

	SURFACE VEHICLE RECOMMENDED PRACTICE	 J2551 SEP2013
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Recommended Practices for Fluid Conductor Carbon and Alloy Steel Tubing Applications		

RATIONALE

This recommended practice has been cancelled and replaced by SAE J2551-1, SAE J2551-2 and SAE J2551-3, making SAE J2551 now a three part recommended practice as follows: SAE J2551-1 is design and fabrication, SAE J2551-2 is performance requirements and SAE J2551-3 is for procurement.

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FOREWORD

The SAE Recommended Practice is intended as a guide to consider when designing and fabricating metallic tubes and tube assemblies for fluid power and general applications. It is subject to change to keep pace with experience and technical advances. Experienced designers and users skilled in achieving proper results, as well as the less experienced may use this outline as a list of considerations to keep in mind.

Fluid power systems are complex and require extensive knowledge of both the system requirements and the various types of tube. Therefore, all-inclusive, detailed, step-by-step instructions are not practical and are beyond the scope of this document. Less experienced designers and users who need more information may consult specialists such as experienced tube designers and fabricators. This guide may improve the communication process.

Following this document is highly recommended by the participating SAE/ISO organizations and their members. Adherence to these guidelines may assure the users they will create tube assemblies that can be efficiently manufactured, conveniently packaged/shipped, proficiently installed on their equipment, will perform adequately and safer to established industry standards and they will be using common practices and components that may be easily serviced anywhere globally.

Safety Considerations—These documents involve considerations to facilitate safer conditions when these products are in use; note these carefully during all phases of design and use of the tube assemblies. Improper selection, fabrication, installation, or maintenance of tube assemblies for fluid-power systems may result in serious personal injury or property damage. Adherence to these recommended practices could reduce the likelihood of component or system failure, thereby reducing the risk of injury or damage. The application of hydraulic tubing with fluids under pressure exposes users to risk due to mechanical or injection hazards and the environment to contamination from leakage. Users are reminded to consider the proper selection of components, fabrication of tubes, installation and maintenance procedures to address this potential risk.

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1. SCOPE

1.1 Purpose

These recommended practices provide general recommendations for designing and fabricating metallic tubes and tube assemblies for fluid power applications utilizing commonly available manufacturing methods and general guidelines for tube selection and application.

1.2 Field of Application

These recommended practices are intended for general application and hydraulic systems on industrial equipment and commercial products. Aircraft and Aerospace applications were not considered during the preparation of this document.

Since many factors influence the pressure at which a hydraulic system will or will not perform satisfactorily, these recommended practices should not be construed as guaranteed minimums. For any application, it is recommended that sufficient testing be conducted and reviewed by both the user and manufacturer to ensure that required performance levels are met.

For use of these recommended practices and connectors in conditions outside the pressure and temperature of limits specified, the manufacturers must be consulted. Both metric and inch tubing should be considered to accommodate hydraulic system design requirements. In the past, these requirements have been met predominantly with inch tubing; for new designs, metric tubing should be considered.

2. REFERENCES

2.1 Applicable Publications

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

SAE J512 Automotive Tube Fittings

SAE J514 Hydraulic Tube Fittings

SAE J518 Hydraulic Flanged Tube, Pipe, and Hose Connections, Four-Bolt Split Flange Type

SAE J533 Flares for Tubing

SAE J1065 Nominal Reference Working Pressures for Steel Hydraulic Tubing

SAE J1231 Formed Tube Ends for Hose Connections and Hose Fittings

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, Caps, and Connectors with ISO 6149-2 Metric Stud Ends

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

SAE J2044	Quick Connect Coupling Specification for Liquid Fuel and Vapor/Emissions Systems
SAE J2593	Information Report for the Installation of Fluid Conductors and Connectors
SAE J2613	Welded Flash Controlled, High Strength Low Alloy Steel Hydraulic Tubing, Sub-Critically Annealed for Bending, Double Flaring, and Bending
SAE J2614	Welded and Cold-Drawn, High Strength Low Alloy Steel Hydraulic Tubing, Sub-Critically Annealed for Bending and Flaring
SAE J2832	Welded Flash Controlled, High Strength (690 MPa Tensile Strength) Low Alloy Steel Hydraulic Tubing, Stress Relieved Annealed for Bending and Double Flaring
SAE J2833	Welded and Cold-Drawn, High Strength (690 MPa Tensile Strength) Low Alloy Steel Hydraulic Tubing, Stress Relieved 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 3304	Plain end seamless precision steel tubes—Technical conditions for delivery
ISO 3305	Plain end welded precision steel tubes—Technical conditions for delivery
ISO 4406	Hydraulic fluid power—Fluids—Method for coding the level of contamination by solid particles
ISO 6162-1	Hydraulic fluid power—Flange connectors with split or one-piece flange clamps and metric or inch screws—Part 1: Flange connectors for use at pressures of 3.5 MPa (35 Bar) to 35 MPa (350 Bar), DN 13 to DN127
ISO 6162-2	Hydraulic fluid power—Flange connectors with split or one-piece flange clamps and metric or inch screws—Part 2: Flange connectors for use at pressures of 35 MPa (350 Bar) to 40 MPa (400 Bar), DN 13 to DN 51
ISO 8434-1	Metallic tube connections for fluid power and general use—Part 1: 24° Compression connectors
ISO 8434-2	Metallic tube connections for fluid power and general use—Part 2: 37° 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° Cone connectors with o-ring weld-on nipples
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

2.1.3 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 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 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 J246	Spherical and Flanged Sleeve (Compression) Tube Fittings
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	Specification for Hydraulic O-Ring Materials, Properties, and Sizes for Metric and Inch Stud Ends, Face Seal Fitting and Four-Screw Flange Tube 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 J1273	Recommended Practices for Hydraulic Hose Assemblies
SAE J1290	Automotive Hydraulic Brake System—Metric Tube Connections
SAE J1677	Tests and Procedures for Steel and Copper Nickel Tubing
SAE J1926-1	Connections for General Use and Fluid Power—Ports and Stud Ends with ASME B1.1 Threads and O-Ring Sealing—Part 1: Threaded Port with O-Ring Seal in Truncated Housing
SAE J1926-2	Connections for General Use and Fluid Power—Ports and Stud Ends with ASME B1.1 Threads and O-Ring Sealing—Part 2: Heavy-Duty (S Series) Stud Ends
SAE J1926-3	Connections for General Use and Fluid Power—Ports and Stud Ends with ASME B1.1 Threads and O-Ring Sealing—Part 3: Light-Duty (L Series) Stud Ends
SAE J2094	Vehicle and Control Modifications for Drivers with Physical Disabilities Terminology
SAE J2435	Welded Flash Controlled, SAE 1021 Carbon Steel Tubing, Normalized for Bending, Double Flaring, and Beading
SAE J2467	Welded and Cold-Drawn, SAE 1021 Carbon Steel Tubing Normalized for Bending and Flaring
SAE J2592	Carbon Steel Tubing for General Use—Understanding Nondestructive Testing for Carbon Steel Tubing

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 272	Fasteners—Hexagon products—Widths across flats
ISO 273	Fasteners—Clearance holes for bolts and screws
ISO 2944	Fluid power systems and components—Nominal pressures
ISO 3448	Industrial liquid lubricants—ISO viscosity classification
ISO 3457	Earth-moving machinery—Guards and shields—Definitions and specifications
ISO 3601	O-ring sealing devices for fluid carrier systems
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 6072	Hydraulic fluid power—Compatibility between elastomeric materials and fluid
ISO 6149	Ports and stud ends with ISO 261 Metric threads and O-ring sealing
ISO 6150	Pneumatic fluid power—Cylindrical quick-action couplings
ISO 6163	Round flange, 8 and 12 screw connections
ISO 6164	Four-screw, one-piece square-flange connections
ISO 6605	Tests and test procedures
ISO 6743-4	Lubricants, industrial oils and related products (Class L)—Part 4: Family H (Hydraulic Systems)
ISO 7241	Quick action couplings
ISO 9974	Metric threaded ports and stud ends
ISO 10583	Test methods for tube connections
ISO 11926	Ports and stud ends with ISO 725 Inch threads and O-ring sealing
ISO 15171	Hydraulic couplings for diagnostic purposes
ISO 16028	Hydraulic flush face quick-action couplings

2.2.3 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 213/A 213M	Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes
ASTM A 268/A 268M	Seamless and Welded Ferritic and Martensitic Stainless Steel Tubing
ASTM 269-96	Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM 312A/A312M	Seamless and Welded Austenitic Stainless Steel Pipes
ASTM A 450/A 450M-96a	General Requirements for Carbon, Ferritic Alloy and Austenitic Alloy Steel Tubing
ASTM A 513	Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Tubing
ASTM A 519	Standard Specification for Seamless Carbon and Alloy Steel Mechanical Tubing
ASTM A 554	Welded Stainless Steel Mechanical Tubing

3. DEFINITIONS

These explanations serve only to clarify this document and are not intended to stand alone. They are presented sequentially, with the former helping to explain the latter.

3.1 Arc

The curved portion of the bend.

3.2 Bend Die

A wheel-shaped die with a groove in the outer circumference that conforms to half the tube circumference. It will most often have a straight section used as half of the clamp set for holding the tube against the die. This type of die is used in rotary draw or compression bending to generate the bend radius.

3.3 Bend Radius

See Centerline radius

3.4 Bender (Tube)

A mechanical device capable of forming a bend in a straight length of material.

3.5 Boost

Device or system to apply a longitudinal positive force in the direction of the bend by either clamping or pushing on the end of the tube being bent. This force will reduce wall thinning of the outside wall and increase the compression and thickness of the inside wall.

3.6 Buckling

Definite folds, creases, or wrinkles formed on the surface of the tube during the bending operation.

3.7 Center to Center

The distance between the theoretical or calculated centers of adjoining bends. Also used for diametric measurement between the centerlines of two tangent points of a bend, (i.e., 180-degree bend for which the center to center distance will be equal to twice the centerline radius)

3.8 Centerline Diameter

The distance from the centerline axis of the tube across to the other centerline of a 180-degree bend.

3.9 Centerline Radius (CLR)

The distance on a bend forming tool from the center of curvature to a point corresponding to the centerline of the tubular shape when mounted in the bend-forming tool – nominal CLR.

3.10 Clamp Die

A tool used in rotary draw and compression bending to clamp the tube against the bend die to prevent the tube from slipping during bending.

3.11 Cold Bending

The bending of tube by cold working at ambient temperatures.

3.12 Compression

The forces that thicken the inside wall of the bend.

3.13 "D" of Bend

Centerline radius (CLR) divided by the tube diameter.

3.14 Degree of Bend (DOB)

The angle expressed in number of degrees, to which the bend is formed.

3.15 Distance Between Bends (DBB)

The actual length of the straight section between the tangent points of two adjoining bends.

3.16 Ductility

The ability of the material to deform plastically without fracture, as measured by elongation or reduction of area in a tensile test.

3.17 Elongation

The increase in length of a test specimen at failure in a tensile test, expressed as a percentage of the original length. The increase in length of material fiber during bending, expressed as a percentage of the original length.

3.18 Extradados

The outside arc of the bend.

3.19 Flat Plane

See Out-of-plane.

3.20 Flash

The excess material created at the weld joint when the tube was produced.

3.21 Flattening

See Ovality.

3.22 Fluid Power

Energy transmitted and controlled using pressurized hydraulic fluids or gases.

3.23 Follower Die

See Pressure die.

3.24 Hump

A rounded protrusion or bulge on the outside radius.

3.25 Hydraulic Pressure Spike

Rapid increase in system pressure that exceeds designed relief valve working pressure setting.

3.26 ID

The inside diameter of the tube.

3.27 Inner Radius

See Intrados.

3.28 Intrados

The inside arc of the bend.

3.29 Mandrel

A tool device used to provide internal support to the tube to prevent excessive flattening, collapse or wrinkling during rotary draw bending. The mandrel is supported by a mandrel rod that runs through the tube ID and is held in location at the bend die.

3.30 Minimum Wall Thickness

The wall thickness specified on the fabrication drawing or computed in accordance with the applicable specification as the minimum acceptable for the design criteria.

3.31 Neutral Axis

That portion of the tube that is neither in compression nor in tension.

3.32 Nominal

Used in reference to wall thickness, generally as a "mean" measurement.