SURFACE VEHICLE STANDARD

J2435™	JUN2020
Issued 1999-04 Revised 2020-06 Superseding J2435 AUG2015	

(R) Welded Flash Controlled, SAE 1021 Carbon Steel Tubing, Normalized for Bending, Double Flaring, Cold Forming, Welding, and Brazing

RATIONALE

This SAE Standard has been revised as part of a Five-Year Review. Document changes include revisions to the scope and applicable and related documents lists; new verbiage in Section 4 and 5.2; clarified 5.3 surface condition requirement; revised or added notes to 8.8 and 8.9; replaced verbiage with inequality symbols in headings of Tables 1 and 3 and body of Tables 1, 2, and 4; revised verbiage placement and added words “miminum” and “maximum” in body of Tables 4 and 5; and revised size ranges in Table 3 heading. Verbiage has been updated throughout the standard to align the document with other recently revised bulk tube standards.

1. SCOPE

This SAE Standard covers normalized electric resistance welded flash controlled single-wall, SAE 1021 carbon steel pressure tubing intended for use as pressure lines and in other applications requiring tubing of a quality suitable for bending, double flaring, cold forming, welding, and brazing. Material produced to this specification is not intended to be used for single flare applications due to the potential leak path caused by the inside diameter (ID) weld bead or scarfed region. Assumption of risks when using this material for single flare applications shall be defined by agreement between the producer and purchaser.

The grade of material produced to this specification is higher in carbon and manganese content than the grade of material specified in SAE J356 and is intended to service higher pressure applications than equivalent sizes of SAE J356. Due to the higher carbon and manganese content, the forming characteristics of the finished tube are diminished versus the SAE J356 product. Special attention to the overall forming requirements of the finished assembly shall be taken into consideration when specifying material produced to this specification. Refer to SAE J2551-1 for additional design and fabrication guidance associated with this material. Nominal working pressures for this material are listed in ISO 10763 and SAE J1065. When required, qualification testing shall be in accordance with ISO 19879.

In an effort to standardize within a global marketplace and ensure that companies can remain competitive in an international market, it is the intent to convert to metric tube sizes which will:

- Lead to one global system.
- Guide users to a preferred system.
- Reduce complexity.
- Eliminate inventory duplications.

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For more information on this standard, visit
https://www.sae.org/standards/content/J2435_202006

2. REFERENCES

2.1 Applicable Documents

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

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 +1 724-776-4970 (outside USA), www.sae.org.

SAE J356	Welded, Flash-Controlled Low-Carbon Steel Tubing Normalized for Bending, Double Flaring, Beading, Forming, and Brazing
SAE J403	Chemical Compositions of SAE Carbon Steels
SAE J409	Product Analysis - Permissible Variations from Specified Chemical Analysis of a Heat or Cast of Steel
SAE J514	Hydraulic Tube Fittings
SAE J533	Flares for Tubing
SAE J1065	Nominal Reference Working Pressures for Steel Hydraulic Tubing
SAE J1677	Tests and Procedures for Carbon Steel and High Strength Low Alloy Steel Tubing
SAE J2551-1	Recommended Practices for Fluid Conductor Carbon, Alloy and High Strength Low Alloy Steel Tubing Applications - Part 1: Design and Fabrication

2.1.2 ISO Publications

Copies of these publications are available online at http://webstore.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 Documents

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

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 +1 724-776-4970 (outside USA), www.sae.org.

SAE J518-1	Hydraulic Flanged Tube, Pipe, and Hose Connections, 4-Screw Flange Connection Part 1: 3.5 MPa to 35 MPa (Code 61)
SAE J518-2	Hydraulic flanged Tube, Pipe, and Hose Connections, 4-Screw Flange Connection Part 2: 42 MPa (Code 62)
SAE J1453-1	Specification for O-Ring Face Seal Connectors: Part 1 - Tube Connection Details and Common Requirements for Performance and Tests

SAE J1453-2 Specification for O-Ring Face Seal Connectors: Part 2 - Requirements, Dimensions, and Tests for Steel Unions, Bulkheads, Swivels, Braze Sleeves, Braze-on Tube Ends, Caps, and Connectors with ISO 6149-2 Metric Stud Ends and ISO 6162 4-Bolt Flange Heads

SAE J1453-3 Specification for O-Ring Face Seal Connectors: Part 3 - Requirements, Dimensions, and Tests for Steel Unions, Bulkheads, Swivels, Braze Sleeves, Caps, and Connectors with SAE J1926-2 Inch Stud Ends

SAE J2467 Welded and Cold-Drawn, SAE 1021 Carbon Steel Tubing Normalized for Bending and Flaring

SAE J2551-2 Recommended Practices for Fluid Conductor Carbon, Alloy and High Strength Low Alloy Steel Tubing Applications - Part 2: General Specifications and Performance Requirements

SAE J2551-3 Recommended Practices for Fluid Conductor Carbon, Alloy and High Strength Low Alloy Steel Tubing Applications - Part 3: Procurement

SAE J2592 Carbon Steel Tubing for General Use - Understanding Nondestructive Testing for Carbon Steel Tubing

2.2.2 ISO Publications

Copies of these publications are available online at http://webstore.ansi.org/.

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 6162-1 Hydraulic Fluid Power - Flange Connections with Split or One-Piece Flange Clamps and Metric or Inch Screws - Part 1: Flange Connectors, Ports and Mounting Surfaces for Use at Pressures of 3.5 MPa (35 bar) to 35 MPa (350 bar), DN 13 to DN 127

ISO 6162-2 Hydraulic Fluid Power - Flange Connections with Split or One-Piece Flange Clamps and Metric or Inch Screws - Part 2: Flange Connectors, Ports and Mounting Surfaces for Use at a Pressure of 42 MPa (420 bar), DN 13 to DN 76

ISO 6164 Hydraulic Fluid Power - Four-Screw, One-Piece Square-Flange Connections for Use at Pressures of 25 MPa and 40 MPa (250 bar and 400 bar)

ISO 8434-2 Metallic Tube Connections for Fluid Power and General Use - Part 2: 37° Flare Fittings

ISO 8434-3 Metallic Tube Connections for Fluid Power and General Use - Part 3: ORFS Fittings

ISO 10583 Aerospace Fluid Systems - Test Methods for Tube/Fitting Assemblies

2.2.3 EN Publications

Copies of these publications are available online at http://webstore.ansi.org/.

EN 10305-3 Steel Tubes for Precision Applications - Technical Delivery Conditions - Part 3: Welded Cold Sized Steel Tubes

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 A450/A450M Standard Specifications for General Requirements for Carbon and Low Alloy Steel Tubes.

ASTM A513/A513M-15 Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing

3. MANUFACTURE

The tubing shall be made from a single strip of flat-rolled steel shaped into a tubular form, the edges of which are joined and fused by electric-resistance welding. After forming and welding, the outside diameter (OD) flash shall be removed to provide a smooth surface. The ID 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 dimensional characteristics listed in Table 1.

The tubing shall be normalized using an atmospherically 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] ≤25.4 OD mm	Maximum Flash Height >25.4 mm OD mm
<0.90	0.13	0.25
≥0.90 to ≤1.65	0.20	0.25
>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 measured with a ball micrometer having a 4.0 mm ± 0.4 mm radius on 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 tubing wall at the point of maximum height of the flash and the average of the wall thickness.

(2) Tubing with an ID that is smaller than the producer's capability to scarf shall be produced as a "flash in" tube. Seam welding techniques shall be applied in order to control the ID flash height. For tubing that is smaller than the producer's capability to scarf, the maximum ID flash height, shall be determined by agreement between the producer and the purchaser.

4. DIMENSIONS AND TOLERANCES

The tolerances applicable to tubing OD 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, refer to ISO 10763 for metric tubing and SAE J1065 for inch tubing. Dimensional tolerances apply only to the OD and tube wall thickness. The ID dimension is a result of the OD and wall thickness tolerances. Cut length and cut length tolerance shall be defined by agreement between the producer and purchaser.

Attention shall be given to the weld area to minimize strip edge mismatch that will result in a sharp step or edge, and a tube wall thickness below the requirements stated in Table 3 adjacent to the weld. Strip edge mismatch will create localized stresses and induce eventual fatigue fracture.

Table 2 - Tubing outside diameter tolerance

Nominal Tubing OD[1][2] mm	Tube OD Tolerance ±mm
≤15.88	0.08
>15.88 to ≤28.57	0.09
>28.57 to ≤50.80	0.13
>50.80 to ≤63.50	0.15
>63.50 to ≤76.20	0.20
>76.20 to ≤88.90	0.23
>88.90 to ≤105.00	0.25

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

(2) Refer to SAE J514 for nominal tubing OD to be used in conjunction with standard hydraulic tube fittings and SAE J533 for recommended maximum nominal wall thickness for double flaring.

Table 3 - Tubing wall thickness tolerances

Nominal Wall Thickness[1] mm	Nominal Tubing Outside Diameter ≤30 mm ±mm[2]	Nominal Tubing Outside Diameter >30 mm to ≤55 mm ±mm[2]	Nominal Tubing Outside Diameter >55 mm to ≤105 mm ±mm[2]
0.71	0.05/0.08	0.08/0.08	0.08/0.08
0.89	0.05/0.10	0.05/0.10	0.05/0.10
1.00	0.05/0.10	0.05/0.10	0.05/0.10
1.25	0.10/0.13	0.08/0.13	0.10/0.20
1.50	0.15/0.15	0.10/0.20	0.10/0.20
1.65	0.15/0.15	0.10/0.20	0.10/0.20
2.00	0.15/0.25	0.15/0.25	0.15/0.25
2.11	0.15/0.25	0.15/0.25	0.15/0.25
2.41	0.15/0.25	0.15/0.25	0.15/0.25
2.50	0.15/0.25	0.15/0.25	0.15/0.25
2.77	0.15/0.25	0.15/0.25	0.15/0.25
3.00	0.15/0.25	0.15/0.25	0.15/0.25
3.05	0.15/0.25	0.15/0.25	0.15/0.25
3.40	0.15/0.25	0.15/0.25	0.15/0.25
3.75	—	0.18/0.28	0.18/0.28
4.00	—	0.18/0.28	0.18/0.28
4.19	—	0.18/0.28	0.18/0.28
4.57	—	0.18/0.28	0.18/0.28
5.00	—	0.20/0.30	0.20/0.30
5.16	—	0.20/0.30	0.20/0.30
5.59	—	0.20/0.30	0.20/0.30
6.00	—	0.36/0.46	0.36/0.46
6.05	—	0.36/0.46	0.36/0.46
6.58	—	0.36/0.51	0.36/0.51

(1) For intermediate wall thickness, the tolerance for the next heavier wall thickness shall apply.
(2) Plus tolerances include allowance for crown on flat-rolled steel.

5. MANUFACTURING STANDARDS

5.1 Straightness

Tubing shall be straightened to a tolerance of 1 mm over a 1000 mm length.

5.2 Tubing End Condition

The tubing shall be produced using normal mill cut-off practices, e.g., punch-cut ends, double-cut ends, or rotary-cut ends. Tube end distortion must be minimized; end condition shall not affect normal re-cut processes performed by the fabricator, e.g., circular saw, nick and shear, laser or punch cut processing methods. Extraordinary end cut processing requirements shall be defined by agreement between the producer and purchaser.

5.3 Surface Condition

The outside surface condition of the tube is critical in order to prevent possible leak paths on double flare connections, mechanical form connections, hose bead connections, or other applications where the outside surface of the tube becomes a sealing surface. The outside surface of the tube shall be free of excessive roll marks, score marks, chatter marks, or other surface imperfections that are considered detrimental to the function of the tubing. Depth of roll marks, score marks, chatter marks, or other surface imperfections shall not reduce wall thickness below the tolerances listed in Table 3.

5.4 Thermal Treatment

The tubing is to be heated to a temperature above the upper transformation point in an atmospherically controlled furnace, and then cooled in a protective atmosphere to produce a finished product that shall meet all requirements of this document.

6. MATERIAL

Tubing shall be made from low-carbon, hot- or cold-rolled steel conforming to the chemical composition in Table 4. The steel shall be made by the 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 conform to the requirements specified. If a product 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	≥0.18 to ≤0.23
Manganese	≥0.60 to ≤0.90
Maximum Phosphorus	0.030
Maximum Sulfur	0.035

7. MECHANICAL PROPERTIES

The finished tubing shall have mechanical properties as shown in Table 5.

Table 5 - Mechanical properties

Properties	Values
Minimum Yield Strength	275 MPa
Minimum Ultimate Strength	415 MPa
Minimum Elongation in 50 mm	25%
Maximum Hardness (Rockwell B)	78(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.