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SURFACE VEHICLE STANDARD

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Submitted for recognition as an American National Standard

(R) WELDED AND COLD DRAWN LOW CARBON STEEL TUBING ANNEALED FOR BENDING AND FLARING

1. ***Scope***—This SAE Standard covers cold worked and annealed electric resistance welded single wall low carbon steel pressure tubing intended for use as hydraulic lines and in other applications requiring tubing of a quality suitable for flaring and bending.

2. ***References***

2.1 Applicable Documents—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

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

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

SAE J514—Hydraulic Tube Fittings

2.1.2 ASTM PUBLICATIONS—Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

ASTM A 370—Methods and Definitions for Mechanical Testing of Steel Products.

3. ***Manufacture***—The tubing shall be made from a single strip of steel shaped into a tubular form, the edges of which are joined and sealed by electric resistance welding. After forming and welding, the tubing shall be normalized and subjected to a cold working operation that shall result in a 15% minimum reduction in cross-sectional area, of which at least 8% shall consist of a reduction in wall thickness. Subsequent to cold working, the tubing shall be annealed in such a manner as to produce a finished product which will meet all requirements of this document. Tubing that has been pickled to remove scale shall be suitably treated to eliminate any embrittlement induced by the pickling process.

4. ***Dimensions and Tolerances***—The tolerances applicable to tubing outside diameter, inside diameter, and wall thickness are shown in Table 1. Tubing shall be subject to any two of the tolerances specified, as designated by the purchaser.

5. ***Quality***—Lengths of finished tubing shall be reasonably straight and have smooth ends free from burrs. Tubing shall be free from scale and injurious defects and have a workmanlike finish. Surface imperfections such as handling marks, die marks, or shallow pits shall not be considered injurious defects provided the imperfections are within the tolerances specified for diameter and wall thickness. The removal of such surface imperfections is not required. There shall be no dimensional indications of the presence of the weld.

The inside of tubing shall be clean and free from any contamination that cannot be readily removed by cleaning agents normally used in manufacturing.

TABLE 1—TUBING OUTSIDE DIAMETER AND WALL THICKNESS TOLERANCE

Nominal Tubing OD[1,2] mm	Nominal Tubing OD[1,2] in	Tolerance OD ± mm	Tolerance OD ± in	Tolerance ID ± mm	Tolerance ID ± in	Tolerance ± Wall Thickness (%)
Up to 9.5	Up to 0.38	0.05	0.002	0.05	0.002	15
Over 9.5 to 15.9 inclusive	Over 0.38 to 0.63 inclusive	0.06	0.0025	0.06	0.0025	10
Over 15.9 to 50.8 inclusive	Over 0.63 to 2.00 inclusive	0.08	0.003	0.08	0.003	10
Over 50.8 to 63.5 inclusive	Over 2.00 to 2.50 inclusive	0.10	0.004	0.10	0.004	10
Over 63.5 to 76.2 inclusive	Over 2.50 to 3.00 inclusive	0.13	0.005	0.13	0.005	10
Over 76.2 to 101.6 inclusive	Over 3.00 to 4.00 inclusive	0.15	0.006	0.15	0.006	10

[1]The actual outside diameter shall be the average of the maximum and minimum outside diameters as determined at any one cross section through the tubing.
[2]Refer to SAE J514 for nominal tubing outside diameters to be used in conjunction with standard hydraulic tube fittings.

6. Material—Tubing shall be made from low carbon steel conforming to the following chemical composition in Table 2.

TABLE 2—CHEMICAL REQUIREMENTS

Element	Cast or Heat Analysis[1] % by Weight
Carbon	0.18 max
Manganese	0.30-0.60
Phosphorus	0.040 max
Sulfur	0.050 max

[1]Check analysis tolerance shall be as specified in SAE J409, Table 3.

7. Mechanical Properties—The finished tubing shall have mechanical properties as tabulated below:

TABLE 3—MECHANICAL PROPERTIES

Yield Strength, min	170 MPa (25 000 psi)
Ultimate Strength, min	310 MPa (45 000 psi)
Elongation in 50 mm (2 in), min	35%[1]
Hardness (Rockwell B scale), max	65[2]

[1]For tubing having nominal outside diameter of 9.5 mm (0.375 in) or less, and/or wall thicknesses of 0.9 mm (0.035 in) or less, a minimum elongation of 25% is permissible.
[2]The hardness test shall not be required on tubing with a nominal wall thickness of less than 1.65 mm (0.065 in). Such tubing shall meet all other mechanical properties and performance requirements.

8. Performance Requirements—The finished tubing shall satisfactorily meet the following performance tests. Test specimens shall be taken from tubing which has not been subjected to cold working after the anneal of the finished sized tubing.

8.1 Flattening Test—A section approximately 75 mm (3 in) in length, cut from the finished tubing, shall not crack or show any flaws when flattened between parallel plates to a distance equal to three times the wall thickness of the section under test. Superficial ruptures resulting from minor surface imperfections shall not be considered cause for rejection.

8.2 Reverse Flattening Test—A test specimen shall be taken from every shipment or every 460 m (1500 ft), whichever is smaller, of finished tubing and split longitudinally 90 degrees on each side of the weld. The section containing the weld shall be opened and flattened with the weld at the point of maximum bend. There shall be no evidence of cracks or lack of penetration or overlaps resulting from flash removal in the weld.

Refer to ASTM A 370, paragraph T5(B), reverse flattening test.

8.3 Expansion Test—A test specimen shall be taken from every shipment or every 460 m (1500 ft), whichever is smaller, of finished tubing and subjected to expansion over a hardened tapered plug having a slope of 0.1:1.0 until the outside diameter has been expanded 25% without evidence of cracking or flaws.

8.4 Pressure Proof Test—Unless otherwise specified, tubing supplied under this document shall have been tested hydrostatically, with no evidence of failure, at a pressure which will subject the material to a hoop (circumferential) stress of 140 MPa (20 000 psi). Test pressures shall be as determined by Barlow's formula for thin hollow cylinders under pressure:

$$P = \frac{2TS}{D} \qquad \text{(Eq.1)}$$

where:

D = outside diameter of tubing, mm (in)

P = hydrostatic pressure, MPa (psi)

S = allowable unit stress of material = 140 MPa (20 000 psi)

T = minimum wall thickness of tubing, mm (in)

No tube shall be tested beyond a hydrostatic pressure of 35 MPa (5000 psi) unless so specified.

8.5 Nondestructive Electric Test—In lieu of the hydrostatic test, where mutually agreed upon by the purchaser and manufacturer, all tubing shall be tested by passing it through an electric eddy current tester which is capable of detecting defects that would prevent the tubing from passing the hydrostatic pressure proof test.

9. Corrosion Protection—The inside and outside of the finished tubing shall be protected against corrosion during shipment and normal storage. If a corrosion preventive compound is applied, it shall be such that after normal storage periods it can readily be removed by cleaning agents normally used in manufacturing.

10. Notes

10.1 Marginal Indicia—The (R) is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.

PREPARED BY THE SAE FLUID CONDUCTORS AND CONNECTORS TECHNICAL COMMITTEE
SC1—AUTOMOTIVE AND HYDRAULIC TUBE AND FITTINGS