SURFACE VEHICLE INFORMATION REPORT

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(R) Nominal Reference Working Pressures for Steel Hydraulic Tubing

RATIONALE

This SAE Information Report has been revised as part of the SAE Five-Year Review process. Revisions include the addition of a forward, a table of contents, simplified table headings, and updated verbiage. Sections 2.1, 2.2, 2.3, and 2.4 were removed from the document as some information in these sections is redundant versus other document sections or is information maintained in other SAE documents. This document continues to recommend metric sized tubing for new designs. The Barlow Formula, the Boardman Formula, and the Lame Formula continue to be retained in Appendix A per a consensus that these formulas are still commonly used in the industry.

FOREWORD

This SAE Information Report assists tube assembly designers in the selection of appropriately sized and pressure rated SAE steel tube materials for hydraulic applications on surface vehicles. These pressure ratings and associated tube materials are intended for fluid power applications; hydraulic systems on surface vehicles, industrial equipment, and commercial products. This SAE Information Report is not intended for use in association with Aircraft and Aerospace applications and these applications were not considered during the preparation of this document.

Many factors influence the pressure capability of bulk tube materials once they are integrated into a hydraulic tube assembly, such as but not limited to, end connection selection, thermal processes used during fabrication, specified bend radius, and the assembly's operating environment. These recommended pressures should not be construed as guaranteed minimums. The information presented herein is based on tubing products which conform to the SAE and ISO standards listed in the reference section.

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

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

SAFETY CONSIDERATIONS

Improper selection of bulk tube materials for inclusion in hydraulic tube assemblies for fluid power systems can result in serious personal injury or property damage. Using the data in this SAE Information Report may reduce the probability of material and system failure.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/J1065_202207/

TABLE OF CONTENTS

1. SCOPE 3
1.1 Purpose 3
1.2 Information Report 3

2. REFERENCES 3
2.1 Applicable Documents 3
2.1.1 SAE Publications 3
2.1.2 ISO Publications 4
2.2 Related Publications 4
2.2.1 SAE Publications 4
2.2.2 ISO Publications 5
2.2.3 ANSI Accredited Publications 6
2.2.4 ASTM Publications 6

3. TUBE SELECTION 6

4. NOMINAL PRESSURES 6

5. INTRODUCTION TO TABLES 7

6. NOTES 12
6.1 Revision Indicator 12

APPENDIX A 13

Table 1 Metric size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J526 and SAE J527 low carbon steel hydraulic tubing at 4 to 1 design factor material strength = 290 MPa minimum tensile (Reference for size dimensions from ISO 3305) 7
Table 2 Metric size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J356, SAE J524 and SAE J525 low carbon steel hydraulic tubing at 4 to 1 design factor material strength = 310 MPa minimum tensile (Reference for size dimensions from ISO 3305) 8
Table 3 Metric size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J2435 and SAE J2467 medium carbon steel hydraulic tubing at 4 to 1 design factor material strength = 415 MPa minimum tensile (Reference for size dimensions from ISO 3305) 9
Table 4 Metric size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J2613 and SAE J2614 alloy steel hydraulic tubing at 4 to 1 design factor material strength = 500 MPa Minimum Tensile (Reference for size dimensions from ISO 3305) 9
Table 5 Metric size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J2832 and SAE J2833 alloy steel hydraulic tubing at 4 to 1 design factor material strength = 690 MPa minimum tensile (Reference for size dimensions from ISO 3305) 10
Table 6 Inch size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J526 and SAE J527 low carbon steel hydraulic tubing at 4 to 1 design factor material strength = 290 MPa minimum tensile 10
Table 7 Inch size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J356, SAE J524, and SAE J525 low carbon steel hydraulic tubing at 4 to 1 design factor material strength = 310 MPa minimum tensile 11
Table 8 Inch size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J2435 and SAE J2467 medium carbon steel hydraulic tubing at 4 to 1 design factor material strength = 415 MPa minimum tensile 11
Table 9 Inch size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J2613 and SAE J2614 alloy steel hydraulic tubing at 4 to 1 design factor material strength = 500 MPa minimum tensile 12
Table 10 Inch size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J2832 and SAE J2833 alloy steel hydraulic tubing at 4 to 1 design factor material strength = 690 MPa minimum tensile 12

1. SCOPE

This SAE Information Report is intended to provide design guidance in the selection of steel tubing and related tube fittings for general hydraulic system applications. The information presented herein is based on tubing products which conform to SAE and ISO standards listed in the reference section. All pressure rating data found in the charts included in this document are calculated per the formula found in ISO 10763 and the main body of this document.

1.1 Purpose

The purpose of this document is to provide nominal reference working pressures for selecting tube material, OD size, and wall thickness for given hydraulic system working pressures based on the recommended 4-to-1 design factor of the applicable burst pressure rating. This Information Report also provides a method of calculating working and burst pressure ratings for SAE and ISO steel tube diameters and wall thicknesses not included in the Tables.

1.2 Information Report

Since many factors influence the pressure at which a hydraulic system will or will not perform satisfactorily, this document should not be used as a “standard” nor a “specification,” and the values shown herein should not be construed as “guaranteed” minimum or absolutes. This document is an information report only. Refer to SAE J2551-1 for information concerning designing, bending, fabrication, and routing of fluid conductor metallic tube assemblies.

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 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 Suitable for Bending, Flaring, Beading, Forming, and Brazing

SAE J527 Brazed Double Wall Low-Carbon Steel Tubing

SAE J2435 Welded Flash Controlled, SAE 1021 Carbon Steel Tubing, Normalized for Bending, Double Flaring, Cold Forming, Welding, and Brazing

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

SAE J2551-1 Recommended Practices for Fluid Conductor Carbon, Alloy and High Strength Low Alloy Steel Tubing Applications - Part 1: Design and Fabrication

SAE J2593 Information Report for the Installation of Fluid Conductors and Connectors

SAE J2613 Welded Flash Controlled, High Strength (500 MPa Tensile Strength) Hydraulic Tubing, for Bending, Double Flaring, Cold Forming, Welding, and Brazing

SAE J2614 Welded and Cold-Drawn, High Strength (500 MPa Tensile Strength) Hydraulic Tubing, for Bending, Flaring, Cold Forming, Welding, and Brazing

SAE J2832 Welded Flash Controlled, High Strength (690 MPa Tensile Strength) Low Alloy Steel Hydraulic Tubing, Stress Relieved, Annealed for Bending, Double Flaring, Cold Forming, and Brazing

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

2.1.2 ISO Publications

Copies of these documents are available online at https://webstore.ansi.org/.

ISO 3305 Plain End Welded Precision Steel Tubes - Technical Conditions for Delivery

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 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 J246 Spherical and Flanged Sleeve (Compression) Tube Fittings

SAE J514 Hydraulic Tube Fittings

SAE J515 Specification for Hydraulic O-Ring Materials Used with Hydraulic Connectors

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 J533 Flares for Tubing

SAE J1231 Formed Tube Ends for Hose Connections and Hose Fittings

SAE J1273 Recommended Practices for Hydraulic Hose Assemblies

SAE J1290 Automotive Hydraulic Brake System - Metric Tube Connections

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 J1677 Tests and Procedures for Carbon Steel and Low Alloy Steel Tubing

SAE J2044 Quick Connect Coupling Specification for Liquid Fuel and Vapor/Emissions Systems

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 Practice 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 documents are available online at https://webstore.ansi.org/.

ISO 2944 Fluid Power Systems and Components - Nominal Pressures

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 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 6163 Round Flange, 8 and 12 Screw Connections

ISO 6164 Four-Screw, One-Piece Square-Flange Connections

ISO 6605 Tests and Test Procedures

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 10583 Test Methods for Tube Connections

2.2.3 ANSI Accredited Publications

Copies of these documents are available online at https://webstore.ansi.org/.

EN 10305-2 Steel Tubes for Precision Applications - Technical Delivery Conditions - Part 2: Welded Cold Drawn Tubes

EN 10305-3 Steel Tubes for Precision Applications – Technical Delivery Conditions – Part 3: Welded Cold Sized 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 A513/A513M Standard Specification Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing

ASTM A450/A450M Standard Specification for General Requirements for Carbon and Low Alloy Steel Tubes

3. TUBE SELECTION

Tube material, size, and wall thickness may be selected from Tables 1 through 10. See Tables 1 through 5 for metric size tubing nominal working pressures and see Tables 6 through 10 for inch sized nominal working pressures. For nominal reference working pressure values for sizes not listed in the Tables calculate the nominal reference working pressure value using the formula in Section 4.

When tube material information discrepancies between this document and associated tubing specifications occur, the current bulk tube specifications shall take precedence.

4. NOMINAL PRESSURES

The nominal reference working pressures listed are based on a design factor ratio of 4- to- 1. The nominal reference working pressures in all tables are derived from the calculated nominal static reference burst pressure and the calculated nominal reference working pressure using the following formulas

The nominal reference burst pressures for these materials are calculated from the following formula:

$$Pb = Rm \left(\ln \frac{D}{d} \right) \quad \text{(Eq. 1)}$$

The nominal reference working pressures in all Tables are calculated from the following formula:

$$Pw = \frac{Pb}{4} \quad \text{(Eq. 2)}$$

where:

Pb = nominal static reference burst pressure in MPa (megapascals)

Pw = nominal reference working pressure in MPa (megapascals)

Rm = minimum tensile strength in MPa (megapascals)

ln = natural logarithm, also referred to as log e

D = nominal tube outside diameter in millimeters

d = nominal tube inside diameter in millimeters

These formulae and the derived nominal reference working pressures are only applicable to the listed tube materials, of which, all have at least a 50% ratio of the minimum yield strength to the minimum tensile strength. When calculating nominal reference pressures for tube materials where this ratio falls below a 50% ratio, formulae listed in Appendix A should be used.

5. INTRODUCTION TO TABLES

Values in all tables are derived from the formula shown in Section 5. The nominal reference working pressures are only applicable to the tube materials identified in the table heading.

Table 1 - Metric size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J526 and SAE J527 low carbon steel hydraulic tubing at 4 to 1 design factor material strength = 290 MPa minimum tensile (Reference for size dimensions from ISO 3305)

Metric Tube Nom OD	Nominal Tube Wall Thickness (mm)									
mm	0.5	1	1.5	2	2.5	3	4	5	6	8
4	21	50								
5	16	37	67							
6	13	30	50							
8	10	21	34	50						
10	8	16	26	37	50					
12	6.3	13	21	30	39	50				
16		10	15	21	27	34	50			
20		8	12	16	21	26	37	50		
25		6	9	13	16	20	28	37	48	
32			7	10	13	15	21	27	34	50
38			6	8	10	13	17	22	28	40
40				8	10	12	16	21	26	37
50				6	8	9	13	16	20	28
60				5	7	8	11	12	16	23
70				4	6	7	9	11	14	19
80					5	6	8	10	12	16

Table 2 - Metric size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J356, SAE J524 and SAE J525 low carbon steel hydraulic tubing at 4 to 1 design factor material strength = 310 MPa minimum tensile (Reference for size dimensions from ISO 3305)

Metric Tube Nom OD	Nominal Tube Wall (mm)									
mm	0.5	1	1.5	2	2.5	3	4	5	6	8
4	22	54								
5	17	40								
6	14	32	54							
8	11	22	37	54						
10	8	17	28	40	54					
12	7	14	22	32	42	54				
16		11	16	22	29	37	54			
20		8	13	17	22	28	40	54		
25		7	10	14	17	21	30	40	51	
32			8	11	13	16	22	29	37	54
38			7	9	11	14	19	24	30	43
40				8	11	13	17	22	28	40
50				7	8	10	14	17	21	26
60				6	7	8	11	14	17	24
70				5	6	7	10	12	15	20
80					5	6	8	11	13	17

Table 3 - Metric size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J2435 and SAE J2467 medium carbon steel hydraulic tubing at 4 to 1 design factor material strength = 415 MPa minimum tensile (Reference for size dimensions from ISO 3305)

Metric Tube Nom OD	Nominal Tube Wall (mm)									
mm	0.5	1	1.5	2	2.5	3	4	5	6	8
4	30	72								
5	23	53								
6	19	42								
8	14	30	49							
10	11	23	37	53						
12	9	19	30	42	56					
16		14	22	30	39	49				
20		11	17	23	30	37	53			
25		9	13	18	23	29	40	53		
32			10	14	18	22	30	39	49	
38			9	12	15	18	25	32	40	57
40				11	14	17	23	30	37	53
50				9	11	13	18	23	29	40
60				7	9	11	15	19	23	32
70				6	8	9	13	16	20	27
80					7	8	11	14	17	23

Table 4 - Metric size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J2613 and SAE J2614 alloy steel hydraulic tubing at 4 to 1 design factor material strength = 500 MPa Minimum Tensile (Reference for size dimensions from ISO 3305)

Metric Tube Nom OD	Nominal Tube Wall (mm)					
mm	2	3	4	5	6	8
20	28	45				
25		35	48			
32		26	36	47		
38			30	38	48	
40				36	45	
50					35	48
60					28	39
70						33
80						28

Table 5 - Metric size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J2832 and SAE J2833 alloy steel hydraulic tubing at 4 to 1 design factor material strength = 690 MPa minimum tensile (Reference for size dimensions from ISO 3305)

Metric Tube Nom OD	Nominal Tube Wall (mm)					
mm	2	3	4	5	6	8
25	30	48				
32		36	50			
38			41	53		
40			39	50		
50				39	48	
60					39	54
70					33	44.7
80						39

Table 6 - Inch size tubing nominal reference working pressures in MPa (MPa X 145 = psi) for SAE J526 and SAE J527 low carbon steel hydraulic tubing at 4 to 1 design factor material strength = 290 MPa minimum tensile

Inch Size Tube Nom SAE Dash Size	Inch Size Tube Nom Tube OD	Inch Size Tube Nom Tube OD	Nominal Tube Wall (mm)												
	mm	inch	0.71	0.89	1.24	1.65	2.11	2.41	2.77	3.05	3.40	3.76	3.96	4.76	6.35
-2	3.18	0.125	43	60											
-3	4.76	0.188	26	34	53										
-4	6.35	0.250	19	24	36	53									
-5	7.94	0.312	15	19	28	39	56								
-6	9.52	0.375	12	15	22	32	43	51							
-8	12.70	0.500		11	16	22	29	35	42	48					
-10	15.88	0.625		9	13	17	23	26	31	35	41	47			
-12	19.05	0.750		7	10	14	18	21	25	28	32	37	39		
-14	22.23	0.875		6	9	12	15	18	21	23	27	30	32	41	
-16	25.40	1.000		5	8	10	13	15	18	20	23	26	27	34	50
-18	28.58	1.125			7	9	12	14	16	18	20	22	24	30	43
-20	31.75	1.250			6	8	11	12	14	16	18	20	21	26	37
-24	38.10	1.500				7	9	10	12	13	14	16	17	21	30
-28	44.45	1.750				6	7	9	10	11	12	14	14	18	25
-32	50.80	2.000				5	7	7	9	10	11	12	13	15	21
-36	57.15	2.250				5	6	7	8	8	9	10	11	13	18
-40	63.50	2.500				4	5	6	7	8	8	9	10	12	16
-48	76.20	3.000				3	4	5	6	6	7	8	8	10	13