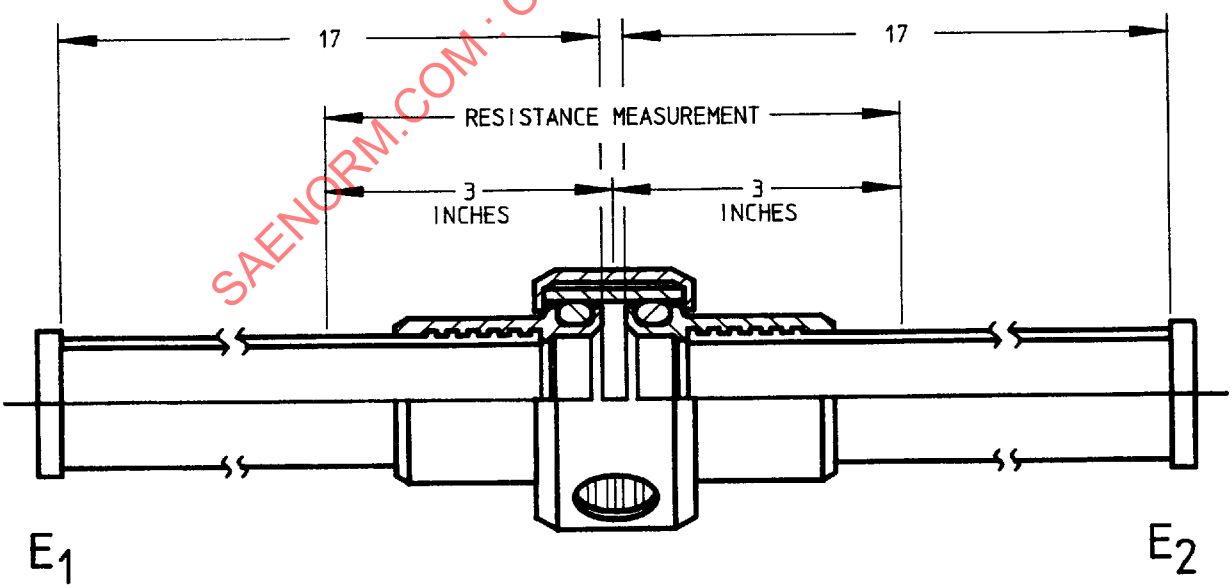

FIGURE 1B - Test Specimen 7

NOTE: End caps E_1 and E_2 to be compatible with test requirements.