SAE International™

SURFACE VEHICLE RECOMMENDED PRACTICE

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Metallic Tube Conductor Assemblies for Fluid Power and General Use—Test Methods for Hydraulic Fluid Power Metallic Tube Assemblies

Foreword—In fluid power systems, power is transmitted and controlled through a fluid (liquid or gas) under pressure within an enclosed circuit. Metallic tube conductor assemblies must be designed to meet these requirements under varying conditions. Testing of metallic tube conductor assemblies to meet performance requirements provides users a basis of assurance for determining design application and for checking compliance with their stated requirements. This standard also provides a means to evaluate functional requirements of new metallic tube conductor materials and end configuration manufacturing processes. This standard is primarily intended for mobile/stationary industrial equipment applications. Aircraft, Automotive and Aerospace applications were not considered during the preparation of this document.

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1. ***Scope***—This SAE standard specifies uniform methods for various types of tests to evaluate functional performance requirements for metallic tube conductor assemblies for hydraulic fluid power applications made from both standard and non-standard metallic tubing and components. See the appropriate listed SAE or ISO tubing and connector standard for chemical, mechanical and dimensional requirements for standard tubing, end components and tube end joint configurations for the standard tube assemblies being tested. See SAE J1065 and ISO 10763 for listed nominal reference working pressures and/or reference formula that may be used to calculate reference working pressures for standard and non-standard metallic tube conductors.

1.1 **Application**—This standard is to be used to qualify metallic hydraulic tube assemblies manufactured with various standard and non-standard tubing materials, tube end components and tube end joining processes, primarily intended for mobile/stationary industrial equipment applications. Aircraft, Automotive and Aerospace applications were not considered during the preparation of this document.

2. ***References***

2.1 **Applicable Publications**—The following standards contain provisions which, through reference in this text, constitute provisions of this document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent edition of the standards indicated as follows. Members of IEC and ISO maintain registers of currently valid International Standards.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J514—Hydraulic Tube Fittings
SAE J518—Hydraulic Flanged Tube, Pipe and Hose Connections; 4-Bolt Type
SAE J533—Flares for Tubes
SAE J1065—Nominal Reference Working Pressures for Hydraulic Steel Tubing
SAE J1453—Fitting- O-Ring Face Seal

2.1.2 ISO PUBLICATIONS—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ISO 6162—Hydraulic Fluid Power - Flange connectors with split or one-piece flange clamps and metric or inch screws
ISO 8434-1—Metallic tube connections for fluid power and general use - Part 1: 24 degree compression connectors
ISO 8434-2—Metallic tube connections for fluid power and general use - Part 2: 37 degree flared connectors
ISO 8434-3—Metallic tube connections for fluid power and general use - Part 3: O-ring face seal connectors
ISO 8434-4—Metallic tube connections for fluid power and general use - Part 4: 24 degree cone connectors with o-ring weld-on nipples

ISO 8434-5—Metallic tube connections for fluid power and general use - Part 5: method of testing threaded hydraulic connections
ISO 8434-6—Metallic tube connections for fluid power and general use - Part 6: 60 degree cone connectors and weld-on nipples
ISO 10763—Hydraulic fluid power - Plain-end, seamless and welded steel tubes - dimensions and nominal working pressures

2.2 Related Publications—The following publications are for information purposes only and are not a required part of this document.

2.2.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J343—Tests and Test Procedures for SAE 100R Series Hydraulic Hose and Hose Assemblies
SAE J356—Welded Flash Controlled Low Carbon Steel Tubing Normalized for Bending, Double Flaring, and Beading
SAE J515—Specifications for Hydraulic O-Ring Materials, Properties and Size for Metric and Inch Stud Ends, Face Seal Connections and Four-Screw Flange Connections
SAE J524—Seamless Low Carbon Steel Tubing Annealed for Bending and Flaring
SAE J525—Welded and Cold Drawn Low Carbon Steel Tubing Annealed for Bending and Flaring
SAE J526—Welded Low Carbon Steel Tubing
SAE J527—Brazed Double Wall Low Carbon Steel Tubing
SAE J1615—Thread Sealants
SAE J1644—Metallic Tube Connections for Fluid Power and General Use - Test Methods for Threaded Hydraulic Fluid Power Connectors
SAE J1677—Tests and Procedures for Low Carbon Steel and Copper-Nickel Tubing
SAE J1926/1—Part 1, Inch Ports and Stud End Connections for Fluid Power and General Use, Threaded Port with O-Ring seal in Truncated Housing
SAE J1926/2—Part 2, Connections for General use and Fluid Power-Ports and Stud Ends with ISO 725 Threads and O-Ring Sealing, Heavy-Duty (S Series) Stud Ends
SAE J1926/3—Part 3, Connections for General use and Fluid Power-Ports and Stud Ends with ISO 725 Threads and O-Ring Sealing, Light-Duty (L Series) Stud Ends
SAE J2244/1—Part 1, Connections for Fluid Power and General Use - Ports and Stud Ends with ISO 261 Threads and O-Ring Sealing, Port with O-Ring Seal in Truncated Housing
SAE J2244/2—Part 2, Connections for Fluid Power and General Use - Ports and Stud ends with ISO 261 Threads and O-Ring Sealing, Heavy-Duty (S Series) Stud Ends - Dimensions, Design, Test Methods, and Requirements
SAE J2244/3—Part 3, Connections for Fluid Power and General Use - Ports and Stud Ends with ISO 261 Threads and O-Ring Sealing, Light-Duty (L Series) Stud End - Dimensions, Design, Test Methods, and Requirement
SAE J2244/4—Part 4, Connections for Fluid Power and General Use - Ports and Stud Ends With ISO 261 Threads and O-Ring Sealing, Heavy-Duty (S Series) External Hex Port Plugs--Dimensions, Design, Test Methods, and Requirements
SAE J2435—Welded Flash Controlled, SAE 1021 Carbon Steel Tubing, Normalized for Bending, Flaring, and Beading
SAE J2467—Welded and Cold Drawn, SAE 1021 Carbon Steel Tubing Normalized for Bending, Flaring and Beading
SAE J2551—Recommended Practices For Hydraulic Tube Assemblies
SAE J2613—Welded Flash Controlled High Strength Low Alloy Steel Hydraulic Tubing, Sub-Critically Annealed for Bending, Flaring & Beading
SAE J2614—Welded and Cold Drawn High Strength Low Alloy Steel Hydraulic Tubing, Sub-Critically Annealed for Bending & Flaring

2.2.2 ISO PUBLICATIONS—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002

ISO 48—Vulcanized rubbers - Determination of hardness (hardness between 30 and 85 IRHD)
ISO 3304—Plain end seamless precision steel tubes - Technical conditions for delivery
ISO 3305—Plain end welded precision steel tubes - Technical conditions for delivery
ISO 3448—Industrial liquid lubricants - ISO viscosity classification - First edition
ISO 3601-3—Fluid systems - Sealing devices - O-rings - Part 3: quality acceptance criteria
ISO 5598—Fluid power systems and components - Vocabulary
ISO 6149—Fluid power systems and components - Metric ports - Dimensions and design
ISO 6508—Metallic materials - Hardness test - Rockwell test (scales A-B-C-D-E-F-G-H-K)
ISO 6605—Hydraulic fluid power - Hose assemblies - Methods of test
ISO 9974—Connections for general use and fluid power - Port and stud ends with ISO 261 threads with elastomeric or metal-to-metal sealing
ISO 10583—Test methods for tube connections
ISO 11926-1—Connections for general use and fluid power - Ports and stud ends with ISO 725 inch threads and O-ring sealing - Part 1: ports with O-ring seal in truncated housing
ISO 11926-2—Connections for general use and fluid power - Ports and stud ends with ISO 725 inch threads and O-ring sealing - Part 2: heavy-duty (S Series) stud ends
ISO 11926-3—Connections for general use and fluid power - Ports and stud ends with ISO 725 inch threads and O-ring sealing - Part 3: light-duty (L Series) stud ends
ISO 19879—Metallic tube connections for fluid power and general Use - Method of testing hydraulic connectors

2.2.3 EUROPEAN AND JAPANESE PUBLICATIONS—Available from ANSI, 25 West 43rd Street, New York, NY 100360-8002

DIN 17120—Welded Circular Steel Tubing
DIN 17121—Seamless Circular Steel Tubing
EN 10210-1—Hot Finished Structural Hollow Sections of Non-Alloy and Fine Grain Structural Steels
JIS 4502—Seamless

3. Definitions—For the purpose of this document, the definitions given in ISO 5598 shall apply.

4. General Requirements for Qualification of Tube Assemblies

4.1 Standard Tests—WARNING—Some of the tests described in this document are considered hazardous; it is therefore essential that, in conducting these tests, all appropriate safety precautions are strictly adhered to. Attention is drawn to the danger of fine jets of high pressure hydraulic fluid which can penetrate the skin. To reduce the hazard to energy release, bleed air out of test specimens prior to pressure testing. Tests shall be set-up and performed by properly trained personnel. Also safety equipment such as safety glasses, hearing protection and metatarsal safety shoes, should be used when working around and on hydraulic test laboratories and equipment.

4.2 Materials of Components for Testing Purposes

4.2.1 TEST BLOCK—Test blocks shall be unplated and hardened to 45 to 55 Rockwell “C”.

4.2.2 TEST SEALS (IF APPLICABLE)—Unless otherwise specified, seals shall be nitrile (NBR) rubber with a hardness of 85, +10/0 IHRD in accordance with SAE J515.

4.3 Typical Tube Assembly Samples—See Figure 1 for typical tube assembly samples, test configurations and test cabinet set up.

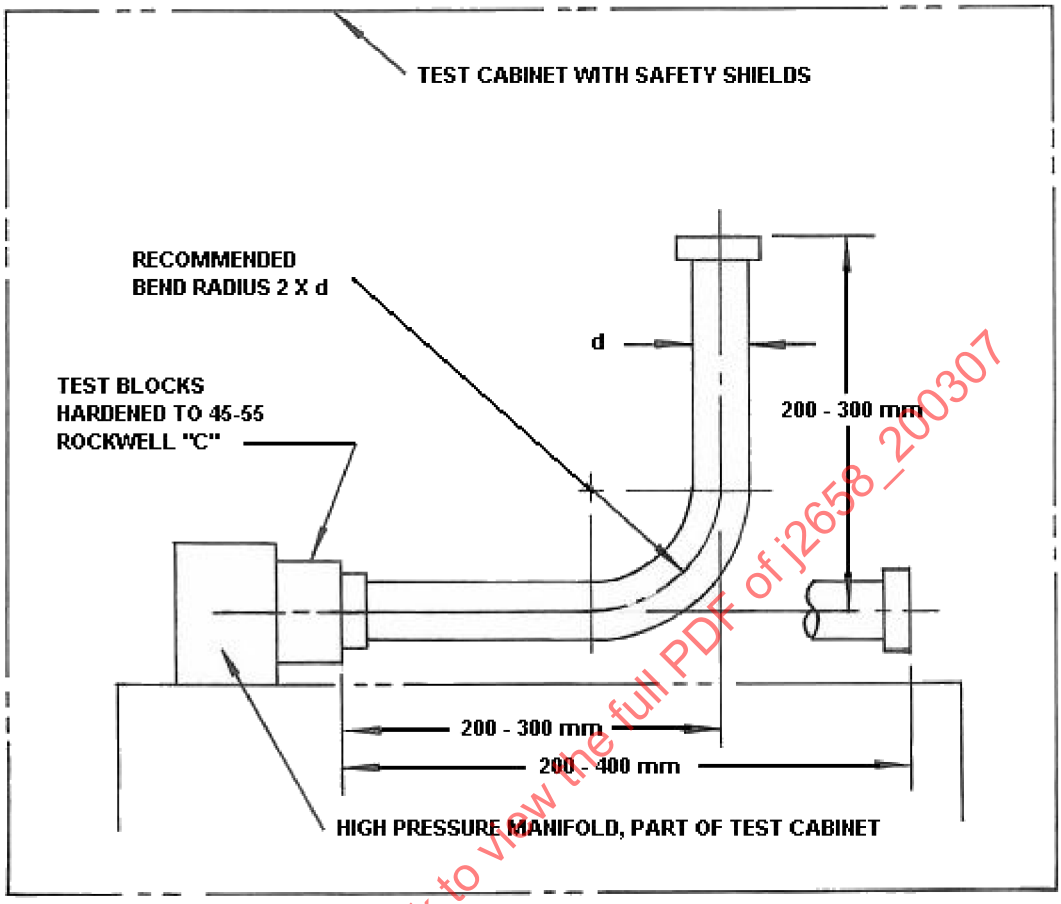


FIGURE 1—TYPICAL TUBE ASSEMBLY SAMPLES, TEST CONFIGURATIONS AND TEST CABINET SET UP

4.4 Test Fluids—Select a hydraulic fluid suitable for most hydraulic systems. Test fluids must be used as agreed upon between the customer and the manufacturer. It is recommended the test fluid be changed frequently to prevent breakdown.

4.5 Test Temperatures—Test temperature (ambient and fluid) shall be 15 to 35 °C unless otherwise specified in the controlling SAE or ISO standard.

4.6 Hardness of the Test Samples—The tube material hardness on the Rockwell “B” scale shall be checked and recorded on the test data form for all test samples.

4.7 Dimensional Checks—The tube assembly shall be inspected for conformity to all dimensions tabulated in the applicable tube specification. Determine finished outside diameter and wall thickness. Take readings at 90 degree intervals around the tube to determine acceptable ovality and wall thickness uniformity. Out of limits dimensions will lead to premature failure of the tubing and cause the test to be unsuccessful. Acceptability of the tubing to be used is based on the total variation between the high and low readings of the applicable SAE/ISO dimensional requirements.

4.8 Thread Lubrication—Lubricate the o-ring and threads with a light coat of system fluid or compatible oil.

4.9 Assembly of Test Samples and Assembly Torque—Tube connections shall be tested as assembled with the required minimum test torques shown in the following conductor and connector standards. Otherwise test at the minimum torque values supplied by the manufacturer. See Figure 1 for the connection of typical tube assembly test samples to a test apparatus.

SAE J514—Hydraulic Tube Connectors (37 Degree Flared, Flareless Type and O-Ring Plugs)
SAE J518—Hydraulic Flanged Tube, Pipe and Hose Connections; 4-Bolt Type
SAE J533—Flares for Tubing; 37 Degree and 45 Degree
SAE J1453—Specifications for O-Ring Face Seal Connectors for Fluid Power
ISO 6162—Hydraulic fluid power - Flange connectors with split or one-piece flange clamps and metric or inch screws
ISO 8434-1—Metallic tube connections for fluid power and general use - Part 1: 24 degree compression connectors
ISO 8434-2—Metallic tube connections for fluid power and general use - Part 2: 37 degree flared connectors
ISO 8434-3—Metallic tube connections for fluid power and general use - Part 3: O-ring face seal connectors
ISO 8434-4—Metallic tube connections for fluid power and general use - Part 4: 24 degree cone connectors with o-ring weld-on nipples

4.10 Reuse of Tube Assembly Samples—Tube assembly samples which pass these tests shall not be tested further, used, or returned to stock.

5. Qualification Tests—See SAE J1065 and ISO 10763 for the applicable rated reference working pressure as it pertains to the reference tube OD, wall thickness and material to be tested. For tube materials, OD's and wall sizes not listed in SAE J1065 and ISO 10763, use the nominal reference working pressure formula to calculate the target pressures for testing purposes. The type of tests selected from Appendix A, timeliness, frequency and configuration of the test samples will be determined by the tube assembly manufacturer and/or agreement between the tube assembly manufacturer and the customer. All tube assembly samples shall be tested in the final form, as the customer would receive a typical part.

See Appendix A for summary work sheet for applicable qualification tests for various metallic tube conductor assembly end connection configuration standards. This work sheet can also be used to qualify non-standard tube assemblies and tube end joining methods.

See Appendix B for the tube assembly test data form. Test results and test conditions shall be reported on this test data form.

5.1 Burst Test—Three samples shall be tested to confirm that the specified conductor(s) shall be capable of withstanding an internal hydrostatic pressure to a minimum of four times the intended working pressure without failure. The rate of pressure rise shall be constant and chosen to reach the final pressure between 30 and 60 seconds.

NOTE— This is a destructive test. Assemblies which have been subjected to this test shall be destroyed.

5.2 Proof Pressure Test—Three samples shall not leak when subjected to an internal hydrostatic pressure equal to two times the specified reference working pressure for 30 to 60 seconds.

5.3 Cyclic Endurance Impulse Test

5.3.1 Six samples, when tested at the respective impulse pressure at 133% of the rated reference working pressure, shall pass a cyclic endurance test for 1 000 000 cycles without leakage or failure of the conductor. Apply a pulsating pressure internally to the hose assemblies at a rate between 0.5 and 1.3 Hz; record the frequency used on the test data sheet in Appendix B. The pressure cycle shall fall within the shaded area of Figure 1 and conform as closely as possible to the curve shown.

NOTE— This is a destructive test. Assemblies which have been subjected to this test shall be destroyed.

5.3.2 The pressure rise rate nominal slope shall be calculated using Equation 1.

$$R = f\,(10\,P - k) \qquad \text{(Eq. 1)}$$

where:

R = Rate of rise (MPa/s)
f = Frequency in Hz
P = Nominal Cyclic Endurance Impulse Test Pressure in Megapascals
k = 5 MPa

The actual rate of pressure rise and pressure drop shall be measured with an oscilloscope or equivalent device and shall be determined to be as close as possible to the pictorial shown on Figure 2, and shall be within a tolerance of ±10% of the calculated nominal value.

5.4 Leakage Test—Three samples of tube assemblies, when assembled to the appropriate connectors and tightened to the minimum torque value shown in the applicable SAE or ISO standard, shall be capable of withstanding a hydrostatic pressure of 70% of the specified minimum burst pressure for a period of between 5.0 to 5.5 min. The rate of pressure rise shall be constant and chosen to reach the final pressure between 30 and 60 seconds.

The hydrostatic pressure shall be reapplied as follows:

Reduce the fluid pressure to 0 MPa.

Re-apply the 70% of minimum burst hydrostatic pressure for another 5.0 to 5.5 min period. The rate of pressure rise shall be constant and chosen to reach the final pressure between 30 and 60 seconds.

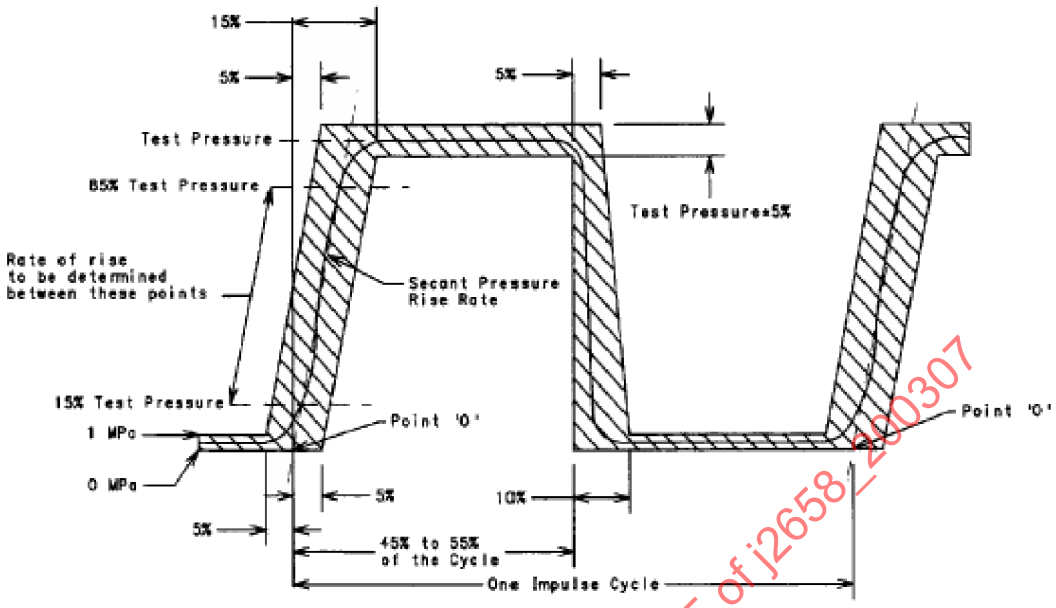
Reject assemblies showing leakage or failure.

NOTE— This is a destructive test. Assemblies which have been subjected to this test shall be destroyed.

5.5 Repeated Assembly Test—Three samples of threaded tube assemblies and connectors shall be assembled and disassembled ten times. Connector threads shall be lubricated with 10W hydraulic oil. The connections shall be tightened to the maximum torque value shown in the applicable SAE or ISO standard. A hydrostatic proof test shall be conducted following the first, fifth, and tenth assembly. There shall be no leakage and the tube nut shall remain free to swivel by hand after the tenth disassembly.

NOTE— This is a destructive test. Assemblies which have been subjected to this test shall be destroyed.

5.6 Resistance To Vacuum Test—Two samples of tube assemblies, when assembled to the appropriate connectors and tightened to the minimum torque value shown in the applicable SAE or ISO standard, shall be capable of withstanding a vacuum of 6.5 kPa (0.065 bar) absolute pressure for 5 minutes without leakage.



NOTES:
1. Secant pressure rise is the straight line drawn through two points on the pressure rise curve; one point at 15% of the test pressure and the other at 85% of the test pressure
2. Point '0' is the intersection of the secant pressure rise with 0 pressure.
3. Pressure rise rate is the slope of the secant pressure rise expressed in MPa/s.
4. Cycle rate shall be uniform at 0.5 to 1.3 Hz.
5. The nominal rate of pressure rise shall be equal to:
   $R = f(10p - k)$
   where: R = rate of pressure rise in MPa/s
   f = frequency in Hz
   p = nominal impulse test pressure in MPa
   k = 5 MPa

FIGURE 2—CYCLIC ENDURANCE IMPULSE PRESSURE METHOD OF DETERMINATION OF RATE OF PRESSURE RISE IN IMPULSE TEST

6. Notes

6.1 Key Words—Qualification, proof, burst, cyclic, endurance, impulse, test, vacuum, rise rate, repeated assembly.

PREPARED BY THE SAE FLUID CONDUCTORS AND CONNECTORS TECHNICAL COMMITTEE SC5—METALLIC TUBING SUBCOMMITTEE

APPENDIX A

INFORMATIVE—APPLICABLE QUALIFICATION TESTS FOR VARIOUS METALLIC TUBE ASSEMBLY END CONNECTION CONFIGURATIONS, STANDARD AND NON-STANDARD

A.1 See Figure A1.

	Tests per SAE J2658					
Tube End Connection Configuration Standard	Burst	Proof	Cyclic Endurance Impulse	Leakage	Repeated Assembly	Resistance to Vacuum
SAE J514 37° Flared Connections and Compression Connections	X	X	X	X	X	X
SAE J518 4-Bolt Flange	X	X	X	X		X
SAE J533 Flared 37° and 45° Connections	X	X	X	X	X	X
SAE J1453 ORFS Connections	X	X	X	X	X	X
ISO 6162 4-Bolt Flange	X	X	X	X		X
ISO 8434-1 24° Cone Compression Connections	X	X	X	X	X	X
ISO 8434-2 37° and 45° Flared Connections	X	X	X	X	X	X
ISO 8434-3 ORFS Connections	X	X	X	X	X	X
ISO 8434-4 24° Cone Weld-on Nipples	X	X	X	X	X	X
Non-Standard New Tubing or Connection Type	X	X	X	X	X	X

FIGURE A1—APPLICABLE QUALIFICATION TESTS FOR VARIOUS METALLIC TUBE ASSEMBLY END CONNECTION CONFIGURATIONS, STANDARD AND NON-STANDARD