SAE Aerospace
An SAE International Group

AEROSPACE STANDARD

SAE AS6116

Issued 2011-11

Aluminum Fittings, Axially Swaged Tube with Flareless Separable, Fluid System Up to 1500 psi (10 340 kPa) Maximum,

Specification for

RATIONALE

This specification is being prepared to provide the performance requirements for aluminum axially swaged, field attachable, 1500 psi, tube fittings.

1. SCOPE

This SAE Aerospace Standard (AS) establishes the requirements for externally swaged aluminum tube fittings on aluminum tubing with flareless separable fitting ends for use in hydraulic supply and return aerospace fluid systems including pneumatic, coolants, and fire extinguishers up to a maximum operating pressure of 1500 psig (10 340 kPa) and a maximum operating temperature range of –65 to +225 ºF (-54 to +107 ºC).

This specification covers a common aluminum fitting that may be used for a range of operating pressures up to 1500 psi with different tubing materials and tubing wall thicknesses, and is assembled with the same tooling in accordance with AS6124. 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.

AMS2700	Passivation of Corrosion Resistant Steels
AMS-QQ-A-225/8	Aluminum Alloy 6061 Bar, Rod, Wire, and Special Shapes; Rolled, Drawn, or Cold Finished
AMS-QQ-A-225/9	Aluminum Alloy 7075 Bar, Rod, Wire, and Special Shapes; Rolled, Drawn, or Cold Finished
AMS-QQ-A-225/6	Aluminum Alloy, 2024, Bar, Rod, and Wire; Rolled, Drawn, or Cold Finished
AMS4083	Aluminum Alloy Tubing, Hydraulic, Seamless, Drawn, Round 1.0MG – 0.6, .20CR (6061-T6) Solution and Precipitation Heat Treated

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
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SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AS6116

AMS4081	Aluminum Alloy, Tubing, Hydraulic, Seamless, Drawn, Round, 1.0Mg - 0.60Si - 0.28Cu - 0.20Cr (6061-T4) Solution Heat Treated and Naturally Aged
AMS4071	Aluminum Alloy, Drawn, Round, Seamless Hydraulic Tubing, 2.5Mg - 0.25Cr (5052-O), Annealed
AMS4070	Aluminum Alloy, Drawn, Round Seamless Tubing, 2.5Mg - 0.25Cr (5052-O), Annealed
AMS2477	Conversion Coating for Aluminum Alloys Low Electrical Resistance Coating
AS478	Identification Marking Methods
AS603	Impulse Testing of Hydraulic Hose, Tubing, and Fitting Assemblies
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
AS33514	Fitting End, Standard Dimensions for Flareless Tube Connection and Gasket Seal
AS5863	Fitting End, 24° Cone, Flareless, Fluid Connection, Design Standard
AS6115	Fitting Assembly, Straight, Male Flareless, Axially Swaged, Hydraulic, Up To 1500 psi
AS6117	Fitting Assembly, Union, Axially Swaged, Hydraulic, Up To 1500 psi
AS6118	Fitting Assembly, Straight, Female Flareless, Axially Swaged, Hydraulic, Up To 1500 psi
AS6119	Fitting Assembly, Elbow, 90°, Axially Swaged, Hydraulic, Up To 1500 psi
AS6120	Fitting Assembly, Elbow, 45°, Axially Swaged, Hydraulic, Up To 1500 psi
AS6121	Fitting Assembly, Tee, Axially Swaged, Hydraulic, Up To 1500 psi
AS6122	Fitting Assembly, Straight, Bulkhead, Flareless, Axially Swaged, Hydraulic, Up To 1500 psi
AS6123	Fitting Assembly, Tee, Axially Swaged On The Run, Male Flareless On The Side, Hydraulic, Up To 1500 psi
AS6124	Aluminum Axially Swaged Fittings, Installation and Inspection Procedure
AS6158	Fitting Assembly, Tee, Axially Swaged On The Run, Female Flareless On The Side, Hydraulic, Up To 1500 psi
AS6159	Fitting Assembly, Tee, Axially Swaged To Female Flareless On The Run, Male Flareless On The Side, Hydraulic, Up To 1500 psi
AS6445	Fitting Assembly, Tee, Axially Swaged On The Run, Bulkhead Flareless On The Side, Hydraulic, Up To 1500 psi
AS6446	Fitting Assembly, Tee, Axially Swaged On The Run, Internal Port End On The Side, Hydraulic, Up To 1500 psi

AS6457 Fitting Assembly, Tee, Axially Swaged To Male Flareless On The Run, Male Flareless On The Side, Hydraulic, Up To 1500 psi

AS6458 Fitting Assembly, Tee, Axially Swaged To Female Flareless On The Run, Female Flareless On The Side, Hydraulic, Up To 1500 psi

AS6192 Fitting Assembly, Elbow, 90°, Axially Swaged, Female Flareless, Hydraulic, Up To 1500 psi

AS6193 Fitting Assembly, Elbow, 45°, Axially Swaged, Female Flareless, Hydraulic, Up To 1500 psi

AS6194 Fitting Assembly, Tee, Axially Swaged, Female Flareless On The Run, Axially Swaged On The Side, Hydraulic, Up To 1500 psi

AS6195 Fitting Assembly, Tee, Male Flareless, Bulkhead Flareless On The Run, Axially Swaged On The Side, Hydraulic, Up To 1500 psi

AS7003 NADCAP Program Requirements

AS7112 National Aerospace and Defense Contractors Accreditation Program (NADCAP) Requirements for Fluid System Components

AS85449/2 Clamp Assembly, Saddle Type, Cushioned, Phosphate Ester Fluid Resistant

AS85449/3 Clamp Assembly, Saddle Type, Cushioned, High Temperature

ARP5416 Aircraft Lightning Test Methods

ARP5412 Aircraft Lightning Environment and Related Test Waveforms

2.2 ASME Publications

Available from American Society of Mechanical Engineers, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900, Tel: 973-882-1170. www.asme.org.

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

2.3 ASTM Publications

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

ASTM A 580 Standard Specification for Stainless Steel Wire

ASTM E 8 Tension Testing for Metallic Materials

ASTM E 499 Standard Test Methods for Leaks Using the Mass Spectrometer Leak Detector in the Detector Probe Mode

ASTM D1193 Standard Specification for Reagent Water

ASTM D1655 Standard Specification for Aviation Turbine Fuels

2.4 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

2.5 PRI Publications

Available from Performance Review Institute, 161 Thornhill 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

2.6 RTCA Publications

Available from Radio Technical Commission for Aeronautics Inc., 1828 L Street, NW, Suite 805, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

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

2.7 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, https://assist.daps.dla.mil/quicksearch .

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

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

MIL-A-8625 Anodic Coatings For Aluminum and Aluminum Alloys

MIL-DTL-5541 Chemical Conversion Coating on Aluminum and Aluminum Alloys

MIL-PRF-16173 Corrosion Preventive Compound, Solvent Cutback, Cold-Application

MIL-PRF-23377 Primer Coatings: Epoxy, High-Solids

MIL-HDBK-831 Preparation of Test Reports

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

AMS-QQ-A-225/8 Aluminum Alloy 6061 Bar, Rod, Wire, and Special Shapes; Rolled, Drawn, or Cold Finished

AMS-QQ-A-225/9 Aluminum Alloy 7075 Bar, Rod, Wire, and Special Shapes; Rolled, Drawn, or Cold Finished

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

AMS5685 Steel, Corrosion Resistant, Safety Wire, 18Cr - 11.5Ni (SAE 30305), Solution Heat Treated, Cold Finished

AMS-QQ-A-225/6 Aluminum Alloy, 2024, Bar, Rod, and Wire; Rolled, Drawn, or Cold Finished

ASTM A 580 Standard Specification for Stainless Steel Wire

3.2.3 Tube Requirements

Aluminum tubing shall meet the requirements of AMS4083, AMS4071, or AMS4070 as defined per Tables 1A and 1B.

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 0.015 in. A sphere with a 0.020 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 + tolerance) will pass through the entire fitting.

3.4.1.2 Maximum Reduction of Cross Section In Swaged Area

The cross-sectional area of the swaged fitting/tubing joint shall not be reduced by more than 12% of the minimum tube internal diameter prior to swage. A ball whose diameter is not less than 0.87 times the minimum tube internal diameter shall pass through the swaged area of the fitting/tubing joint.

3.4.2 Finish

3.4.2.1 Aluminum: As specified in the associated aerospace standard part drawings.

CRES: Passivation per AMS2700

3.4.2.2 Coating Color

The ring shall be anodized (Green) similar to No. 14187, 14193, or 14223 of FED-STD-595. The fitting bore shall be colored green with a pigmented polytetrafluoroethylene (PTFE) or fluid resistant paint.

3.4.2.3 Dry Lube

A lead free solid film lubricant per AS5272 Type I or III, or per AS6449 shall be used to facilitate assembly process.

3.4.2.4 Backup Sealing

The fitting bore shall be enforced with heat cured elastomeric Dimethyl siloxane as an additional backup seal. The elastomeric compound shall be cured at a temperature that does not have adverse effect on the fitting material properties, and shall have a Durometer of (54A-60A) and tensile strength of 800-1150 psi (5,516-7,930 kPa). The elastomeric compound shall be filled and completely bonded in the internal grooves of the fitting ends. The bonded elastomeric seal level shall be determined using the following “Go Gage” values below (e.g. a plug gage with a diameter equals to the maximum tube diameter (Go Gage) shall be possible to pass through the fitting/ring assembly prior to swage with some friction but not causing any damage to the seal). A minimum of two grooves (fitting end sizes -05 and larger) shall be filled with elastomeric Dimethyl siloxane compound. Smaller fitting end sizes shall have a minimum of one groove filled with the sealing compound.

Tube Size (in.)	Go Gage Diameter (in.)
1/4	.2530
5/16	.3155
3/8	.3780
1/2	.5030
5/8	.6290
3/4	.7540
1	1.0040
1-1/4	1.2550
1-1/2	1.5050

3.4.2.5 Aluminum Tubing Test Samples

Aluminum tubing used for impulse, corrosion conditioning, and stress corrosion (including electrical conductivity) tests as defined in Table 6 do require the application of one coat (.0005”-.0009” thick) of fluid resistant epoxy structural primer per MIL-PRF-23377, Type II, Class C1 or C2 on the entire outside of the tubing excluding the tubing area to be swaged with the fitting (up to the maximum insertion depth). Primer and touch-up of tubing after swage in the tube–fitting interface is allowed. For maximum corrosion protection the tubing shall be entirely chemical conversion coated (OD and ID) per MIL-DTL-5541 Type I Class 3 prior to any other primer coat application or as defined in Table 6.

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 name, Cage Code, 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 or other detrimental effects. Heat cured marking (ink, paint) can be used if the marking survives incidental contact with the hydraulic fluids (fluid immersion and fuel aging tests) referenced by this document (incidental contact - the mark shall be legible after immersion in hydraulic fluid and wiped dry).

3.6 Performance

Fittings and tubing when attached per AS6124 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 requirements in accordance with this specification when subjected to the natural and induced environments specified herein.

3.6.1.1 Pressures

a. 6061-T6 aluminum tubing per AMS4083 up to 1500 psi operating pressure in accordance with Table 1A

b. 5052-O aluminum tubing per AMS4070 or AMS4071 up to 1000 psi operating pressure in accordance with Table 1B

3.6.1.2 Temperature

a. Ambient Air: -65 to 225 °F (-54 to 107 °C), except as noted.

b. Fluid: -65 to 225 °F (-54 to 107 °C), except as noted.

3.6.2 Proof Pressure

Test assemblies shall withstand pressure equal to two times the design operating pressure as specified in Table 1A, and 1B 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.

TABLE 1A - TEST PRESSURES FOR 6061-T6 PER AMS4083 TUBING

Dash Size	Tube Size (in)	Tube Wall (in)	Operating Pressure (Min)	Proof Pressure (Min)	Burst Pressure (Min)
-04	.250	.028	1500 psi (10 340 kPa)	3000 psi (20 680 kPa)	6000 psi (41 370 kPa)
-05	.3125	.035			
-06	.375	.035			
-08	.500	.035			
-10	.625	.035	1000 psi (6895 kPa)	2000 psi (13 790 kPa)	4000 psi (27 580 kPa)
-12	.750	.035	900 psi (6205 kPa)	1800 psi (12 410 kPa)	3600 psi (24 820 kPa)
-16	1.000	.035	750 psi (5171 kPa)	1500 psi (10 342 kPa)	3000 psi (20 684 kPa)
		.049 /1/			
-20	1.250	.049	600 psi (4140 kPa)	1200 psi (8270 kPa)	2400 psi (16 550 kPa)
-24	1.500	.049	500 psi (3450 kPa)	1,000 psi (6895 kPa)	2,000 psi (13 790kPa)

/1/: This tube wall is considered qualified by similarity for the same operating pressure only if testing is completed for the thinner .035" wall. Higher operating pressure shall be tested as required in this document or by the procuring activity.

TABLE 1B - TEST PRESSURES FOR 5052-O PER AMS4070 OR AMS4071 TUBING

Dash Size	Tube Size (in)	Tube Wall (in)	Operating Pressure (Min)	Proof Pressure (Min)	Burst Pressure (Min)
-04	.250	.028	1000 psi (6895 kPa)	2000 psi (13 790 kPa)	4000 psi (27 580 kPa)
-05	.3125	.035			
-06	.375	.035	750 psi (5171 kPa)	1500 psi (10 342 kPa)	3000 psi (20 684 kPa)
-08	.500	.028	500 psi (3450 kPa)	1000 psi (6895 kPa)	2000 psi (13 790 kPa)
-10	.625	.028			
-12	.750	.028	300 psi (2070 kPa)	600 psi (4140 kPa)	1200 psi (8270 kPa)
-16	1.000	.028			
-20	1.250	.028	200 psi (1380 kPa)	400 psi (2760 kPa)	800 psi (5515 kPa)
-24	1.500	.028			

3.6.4 Impulse

Fittings shall pass 200 000 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, and 1B. 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 2 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 Table 3 for each tubing material, 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 2 times the maximum torque for sizes -04 through -06 and 1.5 times the maximum torque for sizes -08 through -24 to the values specified in Table 4 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 as shown in Figure 5, 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 h exposure at low pressure and 24 h 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 tube shall not rotate, when subjected to 0.3 times assembly torque (sizes 06 and larger) and 0.15 times assembly torque (sizes 05 and smaller) when tested 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 16, shall not leak after being subjected to 12 lightning strikes when tested in accordance with 4.6.17.

3.6.18 Negative Pressure

Aluminum tube assemblies shall withstand a negative pressure of 14.6 psi (29.7 inches of Hg). The test pass/fail criteria is that a decrease in the negative pressure shall not exceed 0.25 psi (.5 inches of Hg) within 5 minutes when tested in accordance with 4.6.18.

3.6.19 Helium Leakage

Aluminum tube assemblies shall leak helium at a rate of no more than $2.5x10^{-7}$ atm cc/sec at 300 psig with unscratched tubes, at a rate of no more than $5x10^{-6}$ atm cc/sec for scratched tubes at 100 psig for axially swaged ends, and no more than $5x10^{-5}$ atm cc/sec at 100 psig for flareless threaded connection when tested in accordance with 4.6.19.

3.6.20 Coolant Compatibility

Designated test specimens in Table 6A shall not show any leak or material deterioration when tested in accordance with 4.6.20.

TABLE 2 - BENDING STRESSES FOR ALUMINUM TUBING

Tube Size	Tube Wall Thickness (in)	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	0.028	6000	41 360	6.6
0.3125	0.035	6000	41 360	6.6
0.375	0.035	6000	41 360	6.6
0.500	0.035	5500	37 920	6.9
0.625	0.035	5500	37 920	6.9
0.750	0.035	5000	34 470	7.2
1.000	0.035	4000	27 570	8.0
1.250	0.049	4000	27 570	8.0
1.500	0.049	4000	27 570	8.0

NOTES:
/1/ Intersection of the indicated S/N characteristic curve versus stress at the endurance limit (i.e., 1×10^7).
/2/ Refer to Figure 3 for characteristic curves.

TABLE 3 – MINIMUM JOINT STRENGTH FOR ALUMINUM TUBING

Tube Size	Al. 6061-T6 Joint Strength		Al. 5052-O Joint Strength	
	(lb)	(N)	(lb)	(N)
0.250	295	1312	196	872
0.3125	460	2046	307	1366
0.375	663	2950	331	1472
0.500	1178	5240	500	2224
0.625	1227	5458	614	2731
0.750	1590	7073	675	3003
1.000	2356	10 480	942	4190
1.250	2945	13 100	982	4368
1.500	NA	NA	NA	NA

TABLE 4 - TORQUE VALUES

Dash Size	Assembly Torque (lb-in)			Assembly Torque (N.m)		
	Min	Max	Overtightening	Min	Max	Overtightening
04	100	140	280	11	16	32
05	130	180	360	15	20	40
06	150	195	390	17	22	44
08	270	350	525	31	40	60
10	360	430	645	41	49	74
12	460	550	825	52	62	92
16	700	840	1260	79	95	142
20	850	1020	1530	96	115	172
24	900	1080	1620	102	122	183

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 µin 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 µin Ra. The surface texture of forging parting plane shall be 500 µin 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.

NOTE 1: Aluminum tubing 6061-T4 per AMS4081 can be considered qualified by similarity only when both tubing materials 5052-O and 6061-T6 are qualified. Additional tube wall thickness or pressures other than defined in Tables 1A and 1B shall be tested or qualified by analysis.

NOTE 2: Qualification testing of a tee fitting satisfies qualification of other shaped elbows and crosses fittings having the same forging flats dimension.

NOTE 3: Each flareless end type shall be qualified in each size. Qualification of any flareless end connection (male and female) on straight fitting adapters (to axially swaged end) qualifies the flareless end of the same size on shape fittings and vice versa, if the flareless end of all configurations have the same geometry. Other end styles or geometries require separate qualification as agreed upon by the procuring activity.

NOTE 4: Shaped fittings with AS5202 boss end shall be proof, burst, and impulse tested per the applicable paragraph listed in Table 6A. Other tests including Fuel Aging, Hydraulic Fluid Immersion, and Corrosion Conditioning may be qualified by similarity. Testing of the boss end may be satisfied using an MS21915 style adapter made from a 6061-T6 forged body and modified as shown in Figure 1B to allow testing the boss end size at the operating pressures listed in Table 1A regardless of configuration size.

4.3.2 Qualification Test Sequence

Test sequence and procedure shall be as specified in Table 6A or Table 6B as applicable.

TABLE 5 - LENGTH “L” AND CONFIGURATION OF TEST SAMPLES IN INCHES

Tube Size	All Other Tests /1/ /2/	Flexure /3/	Lightning Strike	Vibration	Stress Corrosion /5/
0.250	6	6.0	10	/4/	NA
0.3125	6	7.0	NA	/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/	11.0
0.750	8	11.5	NA	/4/	NA
1.000	8	12.5	10.0	/4/	NA
1.250	8	13.0	NA	/4/	NA
1.500	8	14.5	NA	/4/	NA

/1/ Length shall be free tube length between the fittings.
/2/ All samples for other tests shall be straight to straight, except impulse samples shall have a “tee” on one end or a tee in the middle per Figure 1, for testing with 6061-T6 aluminum tubing. For samples of other tubing materials, straight to straight fittings may be used. Qualification testing of tees satisfies qualification of elbows and crosses.
/3/ Six samples shall have a straight fitting and two shall have a tee fitting. See Figure 4.
/4/ See Table 9.
/5/ See Figure 15.

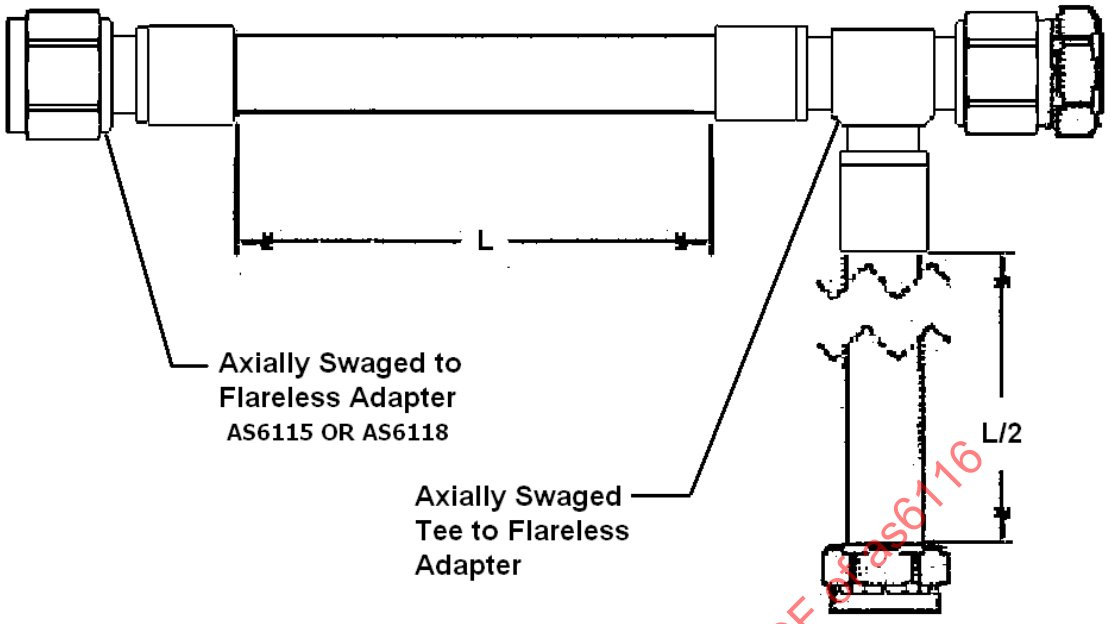

FIGURE 1A - OPTIONAL IMPULSE CONFIGURATION

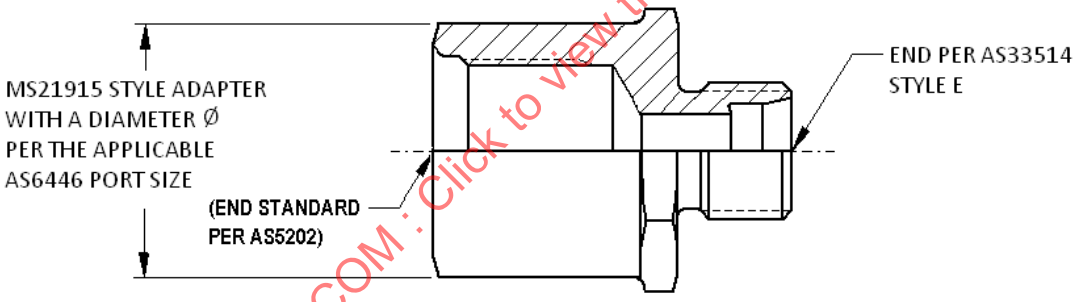

FIGURE 1B - ALTERNATE IMPULSE CONFIGURATION FOR PORT CONFIGURATIONS

TABLE 6A – 6061-T6 ALUMINUM TUBING QUALIFICATION TEST SCHEDULE

Test	Test Para.	Test Sample Number																		
		1, 2	3, 4	5 /5/	6 /4/ /5/	7 /5/	8 /4/ /5/	9 /7/	10 /4/ /7/	11, 12 /4/ /7/	13, 14 /5/	15 to 20	21, 22 /7/	23, 24 /7/	25, 26	27 to 32 /3/ /8/	33, 34 /7/	35, 36 /1/ /5/	37, 38 /2/ /7/	39,40 /4/ /6/ /7/
Inspection	4.6.1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fuel Aging	4.5.2			4	4															
Hydraulic Fluid Immersion	4.5.3					4	4													
Corrosion Cond.	4.5.4										4									
Proof pressure	4.6.2	2, 4	2, 4	3	3	3	3	4	4	3	3	2	2		3	3	3	3		3
Gaseous pressure	4.6.3	5	5		6		6		6										3	5
Impulse	4.6.4			**5**	5	**5**	5	**5**	5											
Burst	4.6.5			**6**	**8**	**6**	**8**	**7**	**9**	5	6							**6**		**7**
Flexure	4.6.6											3	3							
Re-use	4.6.7		3																	
Joint Strength	4.6.8													**2**						
Thermal Shock	4.6.9														4					
Overtightening	4.6.10	3																		
Conductivity	4.6.11							2,6	2,8		2, 5				2,5			2, 5	4,7	
Vibration	4.6.12															4				
System pressure	4.6.13				7		7		7				4			5				6
Tube twisting	4.6.14									4										
Fitt. / tube rotat. trq	4.6.15																2			
Stress corrosion	4.6.16																	4		
Lightning Strike	4.6.17																		5	
Helium Leak	4.6.19			2	2	2	2	3	3							2			2,6	2
Neg. proof pressure	4.6.18									2										
Coolant Compatibility	4.6.20																			4

/1/ Size -10 only
/2/ Sizes -04, and -16 only
/3/ Alternate method requires 6 samples and only two required for standard method.
/4/ The tubes shall be scratched per 4.6.1.2
/5/ The tubes shall be primer coated per 3.4.2.5
/6/ Size -06 and -16 only; Propylene Glycol coolant mixture shall be the test fluid.
/7/ The tubes shall be chemical conversion coated
/8/ A minimum of two vibration specimens of each configuration shall be tested for system pressure leakage per 4.6.13
NOTE: Bold figures are for tests ran up to rupture or specimens subjected to additional tests.

TABLE 6B – 5052-O ALUMINUM TUBING QUALIFICATION TEST SCHEDULE

Test	Test Para.	Test Sample Number			
		1 /1/ /2/	2 /1/ /2/	3 to10	11,12 /1/
Inspection	4.6.1	1	1	1	1
Proof pressure	4.6.2	3	3	3	
Gaseous pressure	4.6.3		5	2	
Impulse	4.6.4	**4**	**4**		
Burst	4.6.5	**5**	**6**		
Flexure	4.6.6			4	
Joint Strength	4.6.8				**2**
Conductivity	4.6.11	2	2		

/1/ The tubes shall be chemical conversion coated
/2/ Sizes 04 through 10 only
NOTE: Bold figures are for tests ran up to rupture or specimens subjected to additional tests.

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: Assembly and subassembly drawings 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 fluid and then pressurized to operating pressure as defined in Tables 1A and, while maintaining the pressure at room temperature; the samples shall be immersed in the fluid for 8 to 10 h and then allowed to air dry for 1 h. Then the samples will be placed at a temperature of -65 °F (-54 °C) for 8 to 10 h. This sequence of fluid immersion and low temperature exposure shall be repeated 20 times in accordance with Table 7. The fuel used shall be one of the following listed in Table 8. There shall be no visible degradation of the fitting finish at the end of this test.

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 ASTM	ASTM D 1655 : JET A ASTM D 1655 : JET A1
FRANCE	AIR3404 AIR3405
UK	DEF STAN 91-86 (NATO F44) DEF STAN 91-91 (Jet A1, NATO F35)
RUSSIAN	GOST 10227-86 : RT GOST 10227-86 : 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 min and then allowed to air dry for the remainder of 1 h. Then the samples shall be aged at +225 °F (+107 °C) in air for 8 to 10 h. This sequence of hydraulic fluid immersion and high temperature exposure shall be repeated 10 times. There shall be no visible degradation of the fitting finish at the end of this test.

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

4.5.4 Corrosion Conditioning

A salt spray test according to RTCA/DO-160, Section 14, category S, shall be performed for a minimum of 96 hours of salt fog exposure and shall include the Temperature Variation (RTCA/DO-160, Section 5, category A) and Humidity (RTCA/DO-160, Section 6, category C) Tests. A complete corrosion conditioning test shall constitue of exposure to the salt fog for a period of a minimum of 24 h, then the storage in an ambient temperature for a minimum of 24 h for drying. This exposure shall be repeated two times then followed by Temperature Variation test (with pressure), and Humidity test (with no pressure). After the completion of the Humidity test, additional two salt spray fog and drying cycles shall be performed to achieve the required 96 hours of exposure.

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 in of the fitting under test. Unless otherwise specified, all temperatures shall have a tolerance of +15 °F, -5 °F (+9 °C, -20 °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, workmanship, and any damage (tear) to the backup seal. The thickness of the backup seal in grooves shall be inspected using the gages listed in 3.4.2.4.

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.

4.6.1.2 Scratched Tube Preparation

Scratched tubing as required in Table 6A shall be prepared as follows. Tube end shall have 3 fabricated scratches of controlled depth as shown in Figure 2. The end of the scratch line shall be visible after the fitting is swaged on the tube.

NOTE: The depth of the induced scratches shall be verified by using laser profile scanning or other means prior to the installation of the tested fitting.

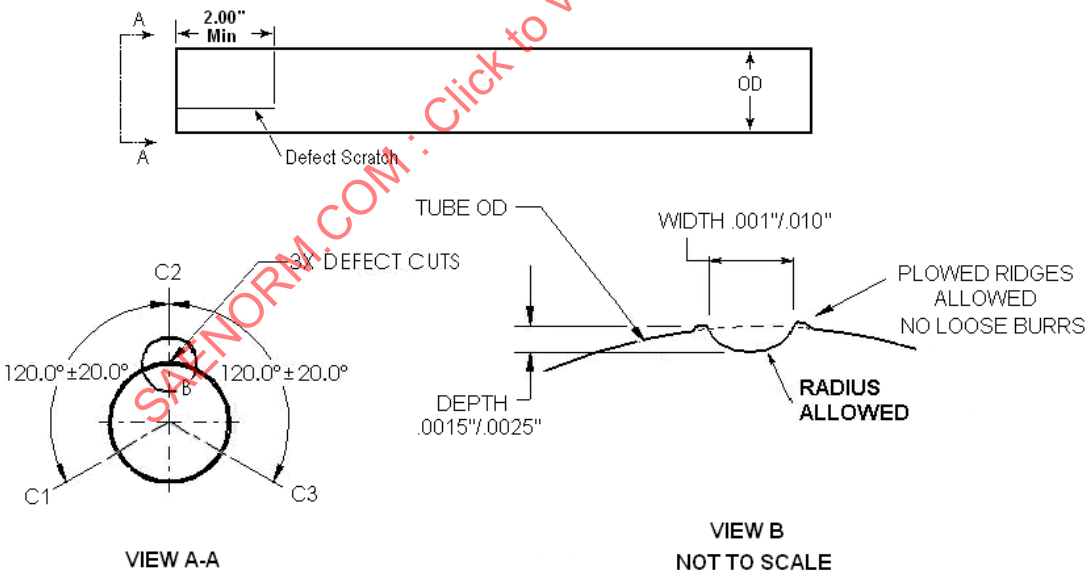

FIGURE 2 – SCRATCH DIMENSIONS

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. The rate of pressure rise shall be 250 to 400 psi/sec (1724 to 2758 kPa/sec) for system pressures of 1500 psi (10 340 kPa). For system pressures under 1500 psi (10 340 kPa), the pressure rise rate shall be 50 to 80 psi/sec (345 to 572 kPa/sec). The test shall be conducted at room temperature.

4.6.3 Gaseous Leakage Test

Test specimens shall not have been exposed to oil or shall be solvent cleaned and air dried 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 min.

4.6.4 Impulse Test

Test assemblies of each tube/fitting combination to be qualified shall be tested per the sequence listed in Table 6A or Table 6B as applicable. Impulse testing shall be in accordance with AS603 except the peak pressure percentage shall be 125% for all aluminum tubing. The maximum temperature shall be +225 °F ± 5 °F (+107 °C ± 3 °C). The minimum temperature shall be -65 °F ± 5 °F (-54 °C ± 3 °C). The impulse cycle rate shall be 70 cpm ± 5 cpm. The rate of pressure rise shall be 18 000 to 100 000 psi/s (124 106 to 689 476 kPa/sec). Hydraulic fluid shall be used as the testing media. Specimens shall complete a minimum of 200 000 impulse cycles and continue to 300 000 cycles or failure.

4.6.5 Burst Pressure Test

Test assemblies shall be pressurized to the proof pressure listed in Tables 1A or 1B as applicable, and held at that pressure for 5 minutes. The pressure shall then be increased at a rate of 250 to 400 psi/sec (1724 to 2758 kPa/sec) for system pressures of 1500 psi (10 340 kPa), and at a rate of 50 to 80 psi/sec (345 to 572 kPa/sec) for system pressures under 1500 psi (10 340 kPa) until failure occurs. No burst, slippage, leakage, or other failure shall occur at a pressure below the burst pressure as specified in Table 1A and 1B. The test shall be conducted at room temperature

4.6.6 Flexural Strength

The flexural test shall be performed in accordance with ARP1185, except the stress level shall be per Table 2. 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 in ± 0.031 in from the tube fitting interface. Testing shall be conducted with the specimen pressurized 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 3. 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 4 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 of 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 AS2094 (ASTM E 8) at a head travel rate of 0.15 in/min ± 0.05 in/min. Strength requirements shall be per 3.6.8.

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 5. After the 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 h. At the end of this period, while the test chamber is still at -65 °F (-54 °C), test fluid at 225 °F ± 5 °F (107 °C ± 3 °C) shall be suddenly introduced into the test assembly at a minimum pressure of 50 psi (345 kPa). Within 15 s after the hot fluid has filled the fitting assembly, a proof pressure test shall be performed in accordance with 4.6.2.

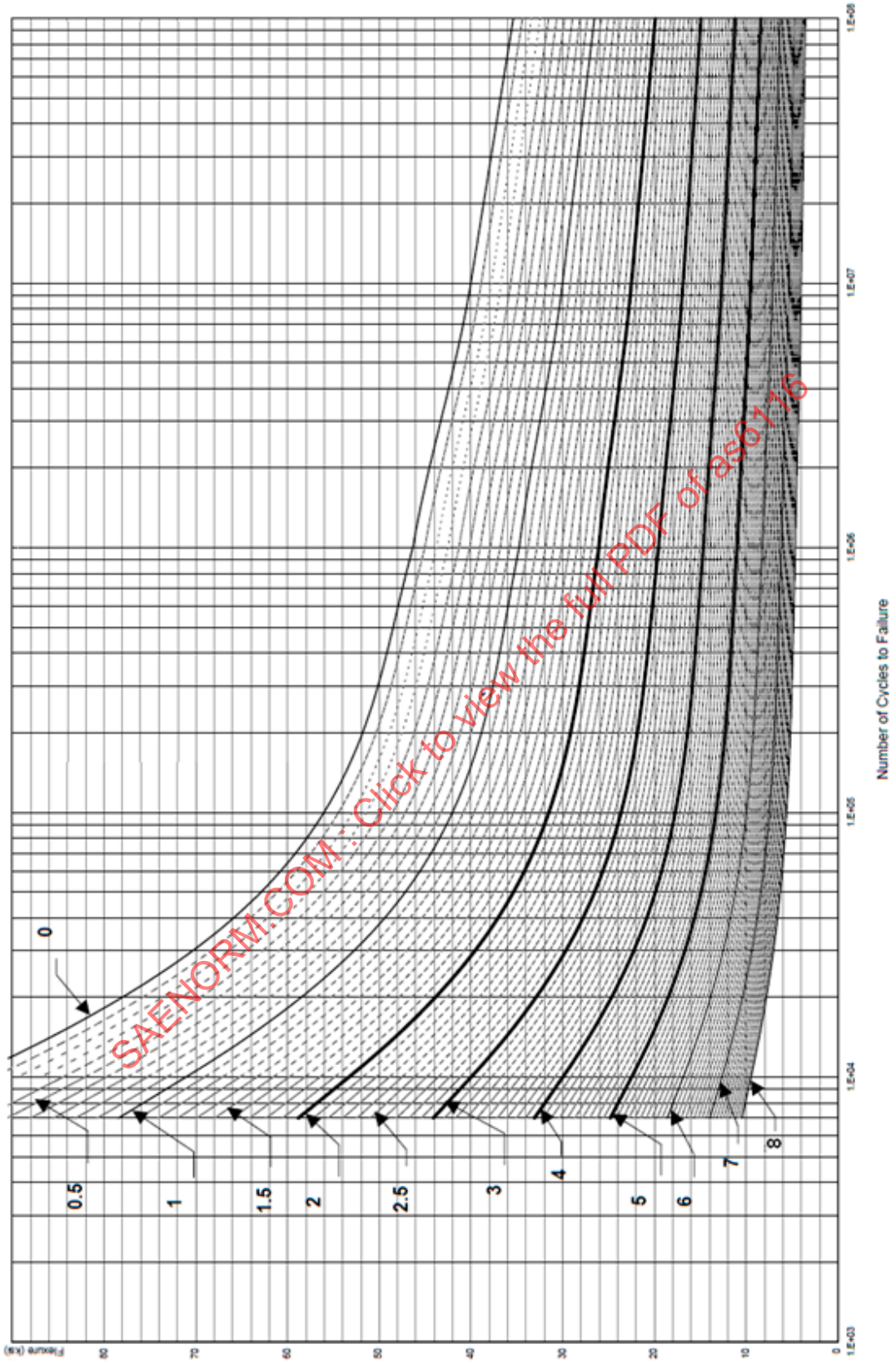

FIGURE 3 - FLEXURE FATIGUE TEST S/N CURVE

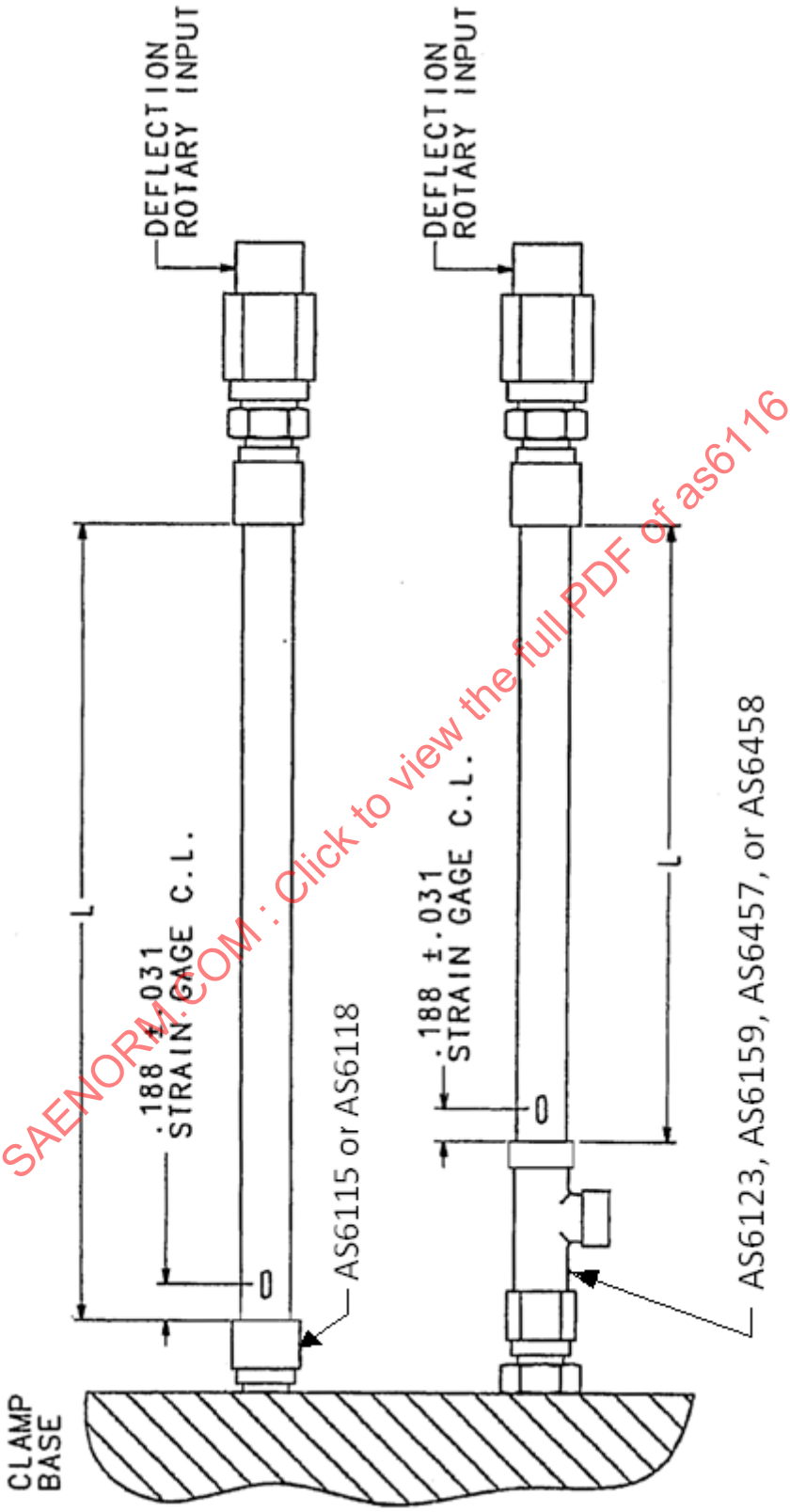

FIGURE 4 - ROTARY FLEXURE TEST SPECIMEN

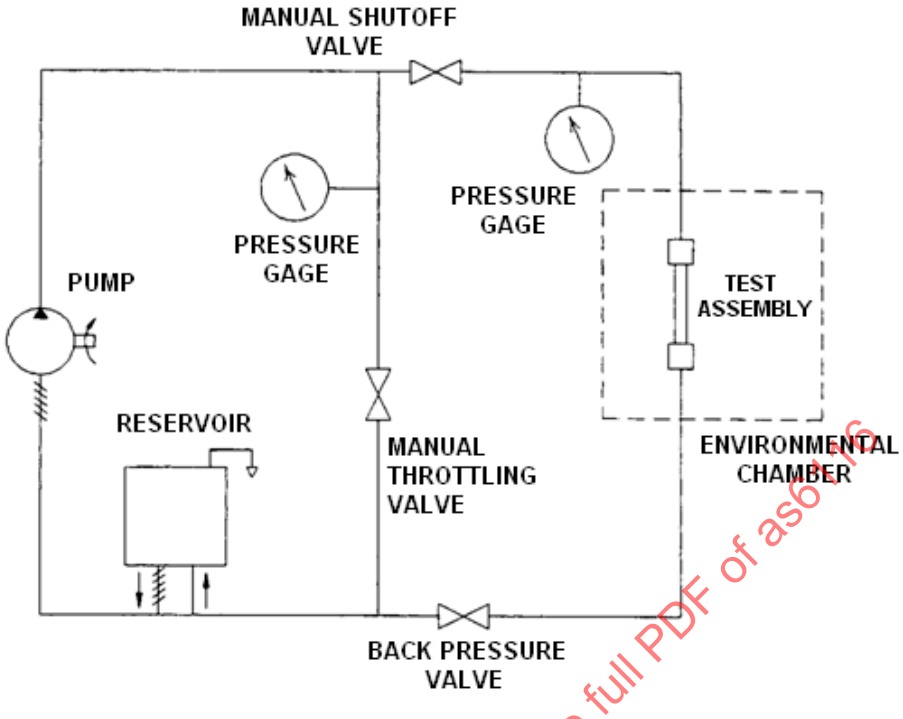

FIGURE 5 – TYPICAL SETUP FOR THERMAL SHOCK TESTING

4.6.10 Overtightening Torque (Separable Only)

The separable fitting shall be torqued to an adapter with an AS5863 or equivalent interface. The torque shall be 2 times the maximum installation torque for sizes -04 through -06 and 1.5 times the maximum installation torque for sizes -08 to -24. 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

An aluminum 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 6). This test shall be performed before and after completion of the test as specified in Table 6A or Table 6B as applicable. The test report shall provide measured resistance values.

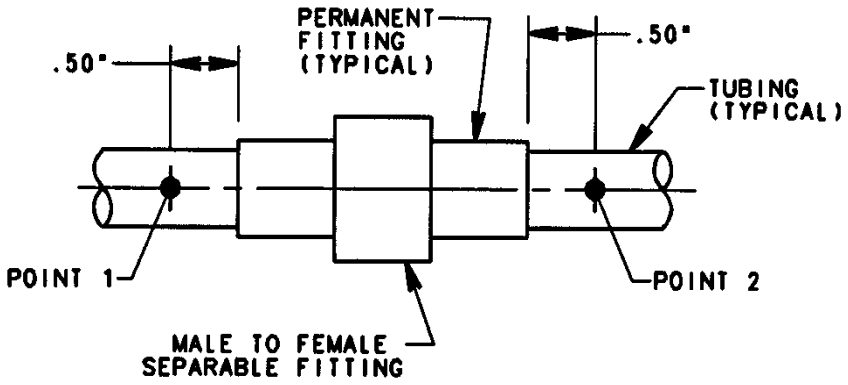

FIGURE 6 – FITTING CONDUCTIVITY

4.6.12 Vibration

Straight and shaped test assemblies with tubing specified in Table 1A shall be installed on a test fixture as illustrated in Figure 7 and Table 9 using AS85449/2 or AS85449/3 or equivalent saddle clamps with 65-75 durometer cushion. 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 and configuration specified in Figure 7, shall be tested using the modified curve W as specified in Figure 8, 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.

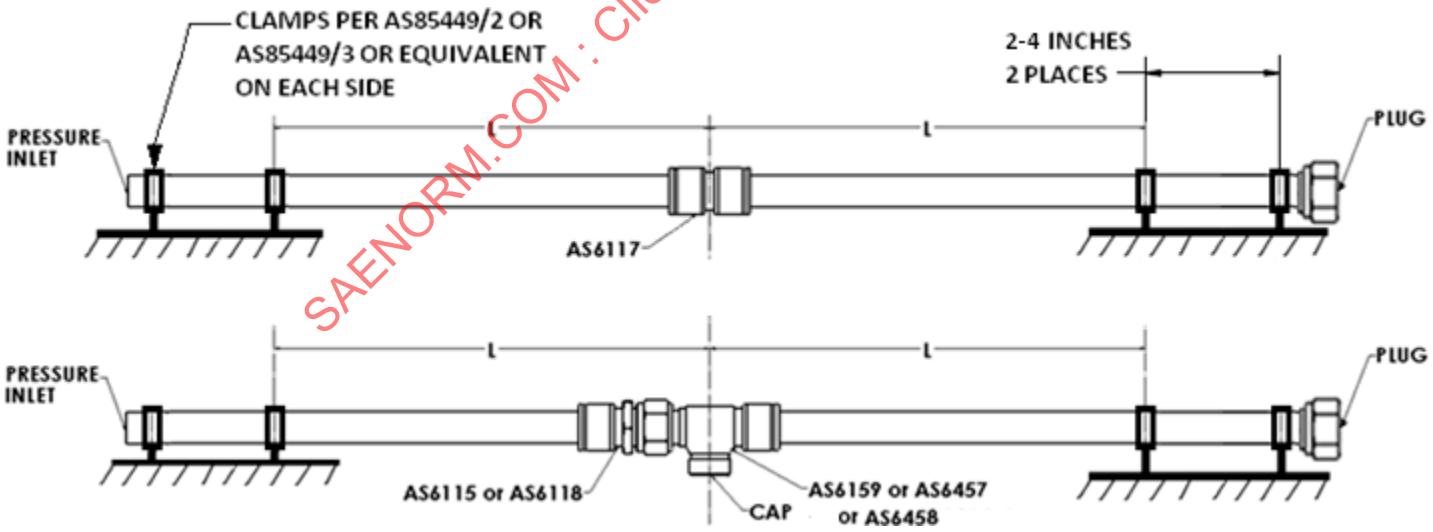

FIGURE 7 - VIBRATION TEST SETUP

TABLE 9 – MINIMUM TEST LENGTHS

Fitting Size	Length L (in)	Length L (mm)
04	6.7	170
05	7.4	188
06	9.3	236
08	10.6	269
10	11.0	279
12	13.2	335
16	13.25	337
20	14.2	361
24	14.7	373

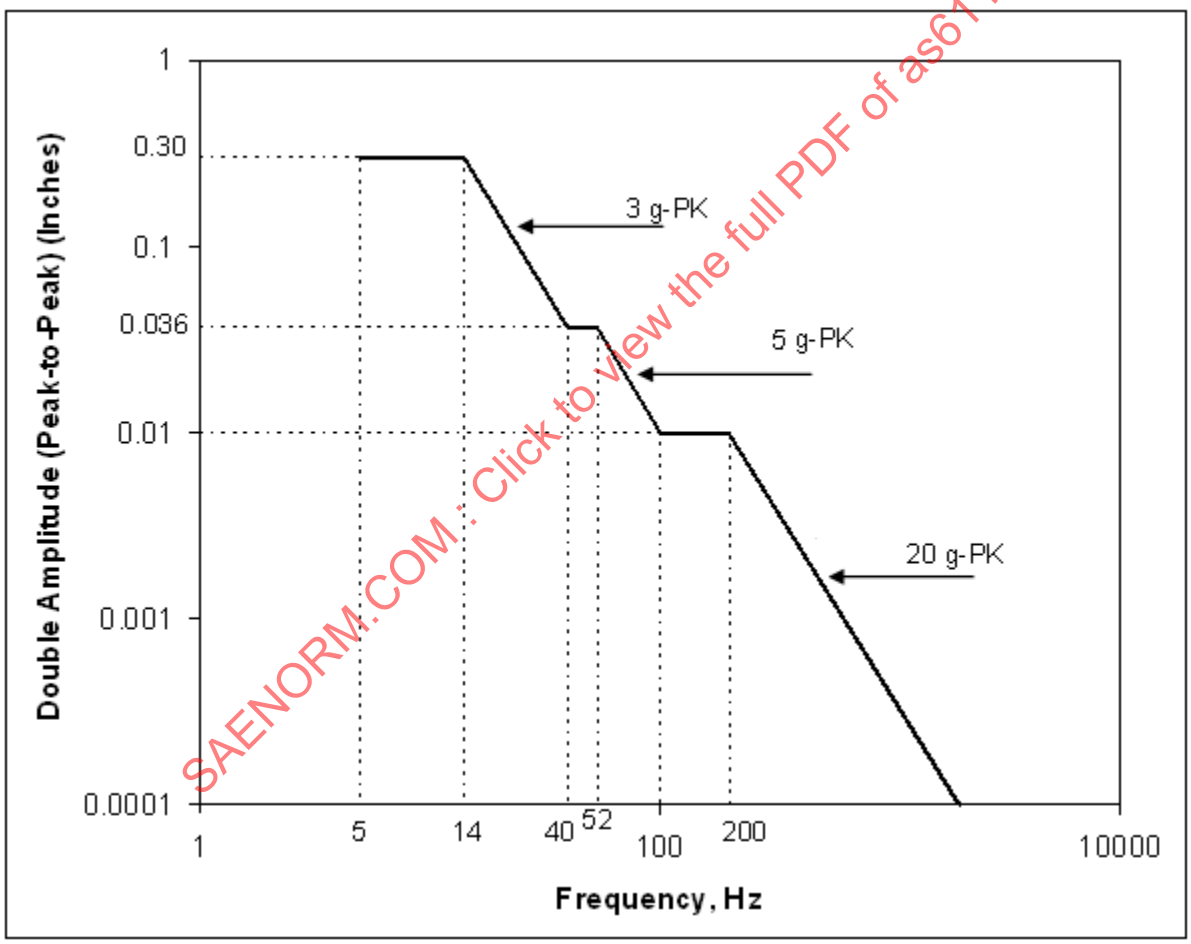

FIGURE 8 – MODIFIED CURVE W

4.6.12.2 Alternate Vibration Test

Test assemblies shall be installed on a test fixture as illustrated in Figure 7 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 of each size and configuration specified in Figure 7 shall be tested in accordance with ISO 7137, 2.2 with a vibration level depending on the aircraft area concerned, category R & H 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

Fitting Size	Series HP
04	S1 & S3
05	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 9 and 10 as follows:

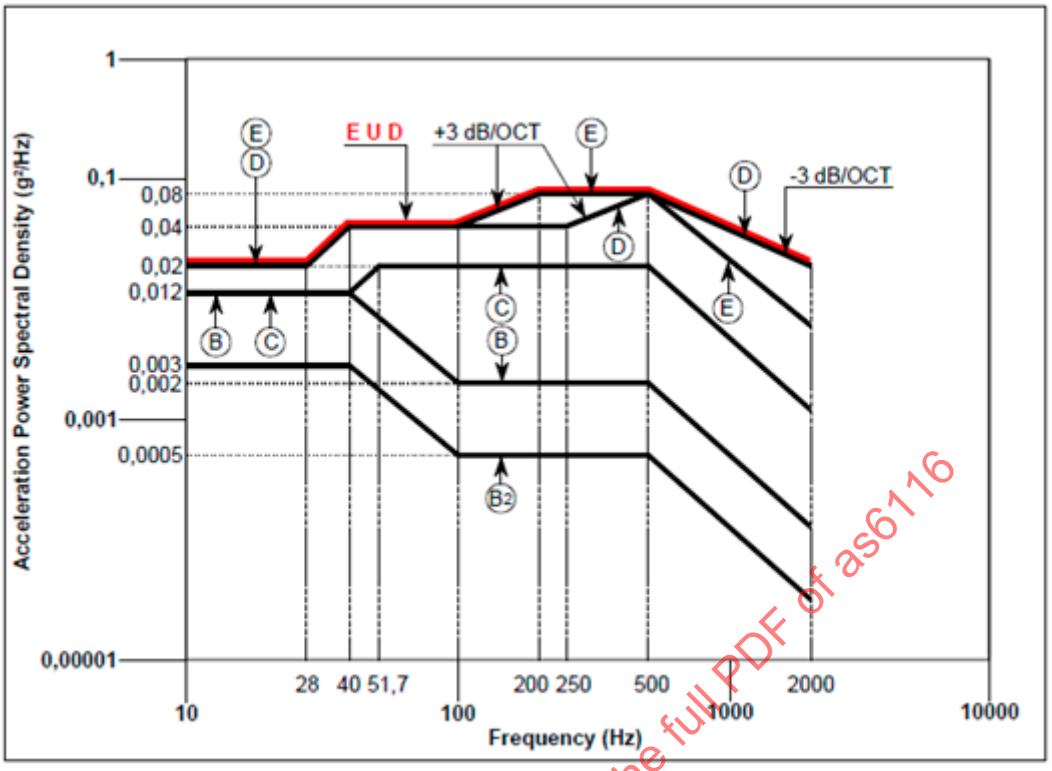

FIGURE 9 - CURVE E U D

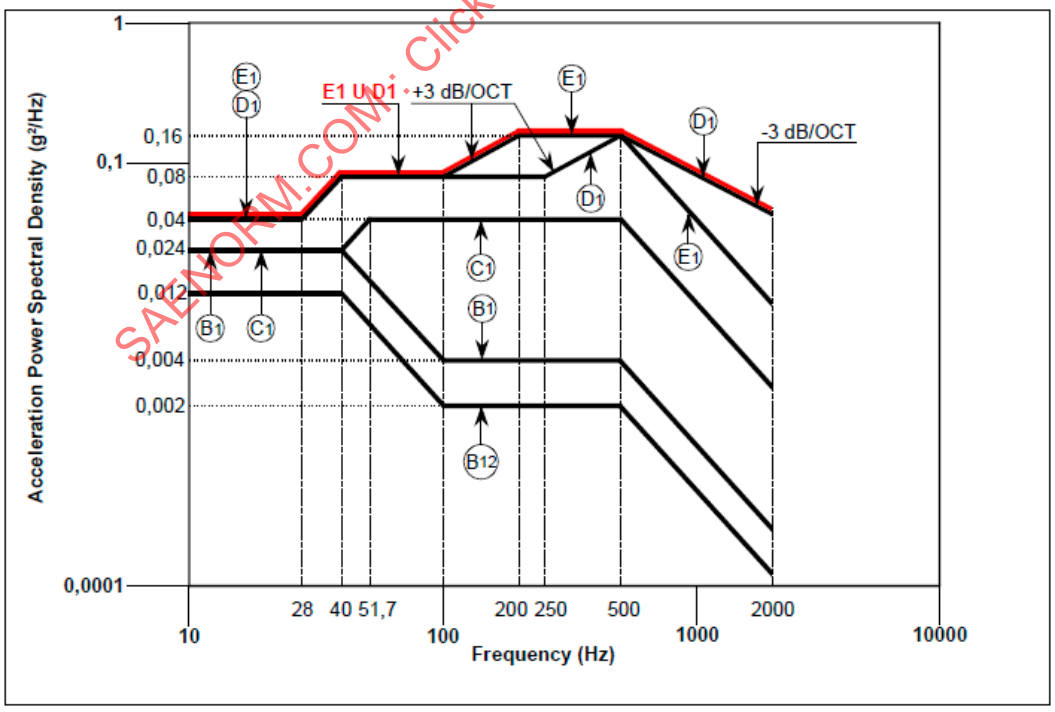

FIGURE 10 - CURVE E1 U D1

NOTE: Figures 9 and 10 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 12
05	1BF, Figure 12
06	1AF, Figure 11
08	1BF, Figure 12
10	3A, Figure 13
12	3A, Figure 13
16	5B, Figure 14
20	1AF, Figure 11

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 min 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 min).

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.

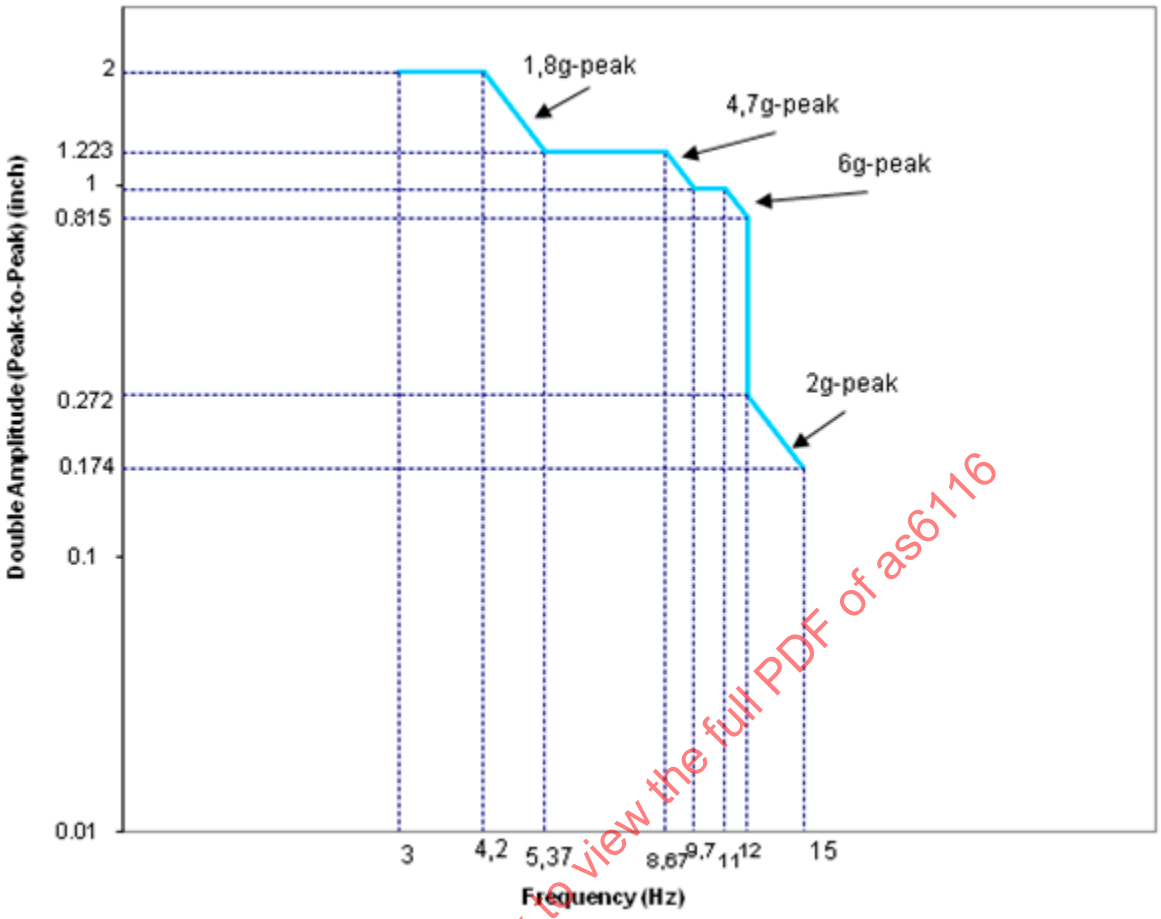

FIGURE 11 - CURVE 1AF

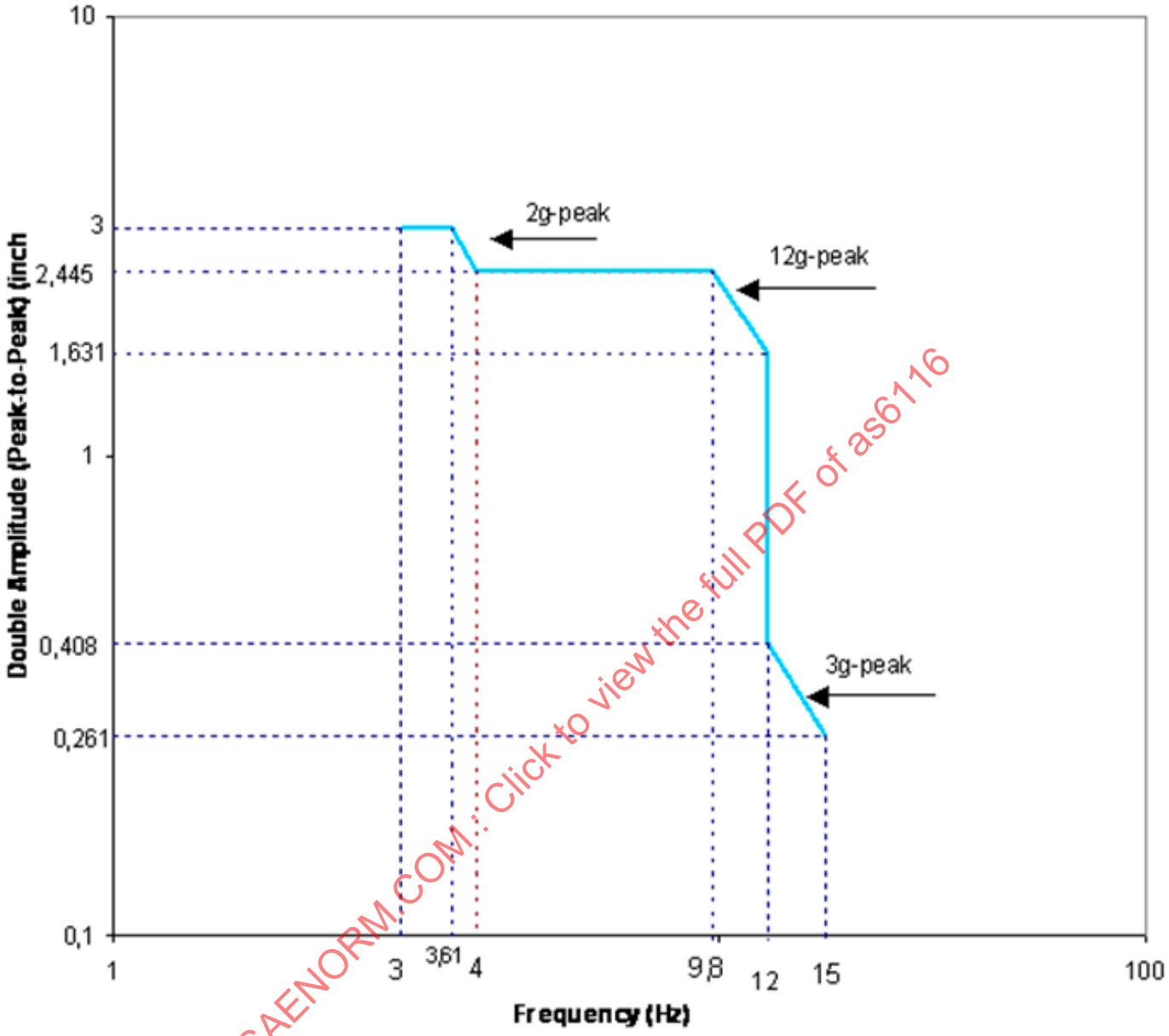

FIGURE 12 - CURVE 1BF

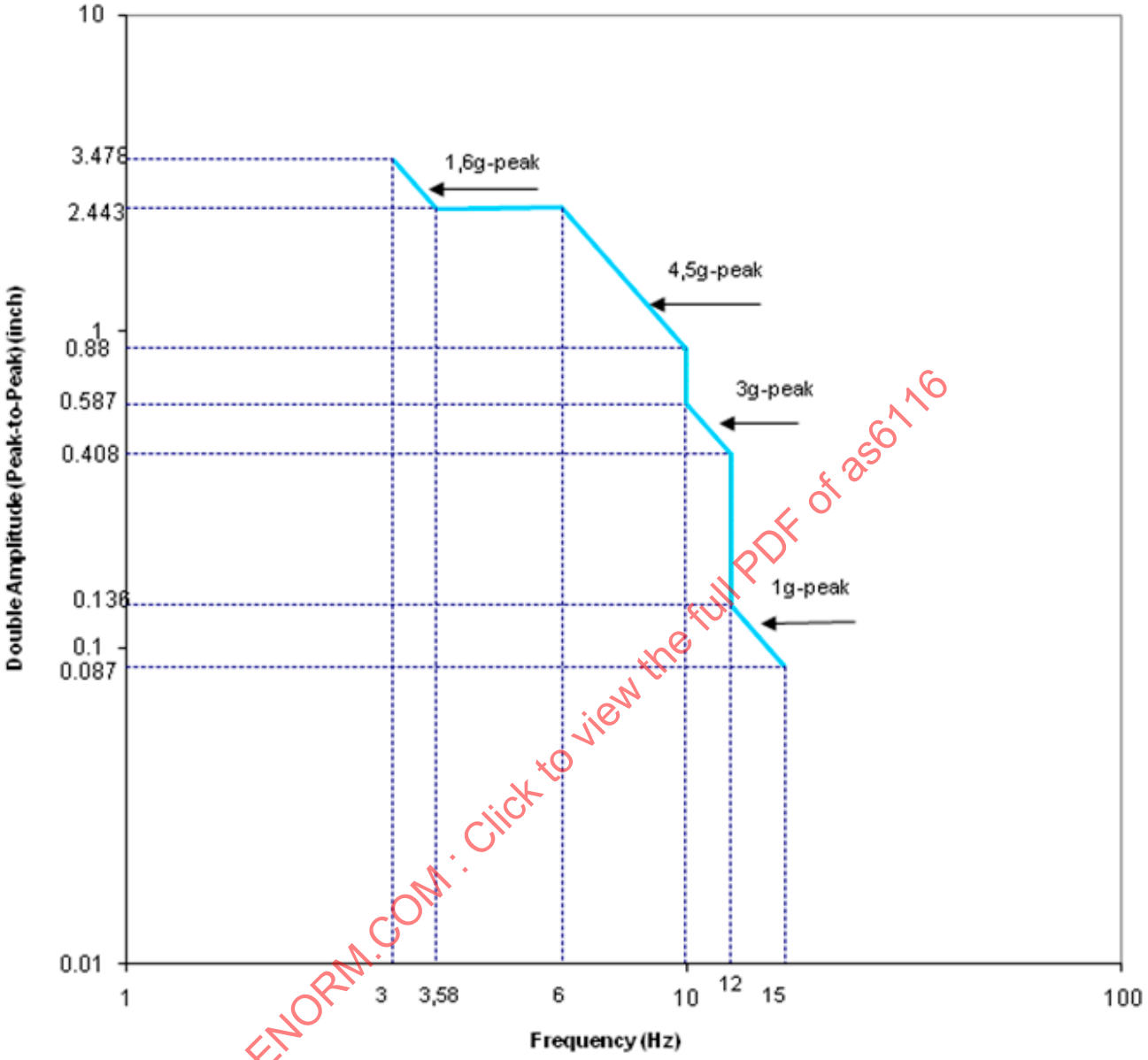

FIGURE 13 - CURVE 3A

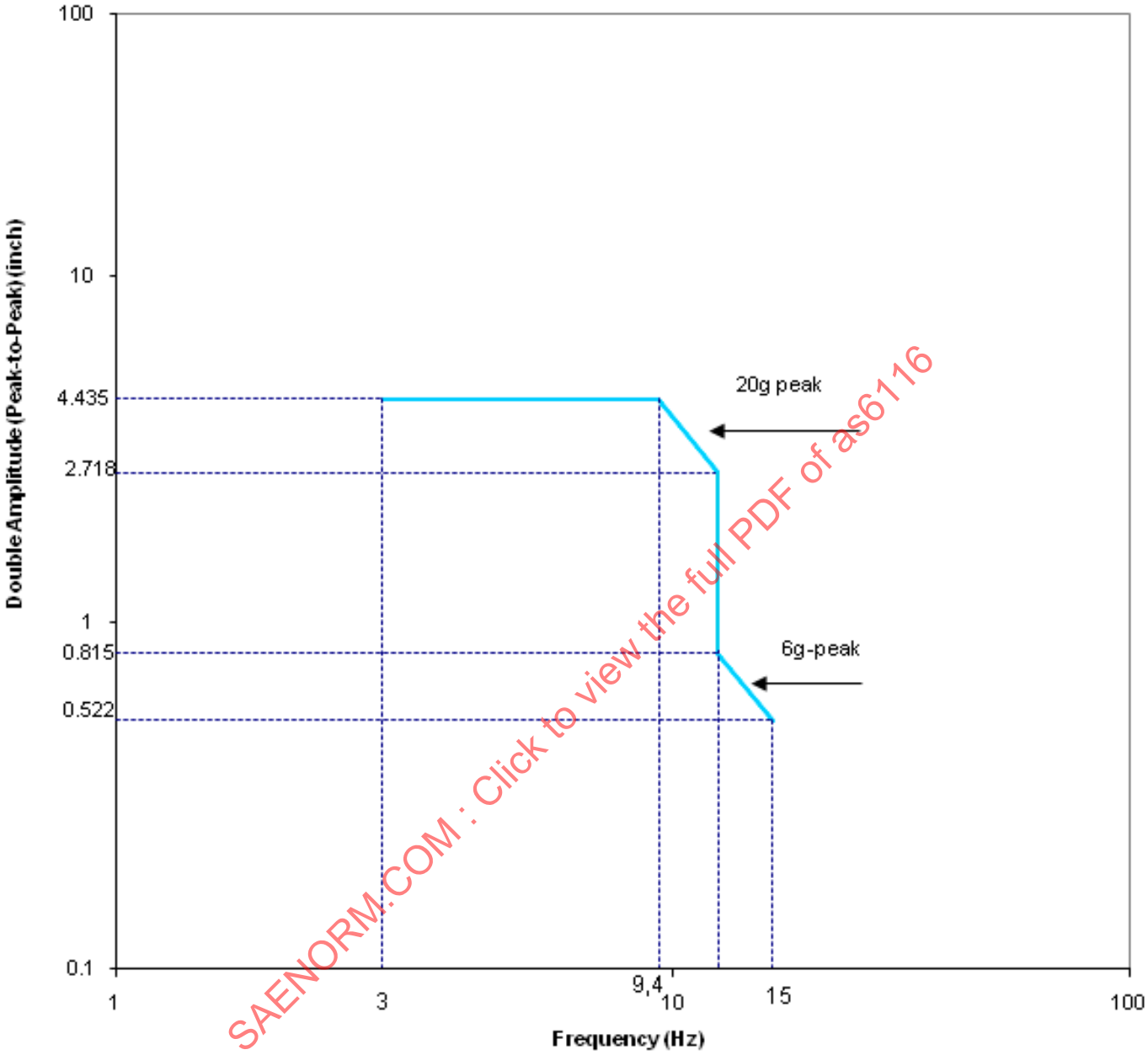

FIGURE 14 - CURVE 5B