

 SURFACE VEHICLE STANDARD	SAE J2833 AUG2009
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Welded and Cold-Drawn, High Strength (690 MPa Tensile Strength) Low Alloy Steel Hydraulic Tubing, Stress Relieved Annealed for Bending and Flaring	

RATIONALE

The working pressures of the modern day mobile equipment hydraulic systems have risen dramatically as compared to the hydraulic pressures in the past. This new hydraulic tubing material has been developed to fill the needs of the hydraulic industry by providing a tube material matched with modern day high pressure hydraulic hose and connectors to help resolve the hydraulic system space constraints and routing issues faced by today's system designers in the hydraulic mobile equipment industry. Aircraft and Aerospace applications were not considered during the preparation of this document.

1. SCOPE

This specification covers sub-critically annealed electric resistance welded and cold-drawn single-wall high strength low alloy steel tubing intended for use in hydraulic pressure lines and in other applications requiring tubing of a quality suitable for bending, flaring, cold forming, welding and brazing.

The grade of material produced to this specification is of micro-alloy content and is considerably stronger and intended to service higher pressure applications using thinner walls than like sizes of the grades of material specified in SAE J525, SAE J2467 and SAE J2614. Due to the alloy content of the material, the forming characteristics of the finished tube are equal to or better, when compared to SAE J525, SAE J2467 and SAE J2614. Nominal reference working pressures for this tubing are listed in ISO 10763 and SAE J1065.

Caution: When brazing or welding is used as a tube end joining method, the structural integrity of the tube material can potentially be compromised due to the degradation of the areas affected by the thermal effect applied to the tubing; therefore, the ISO 10763 and SAE J1065 nominal reference working pressures may not be applicable.

Brazed and/or welded tube assembly configurations made to specific geometry and components bill of material in association with this material, may require qualification testing in accordance with ISO 19879 Test Methods for Hydraulic Fluid Power Connections. Cold forming the tube end configurations avoids this systemic testing by not compromising the tube material structural integrity.

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of this specification to extent specified herein. Unless other specified, the latest issue of the SAE publications shall apply.

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2.1.1 SAE Publications

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

SAE J409	Product Analysis—Permissible Variations from Specified Chemical Analysis of a Heat or Cast of Steel
SAE J525	Welded and Cold Drawn Low-Carbon Steel Tubing Annealed for Bending and Flaring
SAE J533	Flares for Tubing
SAE J1065	Nominal Reference Working Pressures for Steel Hydraulic Tubing
SAE J1677	Tests and Procedures for Steel and Copper Nickel Tubing
SAE J2467	Welded and Cold-Drawn, SAE 1021 Carbon Steel Tubing Normalized for Bending and Flaring
SAE J2614	Welded and Cold-Drawn, High Strength Low Alloy Steel Hydraulic Tubing, Sub-Critically Annealed for Bending and Flaring

2.1.2 ISO Publications

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

ISO 10763	Plain-end, seamless and welded steel tubes—Dimensions and nominal working pressures
ISO 19879	Metallic tube connections for fluid power and general use—Test methods for hydraulic fluid power connections

2.2 Related Publications

The following publications are provided for informational purposes only and are not a required part of this document.

2.2.1 SAE Publications

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

SAE J514	Hydraulic Tube Fittings
SAE J518	Hydraulic Flanged Tube, Pipe, and Hose Connections, Four-Bolt Split Flange Type
SAE J1392	Steel, High Strength, Hot Rolled Sheet and Strip, Cold Rolled Sheet, and Coated Sheet
SAE J1453	Fitting—O-Ring Face Seal
SAE J2551	Recommended Practices for Fluid Conductor Metallic Tubing Applications

2.2.2 ISO Publications

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

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 4200	Plain end steel tubes, welded and seamless—General tables of dimensions and masses per unit length
ISO 4397	Connectors and associated components—Nominal outside diameters of tubes and nominal inside diameters of hoses
ISO 4399	Connectors and associated components—Nominal pressures
ISO 5598	Fluid power systems and components—Vocabulary
ISO 6162	Four-screw split-flange connections
ISO 6605	Tests and test procedures
ISO 8434	Metallic tube connections for fluid power and general use
ISO 10583	Test methods for tube connections

2.2.3 EN Publications

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

EN 10305-2	Steel tubes for precision applications—Technical delivery conditions—Part 2: Welded cold drawn tubes
EN 10305-4	Steel tubes for precision applications—Technical delivery conditions—Part 4: Seamless cold drawn tubes for hydraulic and pneumatic power systems

2.2.4 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 A 513	Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Tubing
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3. MANUFACTURE

The tubing shall be made from a single strip of steel shaped into a tubular shape, the edges of which are joined and fused by electric resistance welding and the tubing hollows are then drawn over a mandrel to the size dimensions shown in Table 1 and Table 2.

The tubing shall be stress relieved annealed via a controlled method to produce a finished product, which will meet all requirements of this document.

4. DIMENSIONS AND TOLERANCES

The tolerances applicable to tubing outside diameter are shown in Table 1. The tolerances applicable to tubing wall thickness are shown in Table 2. For specific common OD's and wall sizes, see ISO 10763 for metric tubing and SAE J1065 for inch tubing. Particular attention shall be given to areas adjacent to the weld to insure against thin spots and/or sharp indentations.

TABLE 1 - TUBING OUTSIDE DIAMETER TOLERANCE

Nominal Tubing OD ⁽¹⁾ mm	Tube OD and ID Tolerance mm
Up to 10	± 0.05
Over 10 to 16	± 0.06
Over 16 to 50	± 0.08
Over 50 to 60	± 0.10
Over 60 to 80	± 0.13
Over 80 to 110	± 0.15

1. OD measurements shall be taken at least 50 mm from the end of tubing.

TABLE 2 - TUBING WALL THICKNESS TOLERANCES

Wall Thickness Range mm	For Nominal Tubing Outside Diameter Through 22 mm (1) mm	For Nominal tubing Outside Diameter Over 22 mm Through 48 mm (1) mm	For Nominal Tubing Outside Diameter Over 48 mm Through 101.60 (1) mm
Up to 0.8	± 0.05	± 0.05	± 0.05
Over 0.8 to 2.4	± 0.05	+ 0.05 -0.08	+ 0.05 -0.08
Over 2.4 to 3.3	+ 0.05 -0.08	+ 0.05 -0.10	± 0.08
Over 3.3 to 3.7	—	+ 0.05 -0.10	± 0.08
Over 3.7 to 4.5	—	+ 0.08 -0.10	+ 0.08 -0.10
Over 4.5 to 5.5	—	± 0.10	+ 0.08 -0.13
Over 5.5	—	+ 0.10 -0.15	+ 0.10 -0.15

1. Plus tolerances include allowance for crown on flat-rolled steel.

5. MANUFACTURING STANDARDS

5.1 Straightness

Tubing shall be straightened to a tolerance of 0.8 mm in 1000 mm. Straightness tolerances shall be measured by placing a 1000 mm straight edge against the tube while lying on its neutral axis. The point of maximum deflection of the tube from the straight edge should not be more than allowed by the specification when measured with a feeler gauge.

5.2 Tubing End Condition

The tubing will be produced using normal mill cut off practices. This shall include, but not limited to, punch-cut ends, double-cut ends and rotary-cut ends. Care shall be taken to minimize the distortion of the tube ends. Distortion of the tube must not affect the normal re-cutting processes that will be performed by the end user. Ends that require further processing will be addressed by agreement between the producer and the tube purchaser.

5.3 Finish

The outside surface finish of the tube is critical to prevent possible leak paths on double flare connections, mechanical formed connections or applications where the outside surface of the tube becomes the sealing surface of the finished connection. The outside surface finish of the tube shall be free of excessive roll marks, score marks, chatter marks or other surface imperfections that may be considered detrimental to the function of the finished tube.

5.4 Thermal Treatment

The tubing is to be stress relieved annealed via a controlled method to produce a finished product, which will meet all requirements of this document. Special attention to the mechanical properties, especially the Rockwell B92 Hardness Target, should be made to produce tubing suitable for bending and forming for hydraulic pressure applications. However, to obtain acceptable hardness characteristics, the yield strength and the tensile strength shall not be compromised and 15% minimum elongation shall be maintained.

6. MATERIAL

The tubing shall be made from alloy steel strip conforming to the chemical composition in Table 3. The steel shall be made by the open-hearth basic oxygen or electric furnace process. A ladle analysis of each heat shall be made to determine the percentages of the elements specified. The chemical composition thus determined shall be reported to the purchaser or purchaser's representative, if requested, and shall be conform to the requirements specified. If a check analysis is required, the tolerances shall be as specified in SAE J409, Table 3.

TABLE 3 - CHEMICAL REQUIREMENTS

Element	Cast or Heat Analysis Weight %
Carbon	0.26 Max
Manganese	1.60 Max
Sulfur	0.035 Max
Phosphorus	0.035 Max
Silicon	0.35 Max
Aluminum	0.020 Min
Micro Alloying Elements	0.15 Max ⁽¹⁾

1. Additions of Nb, Cb, Ti and V are permitted at the discretion of the manufacturer. The contents of these additions are to be reported. All other elements should not be intentionally added without agreement of the purchaser except for elements added to aid with or finish the casting.

7. MECHANICAL PROPERTIES

The finished tubing shall have mechanical properties as shown in Table 4.

TABLE 4 - MECHANICAL PROPERTIES

Properties	Values
Yield Strength, Minimum	620 MPa
Tensile Strength, Minimum	690 MPa
Elongation in 50 mm, Minimum	15% Minimum
Hardness Target	Rockwell B92 ⁽¹⁾
Hardness Maximum	Rockwell B100 ⁽¹⁾

1. The hardness test shall not be required on tubing with a nominal wall thickness of less than 1.65 mm. Such tubing shall meet all other mechanical properties and performance requirements.