AEROSPACE STANDARD

AS5958	REV. E
Issued 2006-01 Revised 2013-10 Superseding AS5958D	

(R) Fittings, Axially Swaged Tube with Flareless Separable, Fluid System For Operating Pressures up to and including 5080 psi (35 000 kPa), Specification for

RATIONALE

Add Blue Anodize and Ink-Jet Options as Identification and Marking methods to 3.4.2.3 and 3.5.2, and correct the joint strength conversion values to Newton in Tables 3A and 3B.

1. SCOPE

This SAE Aerospace Standard (AS) establishes the requirements for externally swaged titanium tube fittings on titanium and CRES tubing with flareless separable fitting for use in hydraulic supply and return aerospace fluid systems up to operating pressure of 5080 psig (35 000 kPa) maximum and an operating temperature range of -65 to +275 °F (-54 to +135 °C).

This specification covers a common 5080 psi pressure titanium fitting that may be used for a range of operating pressures up to 5080 psi with different tubing materials and tubing wall thicknesses, and is assembled with the same tooling in accordance with AS5959. The fitting operating pressure is based on the fitting thread pitch. Extra fine pitch for 5080 psi operating pressure and fine pitch for operating pressures 3000 psi and less. Table 12 shows applicable aerospace fitting part number standard and tubing materials and operating pressures.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS1428 Fluid, Aircraft Deicing/Anti-Icing, Non-Newtonian (Pseudoplastic), SAE Types II, III, and IV

AMS2700 Passivation of Corrosion Resistant Steels

AMS2488 Anodic Treatment - Titanium and Titanium Alloys Solution pH 13 or Higher

AMS4928 Titanium Alloy Bars, Wire, Forgings, Rings and Drawn Shapes, 6Al - 4V, Annealed

AMS4945	Titanium Alloy Tubing, Seamless, Hydraulic 3Al - 2.5V, Controlled Contractile Strain Ratio Cold Worked, Stress Relieved
AMS4946	Titanium Alloy Tubing, Seamless, Hydraulic 3Al -2.5V, Texture Controlled Cold Worked, Stress Relieved
AMS4965	Titanium Alloy, Bars, Wire, Forgings, and Rings 6.0Al - 4.0V Solution Heat Treated and Aged
AMS5561	Steel. Corrosion and Heat-Resistant, Welded and Drawn or Seamless and Drawn Tubing, 9.0Mn - 20Cr - 6.5Ni - 0.28N, High-Pressure Hydraulic
AMS5637	Steel, Corrosion Resistant, Bars and Wire 18Cr - 9.0Ni (SAE 30302) Solution Heat Treated and Cold Drawn 125 ksi (862 MPa) Tensile Strength
AS5685	Steel, Corrosion Resistant, Safety Wire, 18Cr - 11.5Ni (SAE 30305), Solution Heat Treated, Cold Finished
AS478	Identification Marking Methods
AS603	Impulse Testing of Hydraulic Hose, Tubing, and Fitting Assemblies
AS1055	Fire Testing of Flexible Hose, Tube Assemblies, Coils, Fittings, and Similar System Components
ARP1185	Flexure Testing of Hydraulic Tubing Joints and Fittings
AS1241	Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft
AS1376	Alternate Dimensions, Center Body Section, Shape Fluid Fittings, Design Standard
ARP4784	Definitions and Limits, Metal Material Defects and Surface and Edge Features, Fluid Couplings, Fittings and Hose Ends
ARP5412	Aircraft Lightning Environment and Related Test Waveforms
AS5620	Titanium Hydraulic Tubing, Ti-3Al-2.5V Cold Worked and Stress Relieved, Up to 35,000 kPa (5080 psi) Requirements for Qualification Testing and Control
AS5827	Fitting End, Flareless, Extra Fine Thread, Design Standard
AS5863	Fitting End, 24° Cone, Flareless, Fluid Connection, Design Standard
AS5959	Axially Swaged Fittings, Installation and Inspection Procedure
AS5969	Fitting Assembly, Union, Axially Swaged, Hydraulic, 5080 psi
AS5972	Fitting Assembly, Tee, Axially Swaged, Hydraulic, 5080 psi
AS5974	Fitting Assembly, Straight, Female Flareless, Axially Swaged, Hydraulic, 5080 psi
AS5975	Fitting Assembly, Straight, Male Flareless, Axially Swaged, Hydraulic, 5080 psi
AS5767	Fitting Assembly, Tee, Female Flareless, Axially Swaged, Hydraulic, 5080 psi
AS7003	Nadcap Program Requirements
AS7112	National Aerospace and Defense Contractors Accreditation Program (NADCAP) Requirements for Fluid System Components

2.2 AECMA Publications

Available from European Assoc. of Aerospace Ind., Gulledelle 94, B-1200 Brussels, Belgium.

prEN 6123 Aerospace Series Fitting End, 24° Internal Cone, External Thread, Flareless Type, Extra Fine Thread Pitch, Dimension Inch Series

prEN 2808 Aerospace Series Anodizing of Titanium and Titanium Alloys

2.3 ASME Publications

Available from ASME, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), www.asme.org.

ASME B46.1 Surface Texture (Surface Roughness, Waviness, and Lay)

2.4 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM A580 Standard Specification for Stainless Steel Wire

ASTM D740 Standard Specification for Methyl Ethyl Ketone

ASTM D1193 Standard Specification for Regent Water

ASTM D1655 Aviation Turbine Fuels

ASTM E8 Tension Testing for Metallic Materials

2.5 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 7137 Environmental Conditions and Test Procedures for Airborne Equipment

2.6 PRI Publications

Available from Performance Review Institute, 161 Thorn Hill Road, Warrendale, PA 15086-7527, Tel: 724-772-1616, www.pri-network.org.

PD2001 Qualified Product Management Council Procedures for Qualified Products Group

PD2101 Aerospace Quality Assurance, Product Standard, Qualification Procedures, Fluid Systems

2.7 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

RTCA/DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

2.8 U.S. Government Publications

Available from DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6396, http://quicksearch.dla.mil/.

MIL-DTL-5624 Turbine Fuel, Aviation, Grades JP-4 and JP-5

MIL-DTL-83133 Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8), NATO F-35, and JP-8 + 100

MIL-HDBK-831 Preparation of Test Reports

MIL-PRF-5606 Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance (Inactive for New Design as of 29 March 1996)

MIL-PRF-23699 Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number O-156

MIL-PRF-83282 Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base

MIL-PRF-87257 Hydraulic Fluid, Fire Resistant; Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile

FED-STD-595 Colors Used in Government Procurement

TT-I-735 Isopropyl Alcohol

3. TECHNICAL REQUIREMENTS

3.1 Qualification

Fittings supplied in accordance with this document shall be representative of products which have been subjected to and which have successfully passed the qualification tests specified in this standard.

3.1.1 Manufacturer Qualification

A manufacturer producing a product in conformance to this procurement specification shall be accredited in accordance with the requirements of PD2101, AS7003, and AS7112, and shall be listed in a Performance Review Institute (PRI) qualified Manufacturers List (QML).

3.1.2 Product Qualification

All products shall conform to the requirements of this procurement specification and shall be approved in accordance with the requirements of PD2001 and PD2101 for listing in a Performance Review Institute (PRI) Qualified Parts List (QPL).

3.2 Materials

The fitting materials shall be uniform in quality, free from defects, consistent with good manufacturing practices and shall conform to the applicable specifications and the requirements specified herein.

3.2.1 Bars and Forgings

AMS4928 Titanium Alloy Bars, Wire, Forgings, and Rings 6Al - 4V, Annealed

AMS4965 Titanium Alloy, Bars, Wire, Forgings, and Rings 6.0Al - 4.0V Solution Heat Treated and Aged

3.2.2 Wire

AMS5637 Steel, Corrosion Resistant, Bars and Wire 18Cr - 9.0Ni (SAE 30302) Solution Heat Treated and Cold Drawn 125 ksi (862 MPa) Tensile Strength

AS5685 Steel, Corrosion Resistant, Safety Wire, 18Cr - 11.5Ni (SAE 30305), Solution Heat Treated, Cold Finished

ASTM A580 Standard Specification for Stainless Steel Wire

3.2.3 Reinforcement

Composite; a high strength carbon fiber/epoxy resin composite may be used as a reinforcement over the ring.

3.2.4 Tube Requirements

Titanium tubing shall be in accordance with AS5620 and shall meet at least the requirements of AMS4945. Stainless steel tubing shall be in accordance with AMS5561.

3.3 Design and dimensions shall be such that fittings will meet all requirements of this specification and the associated aerospace standard part drawings.

3.4 Fabrication

3.4.1 Fluid Passages

3.4.1.1 Drill Offset

In the run, tees where the fluid passage is bored from each end, the offset between the bores at the meeting point shall not exceed 0.010 inch. A sphere with a 0.015 smaller diameter shall be capable of traversing the bore intersection. The cross sectional area of the bore junction of angle fittings shall not be less than the cross-sectional area of the smaller passage. The mismatch in straight couplings shall be controlled such that a maximum OD tube (nominal +0.003) will pass through the entire fitting.

3.4.2 Finish

3.4.2.1 Titanium: No requirement

3.4.2.2 CRES: Passivation per AMS2700

3.4.2.3 Coating Color

When color is specified on the part standard, the outer ring surface shall be partially or completely colored blue with a pigmented polytetrafluoroethylene (PTFE), fluid resistant paint, or anodize in accordance with prEN 2808 or AMS2488. Final Blue color to be similar to either of the following colors 15095, 15123, 15180, 15182, 15187, 15488, 15200, 15450, 25095, 25488, 35180, 35183, 35250, 35450, 35466 and 35488 of FED-STD-595.

Anodized rings shall be subjected to Fluid Resistance test in accordance with 4.5.3.1. Anodize coating shall show no evidence of peeling, blistering, bleeding, fading, or any other evidence of deterioration as compared to similar parts not exposed to the test media. Separate specimens shall be tested in each medium.

NOTE: Not meeting the exact color requirement shall not be cause for rejection.

3.4.2.4 Dry Lube

The axially swaged fitting may be dry lubed to facilitate the fitting assembly process.

3.5 Identification of Product

All parts shall be identified in accordance with the instructions specified in 3.5.1 and 3.5.2.

3.5.1 AS Standard Symbol and Manufacturer's Trademark

Unless otherwise specified, all fittings shall be marked with the letters "AS" or AS part number," if space permits, the manufacturer's identification or trademark, manufacturer's part number and lot number.

3.5.2 Size, Method, and Location of Marking

Marking shall be accomplished per those permanent methods listed in AS478 which do not cause surface oxidation greater than 0.0005 inch (0.0127 mm) or other detrimental effects. Heat cured marking (ink, paint) may be used for "NO SUFFIX CODE LETTER" parts only (PTFE coated) provided the marking is complete and legible after exposure to hydraulic fluids in accordance with 4.5.2 and 4.5.3.

3.6 Performance

Fittings and tubing when attached per AS5959 or fitting manufacturer's authorized procedures shall meet the following performance requirements:

3.6.1 Environmental Conditions

Permanent and separable fittings shall meet the performance in accordance with this specification when subjected to the natural and induced environments specified herein.

3.6.1.1 Pressures

a. Titanium 5080 psi supply tubing in accordance with Table 1A

b. Titanium and CRES 3000 psi supply tubing in accordance with Table 1B

c. Thin wall titanium return tubing in accordance with Table 1C

3.6.1.2 Temperature

a. Ambient Air: -65 to 275 °F (-54 to 135 °C), except as noted.

b. Fluid: -65 to 275 °F (-54 to 135 °C), except as noted

TABLE 1A - SUPPLY PRESSURES

Operating Pressure Min	Proof Pressure Min	Burst Pressure Min
5080 psi (35 000 kPa)	10 160 psi (70 000 kPa)	20 320 psi (140 000 kPa)

TABLE 1B - 3000 psi SUPPLY PRESSURES

Operating Pressure Min	Proof Pressure Min	Burst Pressure Min
3000 psi (20 600 kPa)	6000 psi (41 300 kPa)	12 000 psi (82 700 kPa)

TABLE 1C - THIN WALL TITANIUM RETURN PRESSURES

Tube Size	Operating Pressure Minimum		Proof Pressure Minimum		Burst Pressure Minimum	
inch	psi	kPa	psi	kPa	psi	kPa
0.500	2000	13 700	4000	27 500	8000	55 100
0.625	2000	13 700	4000	27 500	8000	55 100
0.750	2000	13 700	4000	27 500	8000	55 100
1.000	1500	10 300	3000	20 600	6000	55 100
1.250	1500	10 300	3000	20 600	6000	55 100

3.6.2 Proof Pressure

Test assemblies shall withstand pressure equal to two times the design operating pressure for 5 minutes without visually detectable escape of fluid from the fitting assembly or the tube fitting interface or evidence of permanent deformation when tested in accordance with 4.6.2.

3.6.3 Gaseous Leakage

Test assemblies shall be capable of containment of nitrogen gas without evidence of gas bubbles appearing at the tube/fitting interface, when tested in accordance with 4.6.3. No bubbles shall appear after 1 minute at pressure.

3.6.4 Impulse

Fittings shall pass 300 000 impulse cycles without leakage or other failure, when tested in accordance with 4.6.4.

3.6.5 Burst Pressure

Burst pressure shall be as specified in Table 1A, 1B, and 1C. The fittings shall withstand burst pressure without leakage, slippage, or other failure when tested in accordance with 4.6.5.

3.6.6 Flexural Strength

Fittings shall withstand 10 000 000 cycles of flexure at the stress levels specified in Table 2A, 2B, 2C, and 2D, when tested in accordance with 4.6.6 without leakage or other failure.

3.6.7 Re-Use (Separable Only)

The separable fitting shall be capable of eight reuses, when tested in accordance with 4.6.7.

3.6.8 Joint Strength

Test assemblies shall withstand, without separation, a tensile load as specified in Tables 3A and 3B, when tested in accordance with 4.6.8.

3.6.9 Thermal Shock

The fitting assembly shall withstand the temperature and pressure, when tested in accordance with 4.6.9 without leakage, evidence of permanent deformation, or other malfunction that shall affect assembly or disassembly of the fitting.

3.6.10 Overtightening Torque (Separable only)

The fittings shall pass a proof and gaseous leakage test after being subjected to two times the maximum torque for size -04 through -08 and 1.5 times the maximum torques for sizes -10 through -20 to the values specified in Tables 4A when tested in accordance with 4.6.10.

3.6.11 Fitting Conductivity

The fitting shall be conductive. The maximum resistance shall be 10 mΩ between the two tubes connected to the fitting, when tested in accordance with 4.6.11.

3.6.12 Vibration

The tube assembly shall withstand vibration testing without leakage or other malfunction, when tested in accordance with 4.6.12.

3.6.13 System Pressure

Test assemblies shall withstand 24 hour exposure at low pressure and 24 hours at operating pressure with no visually detectable escape of fluid from the fitting assembly or the tube fitting interface, when tested in accordance with 4.6.13.

3.6.14 Fitting Twisting (Separable Only)

The separable fitting shall not twist more than 2 degrees, when torqued in accordance with 4.6.14.

3.6.15 Fitting/Tube Rotation Torque

The nut shall not loosen or the tube rotate, when subjected to 1.5 times assembly torque in accordance with 4.6.15.

3.6.16 Stress Corrosion

The tube/fitting joint shall not exhibit intergranular or stress corrosion cracking after salt spray exposure in accordance with 4.6.16.

3.6.17 Lightning Strike

The fitting assemblies, sizes 04 and 12, shall not leak after being subjected to 12 lightning strikes when tested in accordance with 4.6.17.

3.6.18 Fire

Titanium and CRES tube assemblies shall withstand a 2000 °F (1093 °C) flame for 15 minutes, when tested in accordance with 4.6.18. There shall be no leakage detected by visual observation or failure of the test assembly prior to the specified time.

TABLE 2A - 5080 psi SUPPLY TUBING BENDING STRESSES

Tube Size inch	Tube Wall Thickness inch	Minimum Endurance Limit /1/ Tube Bending Stress psi /2/	Minimum Endurance Limit /1/ Tube Bending Stress kPa /2/	Minimum Endurance Limit /1/ Tube Bending S/N Curve
0.250	0.022 - 0.025	20 000	137 900	2.4
0.375	0.030 - 0.032	19 000	131 000	2.6
0.500	0.040 - 0.043	18 000	124 000	2.8
0.625	0.050 - 0.054	17 000	117 200	3.0
0.750	0.059 - .0065	16 000	110 300	3.2
1.000	0.079 - 0.088	15 000	103 400	3.4
1.250	0.098 - 0.105	13 700	94 500	3.7

TABLE 2B - 3000 psi TITANIUM SUPPLY TUBING BENDING STRESSES

Tube Size inch	Tube Wall Thickness inch	Minimum Endurance Limit /1/ Tube Bending Stress psi /2/	Minimum Endurance Limit /1/ Tube Bending Stress kPa /2/	Minimum Endurance Limit /1/ Tube Bending S/N Curve
0.250	0.016	20 000	137 900	2.4
0.375	0.019	19 000	131 000	2.6
0.500	0.026	18 000	124 000	2.8
0.625	0.032	17 000	117 200	3.0
0.750	0.039	16 000	110 300	3.2
1.000	0.051	15 000	103 400	3.4
1.250	0.070	13 700	94 500	3.7

NOTES:

/1/ Intersection of the indicated S/N characteristic curve versus stress at the endurance limit (i.e., 1 x 10^7).
/2/ Refer to Figure 2 for characteristic curves.

TABLE 2C - 3000 psi CRES SUPPLY TUBING BENDING STRESSES

Tube Size inch	Tube Wall Thickness inch	Minimum Endurance Limit /1/ Tube Bending Stress psi /2/	Minimum Endurance Limit /1/ Tube Bending Stress kPa /2/	Minimum Endurance Limit /1/ Tube Bending S/N Curve
0.250	0.016 – 0.019	24 000	165 500	2.0
0.375	0.019 – 0.022	22 000	151 700	2.2
0.500	0.026 – 0.030	20 000	137 900	2.4
0.625	0.032 – 0.036	18 000	124 000	2.8
0.750	0.038 – 0.043	16 000	110 300	3.2
1.000	0.049 – 0.055	15 000	103 400	3.4

TABLE 2D - THIN WALL TITANIUM RETURN TUBING BENDING STRESSES

Tube Size inch	Tube Wall Thickness inch	Minimum Endurance Limit /1/ Tube Bending Stress psi /2/	Minimum Endurance Limit /1/ Tube Bending Stress kPa /2/	Minimum Endurance Limit /1/ Tube Bending S/N Curve
0.500	0.022	18 000	124 000	2.8
0.625	0.023	17 000	117 200	3.0
0.750	0.027	16 000	110 300	3.2
1.000	0.028	15 000	103 400	3.4
1.250	0.035	13 700	94 500	3.7

NOTES:

/1/ Intersection of the indicated S/N characteristic curve versus stress at the endurance limit (i.e., 1 x 10^7).
/2/ Refer to Figure 2 for characteristic curves.

TABLE 3A - 5080 psi AND 3000 psi SUPPLY MINIMUM JOINT STRENGTH

Tube Size inch	5080 psi Supply Ti. Tubing Joint Strength pounds	5080 psi Supply Ti. Tubing Joint Strength N	3000 psi Supply Ti Tubing Joint Strength pounds	3000 psi Supply Ti Tubing Joint Strength N	3000 psi Supply CRES Tubing Joint Strength (1) pounds	3000 psi Supply CRES Tubing Joint Strength (1) N
0.250	1100	4895	589	2620	442	1966
0.375	2800	12 460	1325	5894	994	4422
0.500	4700	20 915	2356	10 480	1767	7860
0.625	7900	35 155	3681	16 374	2761	12 282
0.750	11 900	52 955	5301	23 580	3976	17 686
1.000	16 750	74 537	9424	41 920	7069	31 444
1.250	25 000	112 000	14 726	65 505	11 045	49 131

(1) Joint strength for CRES tubing based on 9000 psi burst pressure.

TABLE 3B - THIN WALL TITANIUM RETURN MINIMUM JOINT STRENGTH

Tube Size inch	Titanium Return Joint Strength pounds	Titanium Return Joint Strength N
0.500	1570	6984
0.625	2453	10 911
0.750	3652	16 245
1.000	4710	20 951
1.250	7359	32 734

TABLE 4A - 5080 psi TORQUES

Tube Size inch	Assembly Torque pound-inch			Overtightening N-m
	Min	Max	Overtightening	
0.250	88	133	266	30
0.375	177	221	442	50
0.500	398	442	862	98
0.625	531	575	884	100
0.750	707	752	1128	128
1.000	885	929	1394	158
1.250	1135	1250	1875	212

TABLE 4B - 3000 psi SUPPLY AND RETURN TORQUES

Tube Size inch	Assembly Torque pound-inch			Overtightening N-m
	Min	Max	Overtightening	
0.250	133	147	294	33
0.375	257	283	566	65
0.500	475	525	1050	120
0.625	665	735	1103	125
0.750	855	945	1418	160
1.000	1140	1260	1890	215
1.250	1520	1680	2520	285

3.7 Workmanship

Machined surfaces of fittings shall be free from burrs, longitudinal or spiral tool marks. A burr is defined as any localized sharp deviation from the true contour of the part, as implied by the production drawing, the extreme excursion of which falls outside the tolerance envelope defined on the drawing, or any thin deviation of lesser magnitude which can be dislodged during normal assembly or operation. Unless a finer finish is specified on the applicable drawings, all machined surfaces shall not exceed 125 microinches Ra as defined in ASME B46.1. Unmachined surfaces, such as forging surfaces and bar stock flats, shall be free from blisters, fin folds, seams, laps, cracks, or segregations as defined in ARP4784, and except for forging parting lines, shall not exceed 250 microinches Ra. The surface texture of forging parting plane shall be 500 microinches Ra per ASME B46.1. Surface defects may be explored by suitable etching, and if they can be removed so that they do not appear on re-etching, they shall not be cause for rejection.

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 requirements as specified herein. Unless as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the procuring activity. The procuring activity reserves the right to perform any of the inspections set forth in the specification, where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of Inspection

The examining and testing of fittings shall be classified as:

a. Qualification inspections (4.3)

b. Quality conformance inspections (4.4)

4.3 Qualification Inspections

4.3.1 Qualification Test Samples

Test samples shall consist of the number of samples and lengths specified in Table 5. All specimens for each fitting size are required for qualification.

4.3.2 Qualification Test Sequence

Test sequence and procedure shall be as specified in Tables 6A, 6B, 6C, and 6D.

TABLE 5 - LENGTH /1/ AND CONFIGURATION /2/ OF TEST SAMPLES IN INCHES

Tube Size	All Other Tests	Flexure /3/	Fire/Lightning Strike	Vibration	Stress Corrosion
0.250	6	6.0	10	/4/	NA
0.375	6	7.5	NA	/4/	NA
0.500	8	9.0	NA	/4/	NA
0.625	8	10.0	NA	/4/	/5/
0.750	8	11.5	10	/4/	NA
1.000	8	12.5	10	/4/	NA
1.250	8	13.0	NA	/4/	NA

/1/ Length shall be free tube length between the fittings.
/2/ All samples shall be straight to straight, except impulse samples shall have a “tee” on one end per Figure 3 or a tee in the middle per Figure 1 for testing titanium tubing at 5080 psi. Samples for other tube materials and pressures, straight to straight may be used.
/3/ Six samples shall have a straight fitting and two shall have a tee fitting. See Figure 3.
/4/ See Table 9.
/5/ See Figure 16.

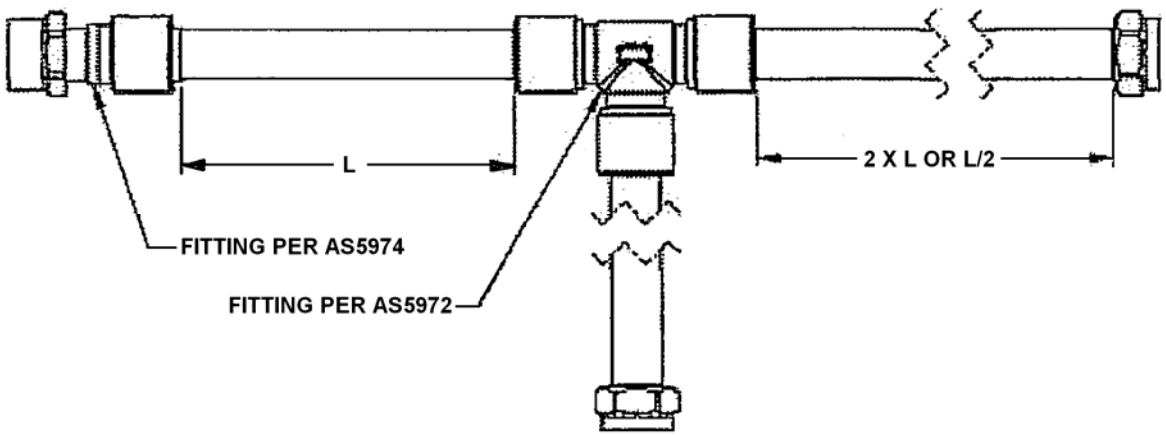

FIGURE 1 - OPTIONAL IMPULSE CONFIGURATION

TABLE 6A - 5080 psi TITANIUM SUPPLY QUALIFICATION TEST SCHEDULE

Test	Test Para.	1, 2	3, 4	5	6	7	8	9	10	11, 12	13, 14	15 to 20	21, 22	23, 24	25, 26	27 to 32 /3/	33, 34	35, 36 /1/	37 to 40 /2/	41 to 43 /4/
Inspection	4.6.1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fuel Ageing	4.5.2			3	3															
Fluid Immersion	4.5.3					3	3													
Corrosion Cond.	4.5.4										4									
Proof pressure	4.6.2	2, 4	2, 4	2	2	2	2	2	2	2	2	2	2		2	2		3		2
Gaseous pressure	4.6.3	5	5		5		5		4										2	
Impulse	4.6.4			**4**	4	**4**	4	**3**	3											
Burst	4.6.5			**5**	**7**	**5**	**7**	**4**	**6**	4	6							**6**		
Flexure	4.6.6											3	3							
Re-use	4.6.7		3																	
Joint Strength	4.6.8													**2**						
Thermal Shock	4.6.9														3					
Overtightening	4.6.10	3																		
Conductivity	4.6.11										3, 5							2, 5		
Vibration	4.6.12															3				
System pressure	4.6.13				6		6		5				4			4				
Tube twisting	4.6.14									3										
Fitt. / tube rotat. trq	4.6.15																2			
Stress corrosion /1/	4.6.16																	4		
Lightning Strike /2/	4.6.17																		3	
Fire	4.6.18																			3

/1/ Size -10 only
/2/ Sizes -4 and -12 only
/3/ Alternate method requires 6 samples and only two required for standard method.
/4/ Size -16 only

NOTE: Bold figures are for tests ran up to rupture or specimens subjected to additional tests.

TABLE 6B - 3000 psi TITANIUM TUBING QUALIFICATION TEST SCHEDULE (1)

Test	Test Para.	1, 2 (2)	3, 4	5,6
Inspection	4.6.1	1	1	1
Proof pressure	4.6.2	3		3
Impulse	4.6.4			4
Burst	4.6.5	6		6
Flexure	4.6.6	4		
Joint Strength	4.6.8		2	
Conductivity	4.6.11	2,5		2,5

/1/ The test schedule in this table was found by analysis to be sufficient for qualifying the fitting sizes listed in Table 2D with the titanium tubing wall listed in Table 2B for 3000 psi system due to qualifying these sizes on lower and higher pressure and tube wall ranges.

/2/ Test to be performed at the minimum endurance stress level shown in Table 2B.

TABLE 6C - 3000 psi CRES TUBING QUALIFICATION TEST SCHEDULE

Test	Test Paragraph	1	2	3	4	5	6	7 to 12	13, 14	15, 16	17, 18	19, 20
Inspection	4.6.1	1	1	1	1	1	1	1	1	1	1	1
Proof	4.6.2	3	2	2	3	2	2	2	2		2	2
Impulse	4.6.4	4	3	3	4	3	3					
Stress Corrosion	4.5.4											3
Burst	4.6.5	6	5	4	7	4	5					4
Flexure	4.6.6							3	4			
Joint Strength	4.6.8									2		
Thermal Shock	4.6.9										4	
Conductivity	4.6.11	2,5			2,5				3,5		3,5	
System Pressure	4.6.13		4		6		4		6			

TABLE 6D - THIN WALL TITANIUM RETURN QUALIFICATION TEST SCHEDULE

Test	Test Paragraph	1, 2	3, 4	5 to 12	13, 14	15 to 20 /1/
Inspection	4.6.1	1	1	1	1	1
Gaseous Pressure	4.6.3	2	2	2		2
Proof	4.6.2	3	3	3		3
Impulse	4.6.4		4			
Burst	4.6.5	**4**				
Flexure	4.6.6			4		
Joint Strength	4.6.8				2	
Vibration	4.6.12					4

/1/ Alternate method requires six samples and only two required for standard method.

NOTE: Bold figures are for tests run up to rupture.

4.3.3 Test Report, Test Samples, and Data

The following data shall be available and submitted when requested:

a. Test Report: The test report shall include a record of all processes used to fabricate the samples including the number, revision level and inspection results, a report of all tests and outline description of the tests and conditions, outlined in MIL-HDBK-831.

b. Test Samples: Test samples when requested by the procuring activity and subjected to qualification testing, shall not be shipped as part of contract order.

c. Drawings: Three sets of assembly and subassembly shall have a cut-away section showing all details in their normal assembly position. The drawing shall identify all details and subassemblies.

NOTE:Log sheets and recorded test data shall remain on file at the source test facility and are not to be sent to the qualifying activity unless specifically requested.

4.3.4 Qualification Inspection Methods

Qualification inspection methods shall consist of all the examinations and tests specified under 4.6.

4.4 Quality Conformance Inspections

Quality conformance inspections shall consist of the following tests:

Individual tests (see 4.4.1) (100% inspection)

4.4.1 Individual Tests

Each fitting shall be subjected to the following tests:

4.4.1.1 Examination of Product (see 4.6.1)

4.4.2 Rejection and Retest

Where one or more items selected from a lot fails to meet the specifications, all items in the lot shall be rejected.

4.4.2.1 Resubmitted Lots

Once a lot (or part of a lot) has been rejected by a procuring activity (government or industry), and before it can be resubmitted for tests, full particulars concerning the cause of rejection, and the action taken to correct the defects in the lot, shall be furnished in writing by the supplier.

4.4.3 Inspection Procedures

All inspection plans shall be single sample plans with an accept number of zero.

4.5 Test Conditions

4.5.1 Preparation of Samples

4.5.1.1 Unless otherwise specified, the length of sample assemblies shall be in accordance with Table 5.

4.5.1.2 At least one test sample for each series of tests shall be assembled with tooling used to qualify any other manufacturer's fittings listed on the QPL. This requirement does not apply to a supplier completing qualification when no other suppliers are qualified.

4.5.2 Fuel Aging

The samples shall be filled with “Low Density” AS1241 Type IV fire resistant fluid and then pressurized to 5080 psi (35 000 kPa) and, while maintaining the pressure at room temperature, the samples shall be immersed in the fluid for 8 to 10 hours and then allowed to air dry for 1 hour. Then the samples will be placed at a temperature of -65 °F (-54 °C) for 8 to 10 hours. This sequence of fluid immersion and low temperature exposure shall be repeated 20 times in accordance with Table 7. The fuels used shall be one of the following listed in Table 8.

TABLE 7 - FLUID SEQUENCE

Sequence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Fluid used F : fuel W : water	F	F	F	W	F	F	F	W	F	F	F	W	F	F	F	W	F	F	F	W

TABLE 8 - FUELS

Specification	Fuel
US MILITARY	MIL-DTL-5624 : JP-5 MIL-DTL-83133 : JP-8
US ATM	ASTM D1655 : JET A ASTM D1655 : JET A1
FRANCE	AIR3404 AIR3405
UK	DEF STAN 91-86 (NATO F44) DEF STAN 91-91 (Jet A1, NATO F35)
RUSSIAN	GOST 10227 : RT GOST 1022 : TS-1
CHINESE	N°3 Jet Fuel

4.5.3 Hydraulic Fluid Immersion

The samples shall be fully preconditioned in “Low Density” AS1241 Type IV fire resistant fluid or the system hydraulic fluid, as applicable. The sample shall be filled with AS1241 hydraulic fluid or system hydraulic fluid, as applicable, and then shall be pressurized to operating pressure. While maintaining the pressure at room temperature, the sample shall be immersed in AS1241 or system fluid, as applicable, for 8 to 10 minutes and then allowed to air dry for the remainder of 1 hour. Then the samples shall be aged at +275 °F (+135 °C) in air for 8 to 10 hours. This sequence of hydraulic fluid immersion and high temperature exposure shall be repeated 10 times.

NOTE: During high temperature exposure, the pressure inside the samples shall not be greater than the operating pressure.

4.5.3.1 Fluid Resistance Anodize Compatibility

Anodized rings shall be immersed at room temperature for 10 days minimum in each of the following fluids: When using anodized rings, the blue anodic coating shall not react, dissolve, disperse or show any other evidence of deterioration during 10 days of exposure to each of the following fluids:

Anti-icing (isopropyl alcohol) per TT-I-735, AMS1428, or equivalent
Hydraulic fluid Phosphate Ester per AS1241
Fuel (Jet A) per ASTM D1655
Lubricating Oil per MIL-PRF-23699
Methyl Ethyl Ketone (MEK) per ASTM D740 or equivalent
Coolant Fluid (60% Propylene Glycol and 40% deionized water per ASTM D1193 Type IV per volume)

4.5.4 Corrosion Conditioning

A salt spray test according to RTCA/DO-160, Section 14 shall be performed for a minimum of 56 days (the RTCA procedure, i.e., the exposure to the salt fog for a period of a minimum of 48 hours and then the storage in an ambient temperature for a minimum of 48 hours for drying, must be repeated in order to reach 56 days).

4.5.5 Test Fluids

Unless otherwise specified, the pressure test fluid shall be hydraulic oil conforming to MIL-PRF-5606, MIL-PRF-87257, or water. Where a high temperature test fluid is required, the test fluid shall be MIL-PRF-83282 hydraulic fluid.

4.5.6 Pressure Measurement

Unless otherwise specified, all pressures shall have a tolerance of -0 to +5%.

4.5.7 Temperature Measurements

Unless otherwise specified, temperature measurements shall be taken within 6 inches of the fitting under test. Unless otherwise specified, all temperatures shall have a tolerance of +15 °F, -5 °F (+9 °C, -3 °C).

4.6 Performance Tests

4.6.1 All fittings shall be visually inspected to determine conformance to this document, with respect to materials, size and workmanship.

4.6.1.1 Tube Preparation

Tubes shall be cut square within 0.5 degrees and all burrs removed from inside and outside of the tube ends. The break or chamfer on either the outside diameter or inside diameter shall not exceed 25% of the tube wall thickness.

4.6.2 Hydraulic Proof Test

Test assemblies shall be mounted to a pressure source and pressurized to two times the design operating pressure and held for 5 minutes. Rate of pressure rise shall be 20 000 psi/min (137 894 kPa/min) ± 5000 psi (34 474 kPa).

4.6.3 Gaseous Leakage Test

Test specimens shall be solvent cleaned and air dried prior to test and shall not have been exposed to oil prior to this test. The specimens shall be connected to a gaseous nitrogen pressure source and immersed in a safety tank filled with water. The specimens shall then be pressurized to 50 to 100 psig (345 to 690 kPa) at room temperature. The test is then repeated at operating pressure. This test duration for each segment shall be 5 minutes.

4.6.4 Impulse Test

Six test assemblies of each tube/fitting combination to be qualified shall be tested. Impulse testing shall be in accordance with AS603 except the peak pressure percentage shall be 125% for sizes -16 and -20 thin wall titanium tubing. The maximum temperature shall be +275 °F ± 5 °F (+135 °C ± 3 °C) for titanium and CRES tubing. The minimum temperature shall be -65 °F ± 5 °F (-54 °C ± 3 °C). The impulse cycle rate shall be 70 cpm ± 5 cpm. The pressure rise rate for testing conducted at 5080 psi shall be 125 000 to 300 000 psi/s. For testing other pressure classes, the pressure rise rates specified in AS603 shall be used. Hydraulic fluid shall be used as the testing media. Specimens shall complete a minimum of 300 000 impulse cycles and continue to 450 000 cycles or failure.

4.6.5 Burst Pressure Test

Test assemblies shall be pressurized to the proof pressure and held at that pressure for 5 minutes. The pressure shall then be increased at a rate of 20 000 psi/min (137 894 kPa/min) ± 5000 psi/min (34 474 kPa/min) until destruction occurs. No burst, slippage, leakage, or other failure shall occur at a pressure below the burst pressure as specified in Tables 1A, 1B, and 1C.

4.6.6 Flexural Strength

The flexural test shall be performed in accordance with ARP1185, except the stress level shall be per Tables 2A, 2B, 2C, and 2D. Bending stresses shall be applied by the rotary flex method. The stress imposed will be the dynamic bending stress. The bending stress shall be measured by two strain gages mounted 90 degrees apart on the tube 0.188 inch ± 0.031 inch from the tube fitting interface. Testing shall be conducted with the specimen pressurize to the operating pressure. The cycling rate of flexure shall be 30 to 60 cps. Data points generated by testing shall be plotted on an S/N curve (stress/number of cycles). Refer to Figure 2. Two straight specimens in each size shall complete 10 000 000 cycles without leakage or other failure. Six other samples, four with straight fittings and two with tee-shaped fittings, shall be tested at higher stress levels to develop a fatigue (S/N) curve. Any of these six samples that complete 10 000 000 cycles need not be tested to failure.

4.6.6.1 Rotary Beam Method

Figure 2 illustrates the flexural loading by imposing a concentrated rotating load on the free end of the tube assembly.

4.6.7 Re-Use, Separable End Only

Screw together and unscrew the threaded connections eight times. The initial tightening shall consist of loosening the nut after the initial tightening and re-tightening. Each cycle shall include the complete removal of the fitting from the mating adapter. One half the threaded connections shall use minimum torque and the other half shall use maximum torque values shown in Table 4. Following the first, fourth and eight installations, conduct a proof test. After the eighth installation there shall be no evidence of the following defects:

- Leakage during any of the proof test
- Inability to assemble the fitting to the interface point by hand
- Nut deformation preventing engagement of the nut hexagon with an open-end wrench
- Gaseous leakage following the final installation.

4.6.8 Joint Strength Test

Test assemblies shall be mounted in a tensile test machine and be tested in accordance with ASTM E8 at a head travel rate of 0.15 inch/minute ± 0.05 inch/minute. Strength requirements shall be per 3.6.8.

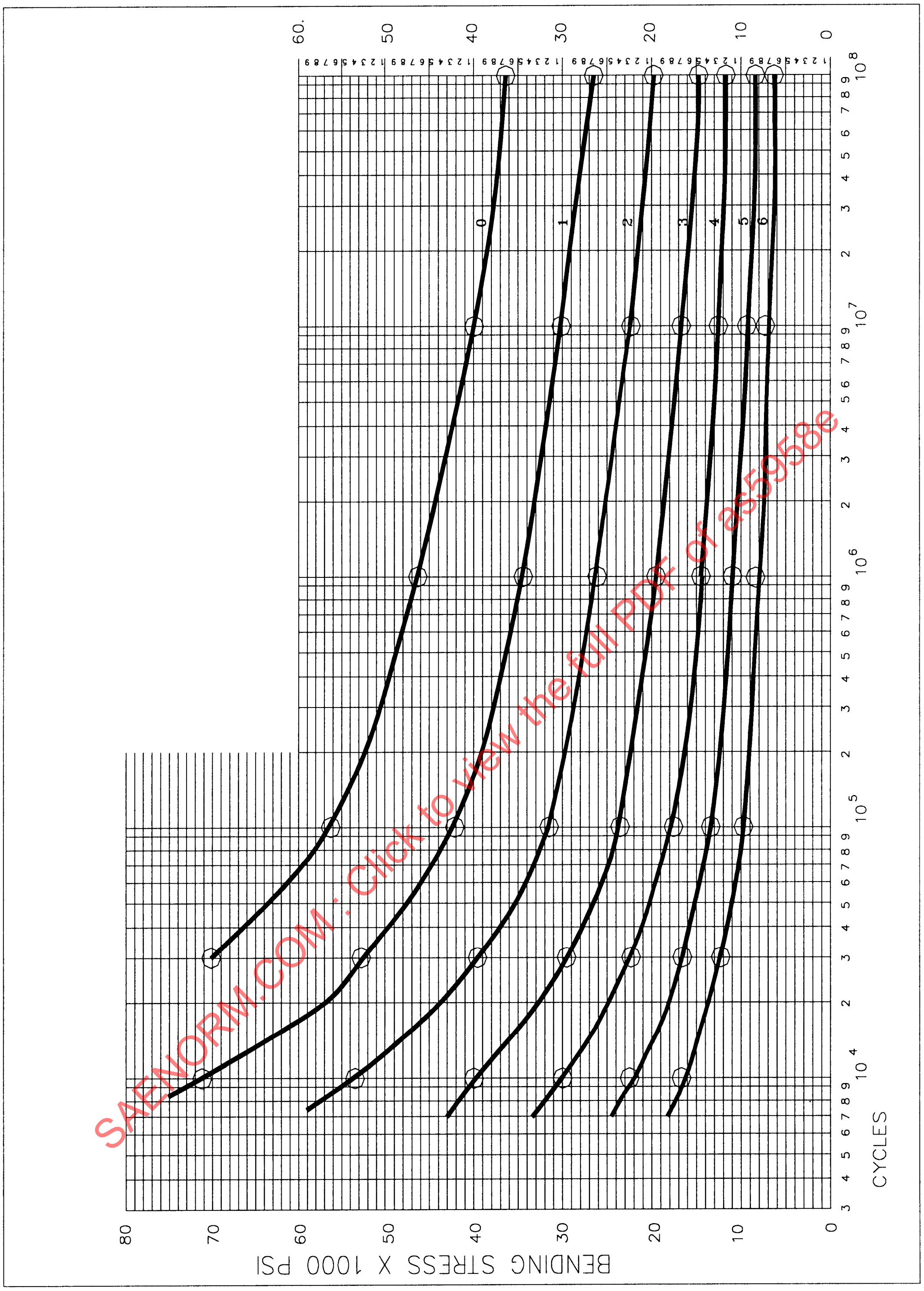

FIGURE 2 - FLEXURE FATIGUE TEST S/N CURVE

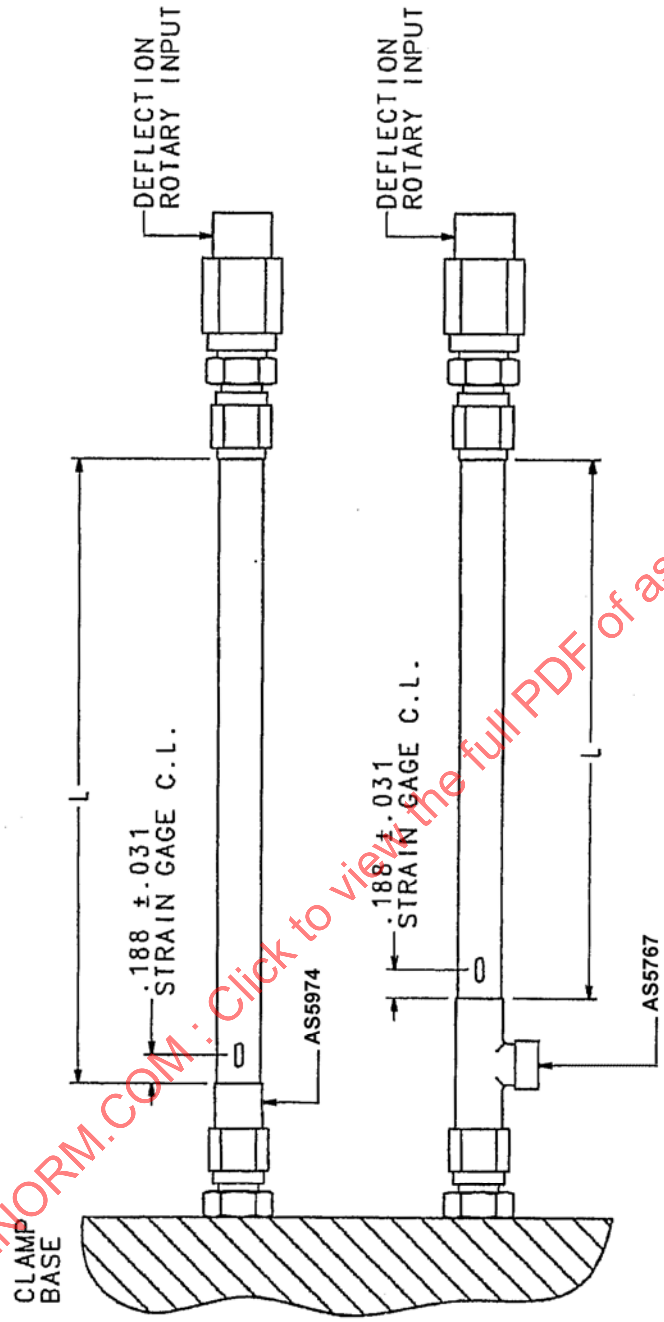

FIGURE 3 - ROTARY IMPULSE TEST SPECIMEN

4.6.9 Thermal Shock Test

Use MIL-PRF-5606 hydraulic fluid for this test. The fitting assembly shall be mounted in a high temperature test set up with one end free to move. A typical test set up is shown in Figure 4. After the initial proof test, the fitting shall be filled with hydraulic fluid, the ambient temperature of the test chamber shall be reduced to -65 °F ± 2 °F (-54 °C ± 1 °C) for a minimum of 2 hours. At the end of this period, while the test chamber is still at -65 °F (-54 °C), test fluid at 275 °F ± 5 °F (135 °C ± 3 °C) shall be suddenly introduced into the test assembly at a minimum pressure of 50 psi (350 kPa). Within 15 seconds after the hot fluid has filled the fitting assembly, a proof pressure test shall be performed in accordance with 4.6.2.

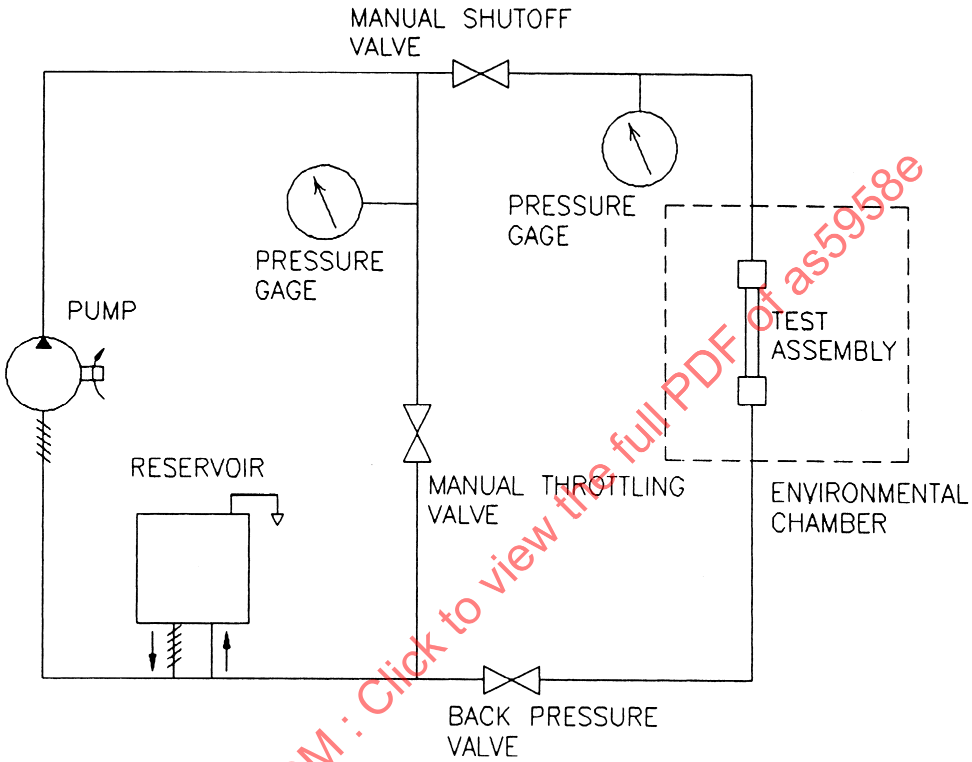

FIGURE 4 - TYPICAL SETUP FOR THERMAL SHOCK TESTING

4.6.10 Overtightening Torque (Separable Only)

The separable fitting shall be torqued to an adapter with a prEN6123, AS5827 or equivalent interface. The torque shall be 2 times the maximum installation for sizes -04 to -08 and 1.5 times the maximum installation torque for sizes -10 to -20. There shall be no leakage when proof pressure tested per 4.6.2 and gaseous leakage tested per 4.6.3.

4.6.11 Fitting Conductivity

A titanium adapter shall be attached to the end fitting using the minimum assembly torque. Ohmic resistance measurements shall be carried out twice for each test sample in order to confirm the value. An ohmmeter with four measurement test points can be used with a direct current of 1A minimum with a measurement accuracy of 1%. Measurement shall be performed between point 1 and point 2 (see Figure 5). This test shall be performed before and after corrosion conditioning per 4.5.4. The test report shall provide measured resistance values.

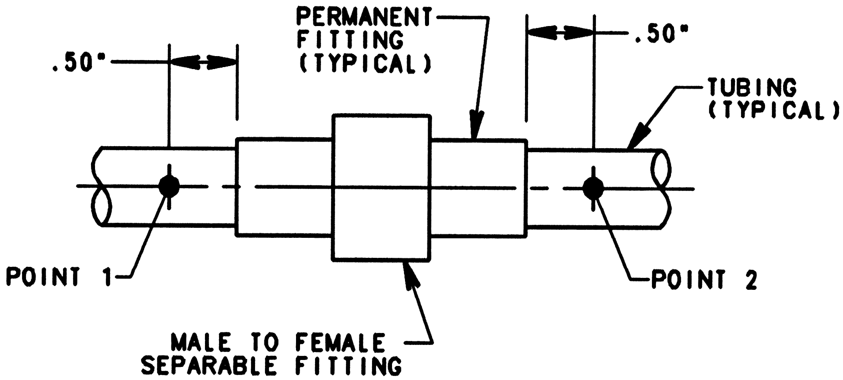

FIGURE 5 - FITTING CONDUCTIVITY

4.6.12 Vibration

Test assemblies shall be installed on a test fixture as illustrated in Figure 5 and Table 9. The test assemblies shall be filled with hydraulic fluid and pressurized to nominal operating pressure. Each test assembly shall be tested using either:

a. Standard vibration test defined in 4.6.12.1, or

b. Alternate vibration test defined in 4.6.12.2. The Alternate Vibration test may be used only if the test installation has no resonant frequencies below 40 Hz. Resonance frequencies are defined as response peaks that are greater than twice the input acceleration amplitude.

After exposure to the vibration test, the equipment shall be inspected and shall show no evidence of structural failure of the tube or fitting. The presence of a detectable crack constitutes a vibration test failure. There shall be no leakage of hydraulic fluid.

4.6.12.1 Standard Vibration Test

Test assemblies shall be vibration tested as specified in RTCA/DO-160, section 8, categories R and H for fixed-wing aircraft, using the robust sinusoidal test procedure except as follows:

a. Performance testing is not applicable.

b. Two test assemblies of each size shall be tested using modified curve W, as specified in Figure 7, and curve P as defined in RTCA/DO-160.

c. If the test assemblies are axisymmetric, testing needs to be performed in only one axis perpendicular to the tube centerline.

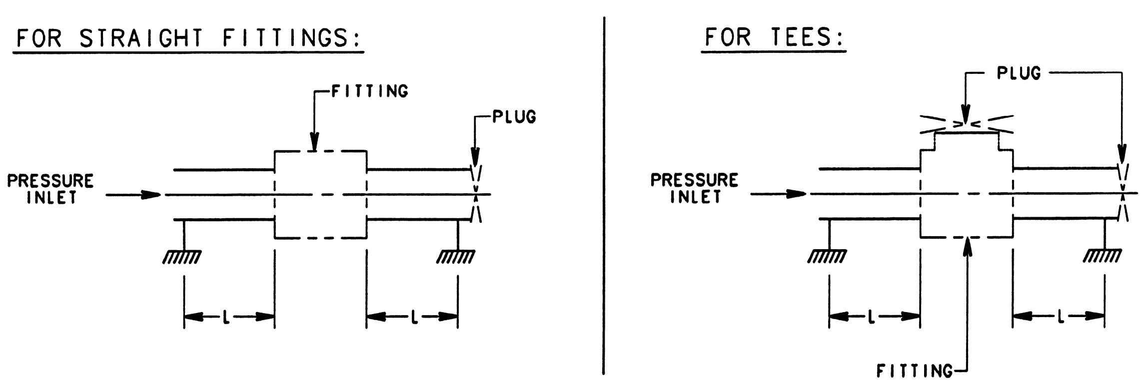

FIGURE 6 - VIBRATION TEST SETUP

TABLE 9 - TEST LENGTHS

Size Code	Length L inch	Length L mm
04	5.7	145
06	8.7	220
08	9.8	250
10	11	280
12	12.2	310
16	14	355
20	15.7	400

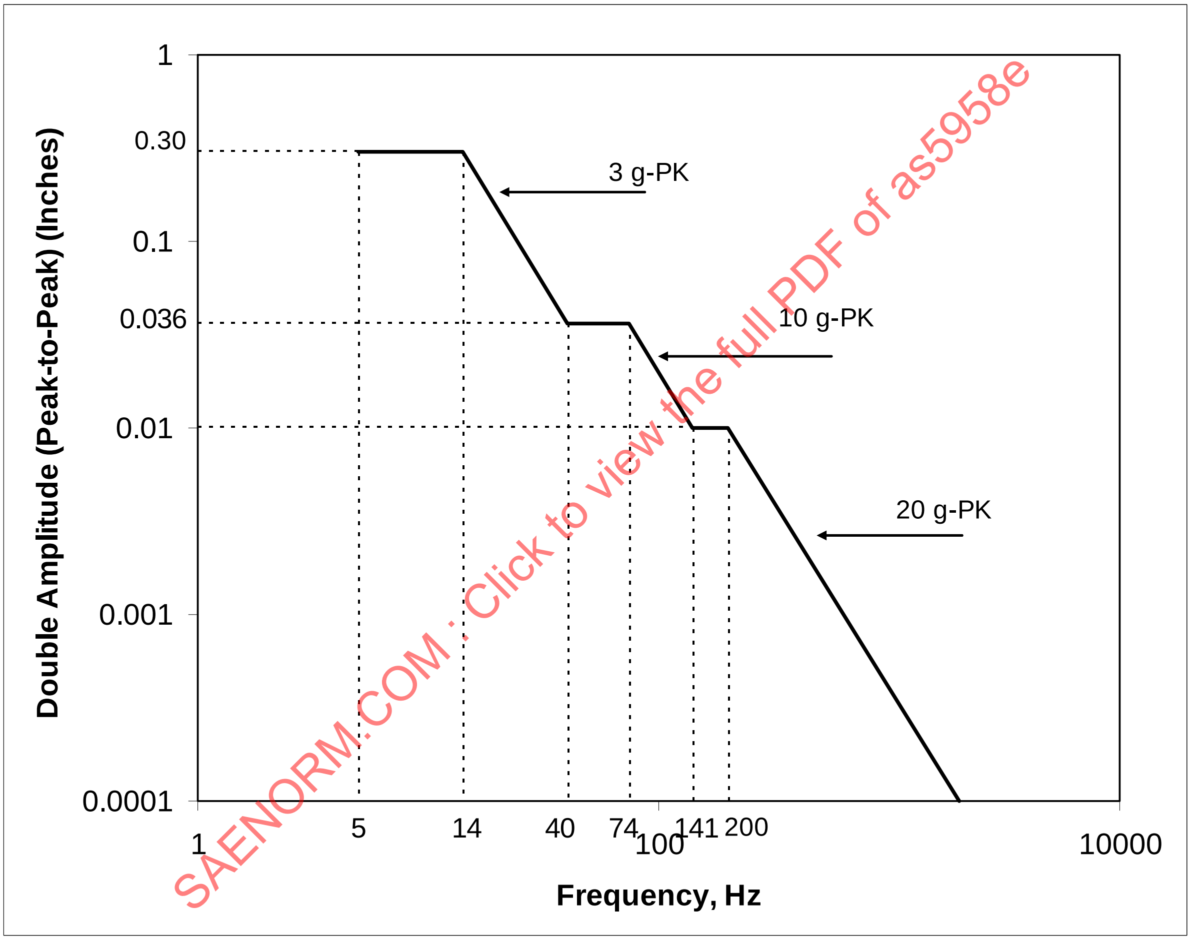

FIGURE 7 - MODIFIED CURVE W

4.6.12.2 Alternate Vibration Test

Test assemblies shall be installed on a test fixture as illustrated in Figure 5 and Table 9. Testing shall include both 4.6.12.2.1 (Normal Flight Conditions) and 4.6.12.2.2 (Windmilling - Sustained Engine Imbalance) tests.

4.6.12.2.1 Normal Flight Conditions

Six assemblies shall be tested in accordance with ISO 7137, with a vibration level depending on the aircraft area concerned, category T curves:

Two assemblies with curves E, E1, P (all sizes);
Two assemblies with curves D, D1, P (sizes: see below);
Two assemblies with curve P, W (sizes: see below).

Test procedure used shall be "Robust vibration test procedure-fixed-wing aircraft"

E, E1 and P: for wing and wheel well	noted S1
D, D1 and P: for nacelle and pylon	noted S2
W and P: for landing gear, engine and gearbox	noted S3

All curves in a given category must be performed.

According to the areas the fittings will be placed in, series are to be performed according to Table 10:

TABLE 10 - SERIES

Size Code	Series HP
04	S1 & S3
06	S1 & S3
08	S1 & S3
10	S1 & S3
12	S1 & S3
16	S1 & S2 & S3
20	S1

A test reduction can be achieved by running tests according to the following series:

S4: (E U D), (E1 U D1) and P: This series would be valid for series S1 and S2.

or

S5: (E U D), (E1 U D1), P and W to comply with S1, S2 and S3 series to cover all areas. This would be more demanding for the fittings, but would allow to running the testing with only two samples following four curves rather than three sets of two samples following three, three and two curves respectively.

Where (E U D) and (E1 U D1) are defined in Figures 8 and 9 as follows:

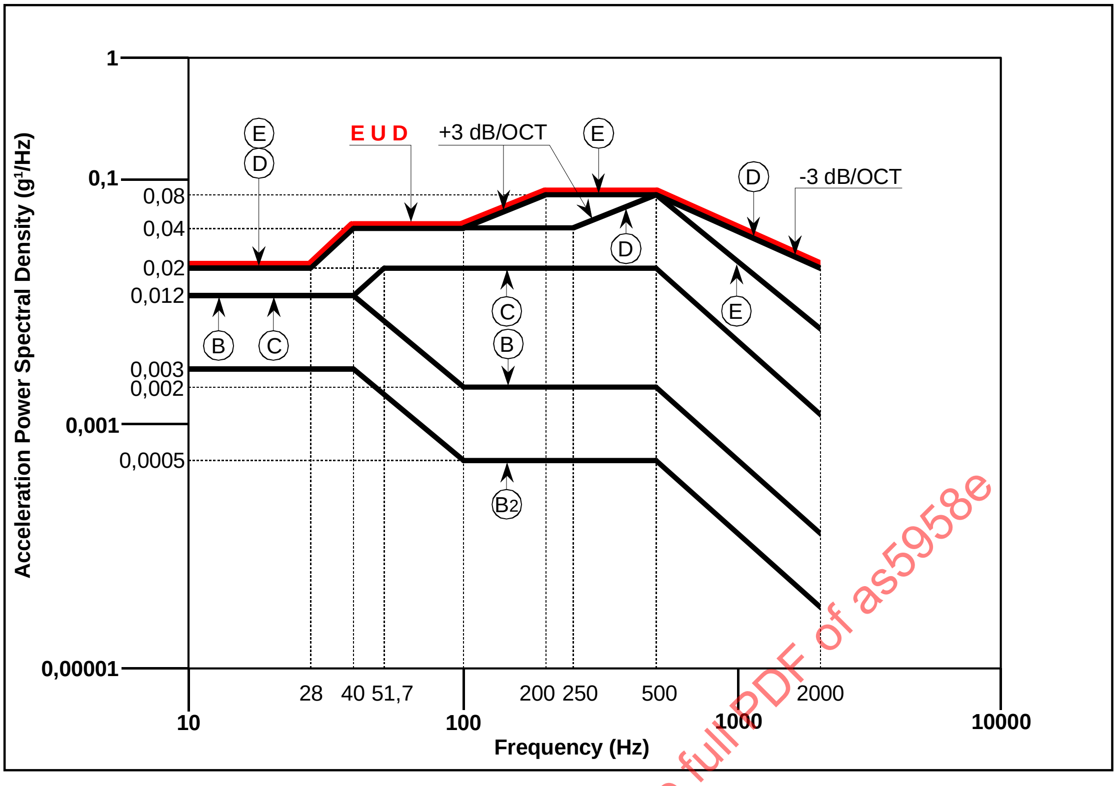

FIGURE 8 - CURVE E U D

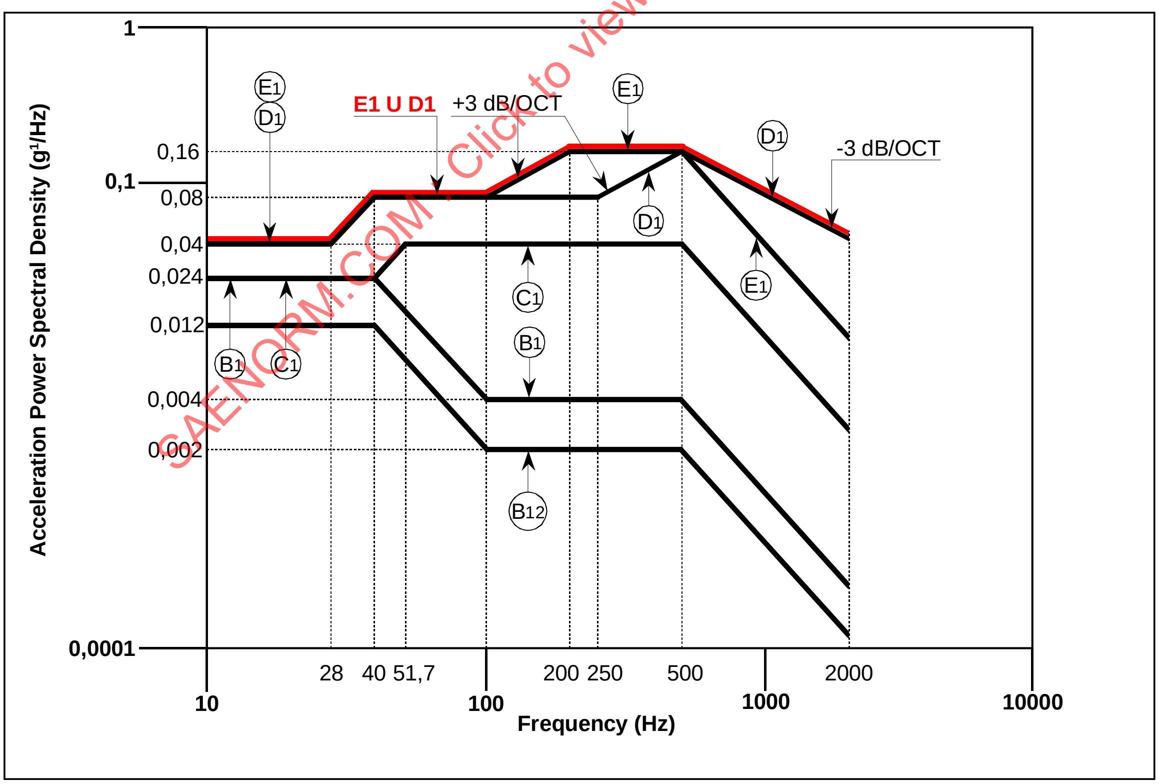

FIGURE 9 - CURVE E1 U D1

NOTE: Figures 8 and 9 are explanatory only. For accurate values, refer to ISO 7137.

4.6.12.2.2 Windmilling - Sustained Engine Imbalance

Two assemblies shall be tested if the test installation has a resonance below 20 Hz. If there is no resonance below 20 Hz, the windmilling test does not need to be performed.

NOTE: According to the area the fitting will be placed in, different windmilling testing curves will have to be performed. Curves to be performed are shown in Table 11.

TABLE 11 - WINDMILLING CURVES

Size Code	Curve
04	1BF, Figure 11
06	1AF, Figure 10
08	1BF, Figure 11
10	3A, Figure 12
12	3A, Figure 12
16	5B, Figure 13
20	1AF, Figure 10

In each of the equipment's three orthogonal axes, perform the following sinusoidal test procedure:

Step 1: Between 6 and 15 Hz (cruise phase)

With the equipment operating, sweep cycle the vibration frequency over the appropriate frequency range from the lowest (6 Hz) to the highest (up-sweep) to the lowest (down-sweep) with a logarithmic sweep rate not to exceed 0.5 octave/minute. During the initial up-sweeps, record plots of the accelerometers at the response locations selected and identify the critical frequencies.

Critical frequencies are defined at those frequencies where:

mechanical vibration resonance have peak acceleration amplitudes greater than twice the input acceleration amplitude, or

a change in performance or behavior is noticeable whether or not performance standards are exceeded.

If any, select the most severe frequency.

For the critical frequency identified (if one), dwell at this frequency for 160 minutes minimum. During the resonance dwell, the applied frequency shall be adjusted, if necessary, to maintain the maximum acceleration response at the vibration resonance being dwelled.

Any change in the critical frequency that occurs during the test shall be noted.

If no critical frequency is identified, then no dwells need to be performed. Continue sweep cycling the vibration frequency over the appropriate frequency range with a logarithmic sweep rate not to exceed 0.5 octave/minute for 160 minutes minimum.

At the completion of the test, the equipment shall be inspected and shall show no evidence of structural failure of any internal or external component.

Note that the time spent performing the initial up-sweeps may be included in the total sweep time (160 minutes).

Step 2: Between 3 and 6 Hz (descent phase)

With the equipment operating, perform one sinusoidal linear frequency sweep from the highest (6 Hz) to the lowest (3 Hz) at a sweep rate not to exceed 0.0025 Hz/s.

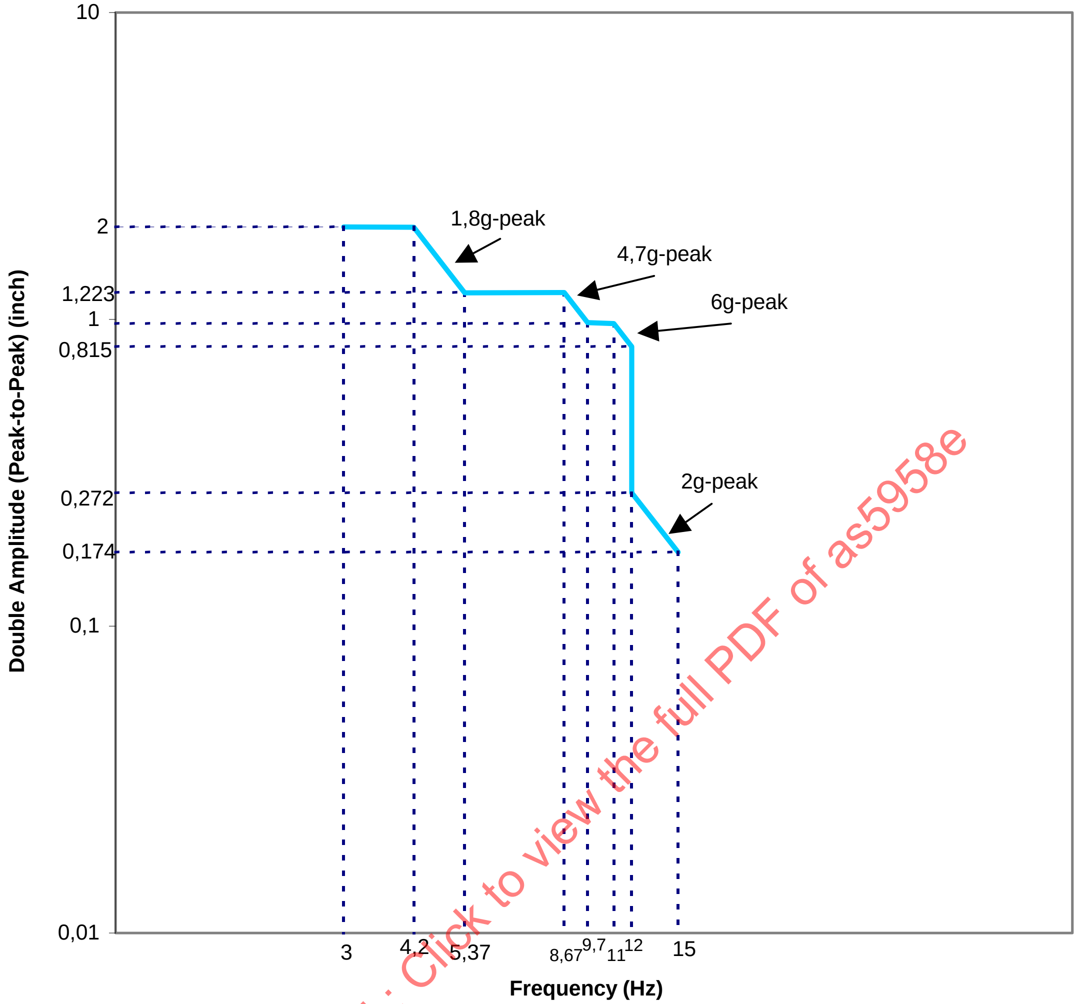

FIGURE 10 - CURVE 1AF

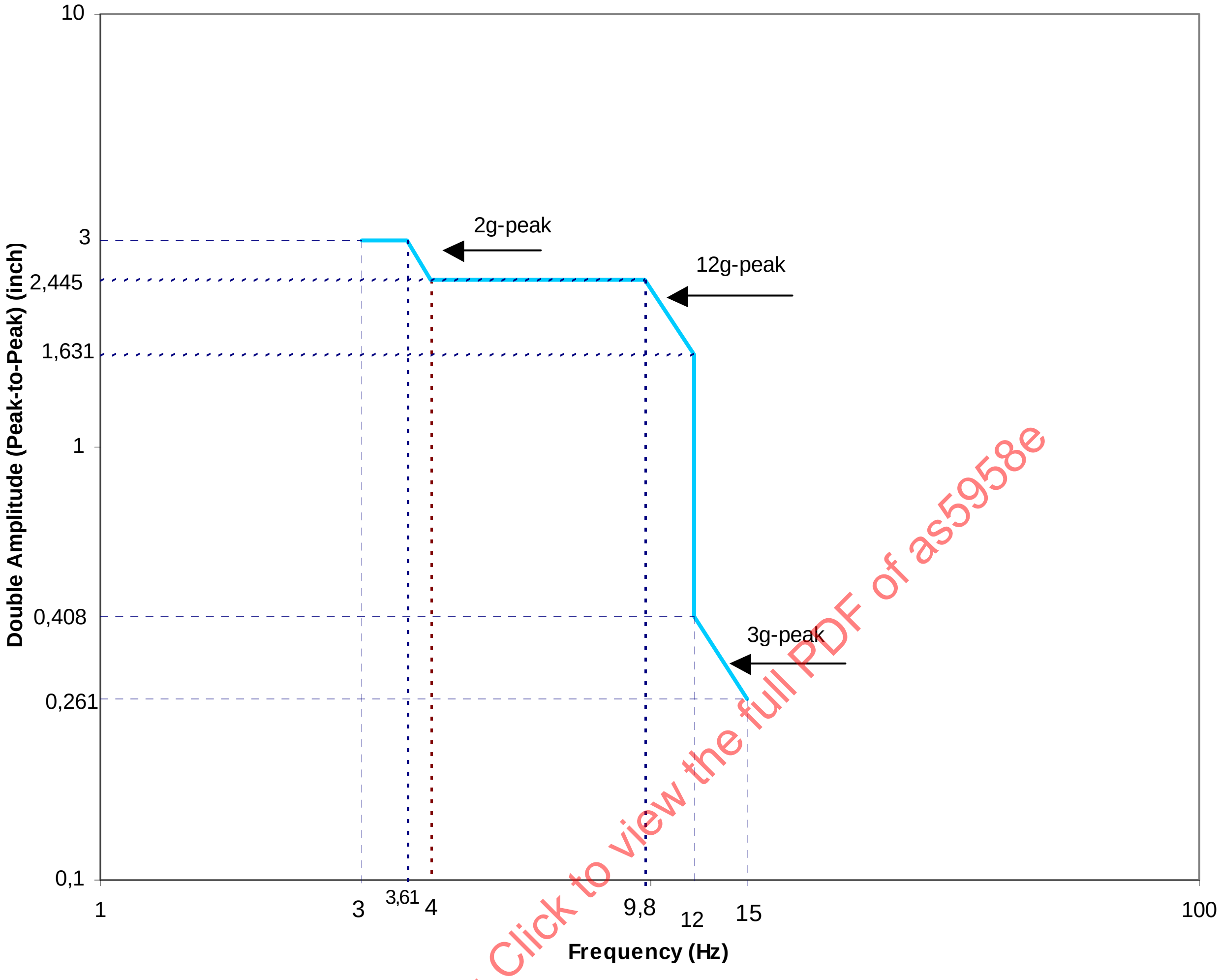

FIGURE 11 - CURVE 1BF

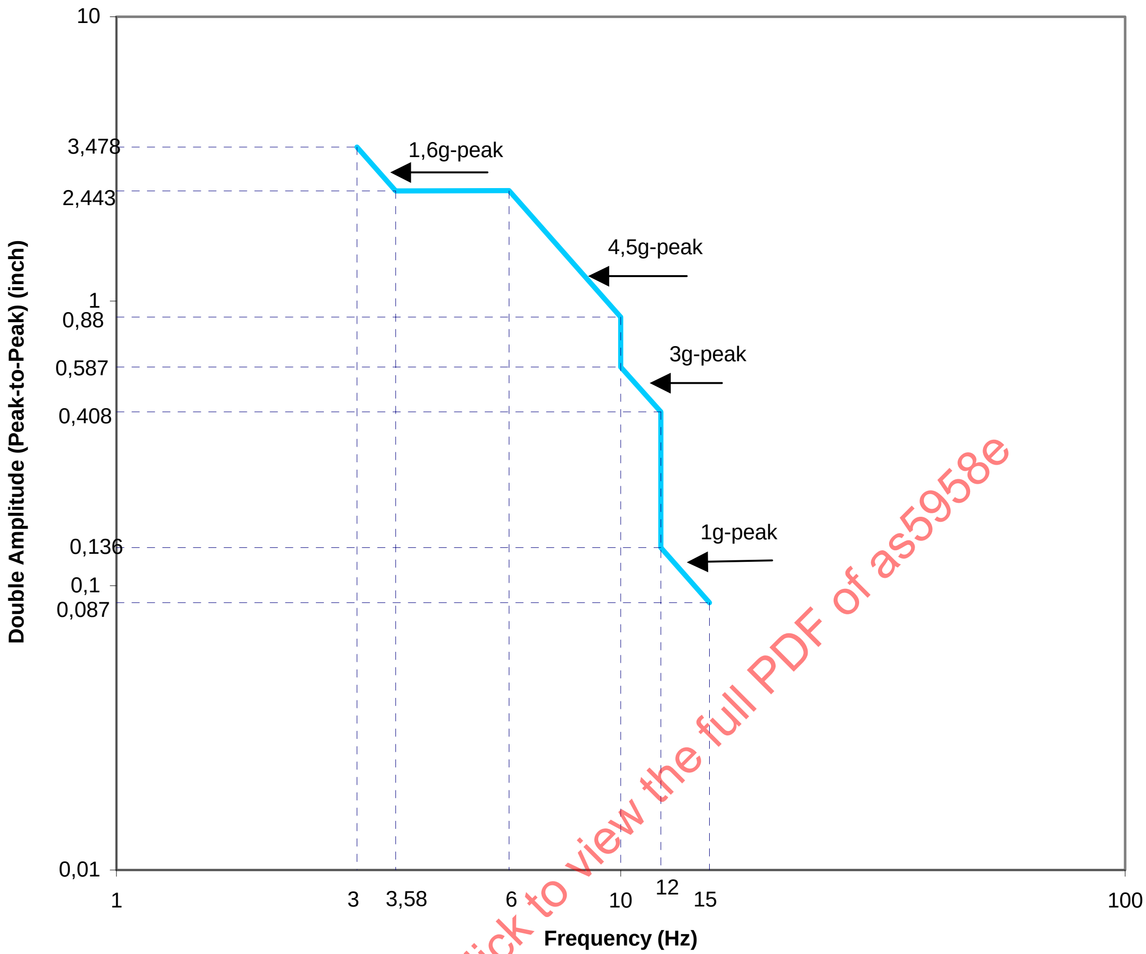

FIGURE 12 - CURVE 3A

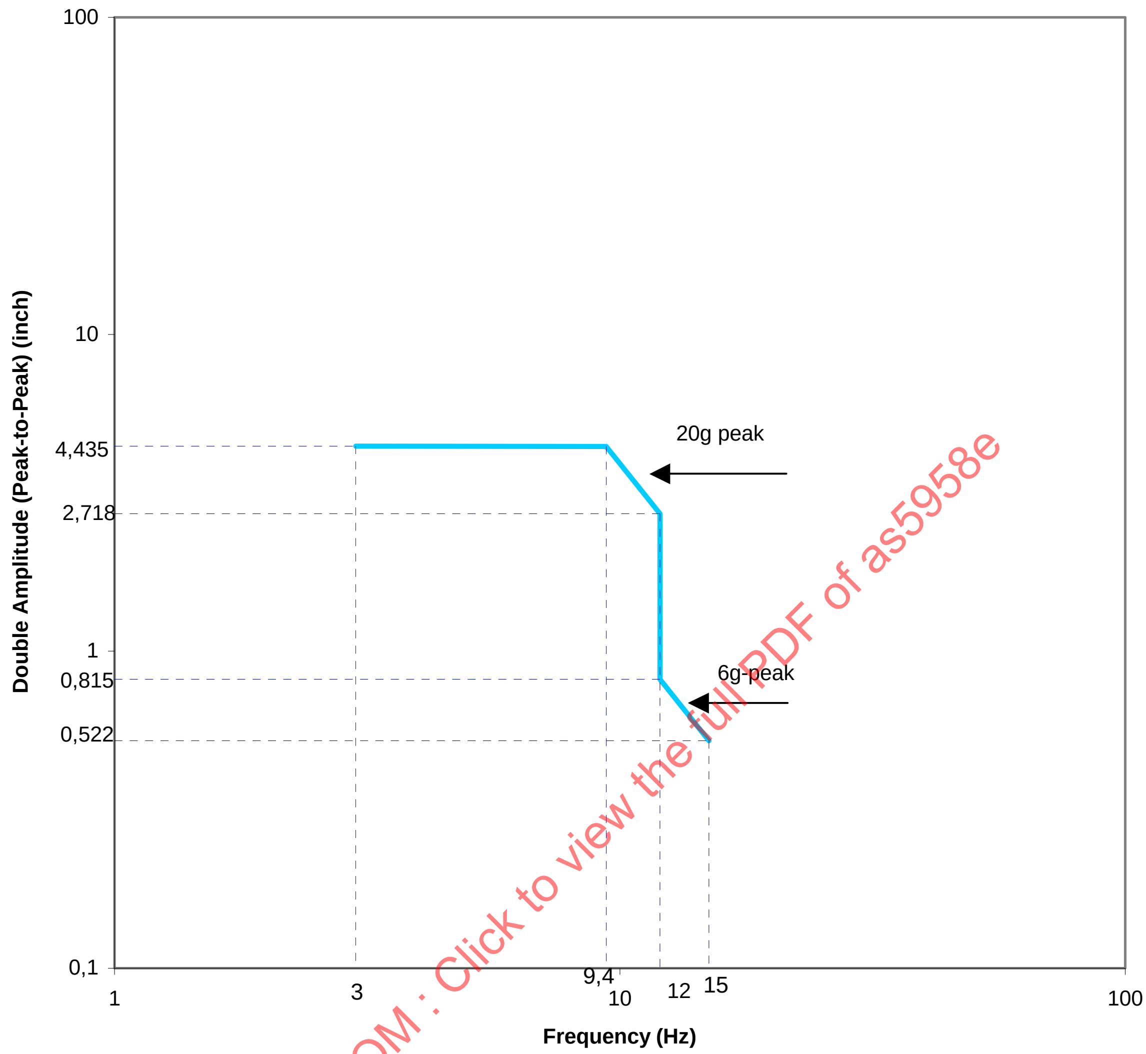

FIGURE 13 - CURVE 5B