SAE International™

SURFACE VEHICLE STANDARD

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Welded Flash Controlled, High Strength (690 MPa Tensile Strength) Low Alloy Steel Hydraulic Tubing, Stress Relieved Annealed for Bending and Double 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 SAE Standard covers stress relieved electric resistance welded flash controlled single wall high strength low alloy steel tubing intended for use in high pressure hydraulic lines and in other applications requiring tubing of a quality suitable for bending, double flaring and cold forming. Material produced to this specification is not intended to be used for single flare applications due to the potential leak path that would be caused by the ID weld bead.

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 J356, SAE J2435 and SAE J2613. Due to the alloy content of the material, the forming characteristics of the finished tube are equal to or better, when compared to SAE J356, SAE J2435 and SAE J2613. 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.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

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 J356 Welded Flash-Controlled Low-Carbon Steel Tubing Normalized for Bending, Double Flaring, and Beading

SAE J409 Product Analysis—Permissible Variations from Specified Chemical Analysis of a Heat or Cast of Steel

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 J2435 Welded Flash Controlled, SAE 1021 Carbon Steel Tubing, Normalized for Bending, Double Flaring, and Beading

SAE J2613 Welded Flash Controlled, High Strength Low Alloy Steel Hydraulic Tubing, Sub-Critically Annealed for Bending, Double Flaring, and Bending

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

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. After forming and welding, the outside flash shall be removed to provide a smooth surface. The inside flash shall be of uniform contour, free from saw-tooth peaks and controlled in height by seam-welding techniques or by cutting, not by hammering or rolling. The inside flash height shall conform to the following as in Table 1.

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

TABLE 1 - INSIDE FLASH HEIGHT

Nominal Wall Thickness mm	Maximum Flash Height[1][2] Through 25.4 mm OD mm	Maximum Flash Height Over 25.4 mm OD mm
Less than 0.90	0.13	0.25
0.90 through 1.65	0.20	0.25
Greater than 1.65	0.25	0.25

1. For tubes having an ID greater than 8 mm, the height of the inside weld flash shall be measure with a ball micrometer having a 3.96 mm ± 0.41 mm radius from the anvil or ballpoint. For tubes having an ID 8 mm or less, screw thread micrometers shall be used. The height of the flash shall be the difference between the thickness of the tube wall at the point of maximum height of the flash and the average of the wall thickness measured at points adjacent to both sides of the flash.
2. Tubing with an ID that is smaller than the producer's capability to scarf the ID weld bead, shall be produced as "flash in" tubing. Seam welding techniques may be applied to control the ID flash height. The maximum ID flash height, however, will be determined by agreement between the producer and the purchaser.

4. DIMENSIONS AND TOLERANCES

The tolerances applicable to tubing outside diameter are shown in Table 2. The tolerances applicable to tubing wall thickness are shown in Table 3. 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 2 - TUBING OUTSIDE DIAMETER TOLERANCE

Nominal Tubing OD[1] mm	Tube OD and ID Tolerance mm
Up to 10	±0.06
Over 10 to 16	±0.08
Over 16 to 30	±0.09
Over 30 to 50	±0.13
Over 50 to 60	±0.15
Over 60 to 80	±0.20
Over 80 to 90	±0.23
Over 90 to 110	±0.25

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

TABLE 3 - TUBING WALL THICKNESS TOLERANCES

Wall Thickness Range mm	Nominal Tubing Outside Diameter Through 22 mm mm[1]	Nominal Tubing Outside Diameter Over 22 mm Through 48 mm mm[1]	Nominal Tubing Outside Diameter Over 48 mm Through 110 mm[1]
Up to 0.8	+0.05 -0.08	+0.05 -0.08	+0.05 -0.08
Over 0.8 to 1.0	+0.05 -0.10	+0.05 -0.10	+0.05 -0.10
Over 1.0 to 1.4	+0.10 -0.13	+0.08 -0.13	+0.10 -0.20
Over 1.4 to 1.9	±0.15	+0.10 -0.20	+0.10 -0.20
Over 1.9 to 3.7	+0.15 -0.25	+0.15 -0.25	+0.15 -0.25
Over 3.7 to 4.9	---	+0.18 -0.28	+0.18 -0.28
Over 4.9 to 5.9	---	+0.20 -0.30	+0.20 -0.30
Over 5.9 to 6.5	---	+0.36 -0.46	+0.36 -0.46
Over 6.5	---	+0.36 -0.51	+0.36 -0.51

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 it's 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 4. 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 4 - 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.