



SURFACE VEHICLE INFORMATION REPORT

SAE

J1065 SEP2009

Issued 1974-01
Revised 2009-09

Superseding J1065 FEB2003

(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 and to bring this document into line with global standardization. The Barlow Formula, The Boardman Formula and The Lame Formula were placed in Appendix A for a period of five years during the previous publication of this revised document. After the five year period this information was to be removed from this information report. However, the hydraulic user community is not yet comfortable with removing these formulas. Therefore, these formulas will remain for another five year period at which time removal will be discussed further. In this revision ISO 10763 is the only formula that has been used to calculate the working pressures presented in the body of the document.

Tables 1 through 5 have been reallocated to comply with SAE guidelines to present our FCCTC tube standards in metric sizes.

Tables 6 through 10 have been allocated and updated to show compliance with all appropriate currently available SAE carbon steel and alloy steel tube standards in inch sizes.

The eventuality of the USA converting to hard metric tube sizes is in the hands of the OEM's. Until this conversion happens, the hard metric tube sizes, which have very low usage in the USA, will remain difficult to source, more expensive and therefore, will probably remain in the future, rather than the present, of which we as standards writers, continue to contemplate. Perhaps one day the inch size tubing and components will be of a minority of usage and the hard metric will be the majority of usage.

Please note the changes as follows:

- a. Added Rationale and statement concerning metric size tubing and inch size tubing
- b. Updated Applicable Publications and Related Publications
- c. In 1.5 added reference information to SAE J2658 and SAE J2593, removed reference to SAE J343, this SAE hose standard is not applicable to hydraulic tube assemblies.
- d. In 3. added current standards take precedence statement
- e. In 4. added reallocated Tables 1 through 5 for the various materials of metric tube sizes and added Tables 5 through 10 for the various materials of inch size tubing.
- f. In Tables 8 and 9 removed unneeded nominal reference working pressures that are unreasonably high.
- g. Updated all pressures rounded using "rule of seven".
- h. Removed bold line and note concerning SAE J533 Flaring from all tables because this information has been proven inaccurate, inconsistent and no particular value to the tube fabrication manufacturers.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2009 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

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>

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.

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 desired 4 to 1 design factor of the applicable burst pressure rating.

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. See SAE J2551 for information concerning designing, bending, fabrication and routing of fluid conductor metallic tube assemblies.

1.3 Minimum Tensile Strength

Within the fluid power industry, many criteria are used for determining the pressure capability of steel tubing. In this document, consideration is given to specified minimum tensile strength of the materials to calculate the nominal minimum burst pressure of the specified steel tubing. The actual tensile strength of the material can be easily determined by common methods of testing.

1.4 Straight Tube Sections

The nominal reference working pressures listed in this document are for straight tube sections of the listed tubing materials only. Factors such as the thinning of tube walls due to forming operations, shock loads, and vibration characteristics of the system should also be considered when designing all hydraulic tubes and tube assemblies, especially in high pressure applications.

Operating at 100% of the Reference Working Pressures

When designing systems that operate at 100% of the charted reference working pressure, in conjunction with the materials being subjected to bending, cold forming, wall thinning, brazing, welding, side loads, shock loads and extreme vibrations, the maximum yield strength of the material may be compromised and may cause premature failure of the tube material. Therefore, a good recommended practice is to design hydraulic systems to operate at a level less than the calculated maximum reference working pressures of the materials used. This diminished level may vary from application to application, depending on the operating conditions, pressure spikes and designer discretion, 90% is commonly used.

1.5 Endurance Testing

It is impractical to specify in this report guaranteed allowable working pressures that will satisfy all design criteria for every hydraulic system. Therefore, endurance testing in accordance with SAE J2658 and/or ISO 19879 is recommended. See SAE J2593 Information Report for the Installation of Fluid Conductors and Connectors for installation guidance, recommended assembly sequence and recommended tightening torque values.

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 and ISO 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 J356	Welded Flash-Controlled Low-Carbon Steel Tubing Normalized for Bending, Double Flaring, and Beading
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 J533	Flares for Tubing
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 J2551	Recommended Practices for Fluid Conductor Metallic Tubing Applications
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 Beading
SAE J2614	Welded and Cold-Drawn, High Strength Low Alloy Steel Hydraulic Tubing, Sub-Critically Annealed for Bending and Flaring
SAE J2658	Metallic Tube Conductor Assemblies for Fluid Power and General Use—Test Methods for Hydraulic Fluid Power Metallic Tube Assemblies
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 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 J246 Spherical and Flanged Sleeve (Compression) Tube Fittings
- SAE J514 Hydraulic Tube Fittings
- 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 J518 Hydraulic Flanged Tube, Pipe, and Hose Connections, Four-Bolt Split Flange Type
- 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, 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 J1677 Tests and Procedures for Steel and Copper Nickel Tubing
- SAE J2044 Quick Connect Coupling Specification for Liquid Fuel and Vapor/Emissions Systems
- 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 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 8434-4	Metallic tube connections for fluid power and general use—Part 4: 24° Cone connectors with o-ring weld-on nipples
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. TUBE SELECTION

Tube material, size and wall thickness may be selected from Tables 1 through 4.

NOTE: When tubing information discrepancies between this document and associated tubing specifications occur, the current tubing and end connection specifications shall take precedence.

4. NOMINAL PRESSURES

See Tables 1 through 5 for metric size tubing nominal reference working pressures. See Tables 6 through 10 for inch size nominal reference working pressures. The nominal reference working pressures listed are based on a design factor ratio of 4 to 1 between the calculated nominal static reference burst pressure and the calculated nominal reference working pressure using the following formulas:

$$\text{Burst Pressure -- } P_b = R_m, \min \left(\ln \frac{D}{d} \right) \quad (\text{Eq. 1})$$

$$\text{Working Pressure -- } P_w = \frac{P_b}{4} \quad (\text{Eq. 2})$$

where:

- P_b is the nominal static reference burst pressure in MPa (megapascals)
 P_w is the nominal reference working pressure in MPa (megapascals)
 R_{m, min} is the minimum tensile strength in MPa (megapascals)
 ln is the natural logarithm, also referred to as log e
 D is the nominal tube outside diameter in millimeters
 d is the nominal tube inside diameter in millimeters

NOTE: 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.

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 3304 and ISO 3305)

Metric Size Tubing Nom Tube OD mm	Nominal Wall Thickness in mm									
	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	8.0
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 3304 and ISO 3305)

Metric Size Tubing Nom Tube OD mm	Nominal Wall Thick- ness in mm 0.5	Nominal Wall Thick- ness in mm 1.0	Nominal Wall Thick- ness in mm 1.5	Nominal Wall Thick- ness in mm 2.0	Nominal Wall Thick- ness in mm 2.5	Nominal Wall Thick- ness in mm 3.0	Nominal Wall Thick- ness in mm 4.0	Nominal Wall Thick- ness in mm 5.0	Nominal Wall Thick- ness in mm 6.0	Nominal Wall Thick- ness in mm 8.0
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

SAENORM.COM : Click to view the full PDF of J1065_200909

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 3304 and ISO 3305)

Metric Size Tubing Nom Tube OD mm	Nominal Wall Thickness in mm									
	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	8.0
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 3304 and ISO 3305)

Metric Size Tubing Nom Tube OD mm	Nominal Wall Thickness in mm					
	2.0	3.0	4.0	5.0	6.0	8.0
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 3304 and ISO 3305)

Metric Size Tubing Nom Tube OD mm	Nominal Wall Thick- ness in mm					
	2.0	3.0	4.0	5.0	6.0	8.0
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 HYDRAULIC STEEL HYDRAULIC TUBING AT 4 TO 1 DESIGN FACTOR
 MATERIAL STRENGTH = 290 MPa MINIMUM TENSILE

Inch Size Tubing Nom SAE Dash Size	Inch Size Tubing Nom Tube OD mm	Inch Size Tubing Nom Tube OD inch	Nom Wall Thick- ness in mm												
			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

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

Inch Size Tubing	Inch Size Tubing	Inch Size Tubing	Nom Wall Thick- ness in mm												
Nom SAE Dash Size	Nom Tube OD mm	Nom Tube OD 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	46	64											
-3	4.76	0.188	28	36	57										
-4	6.35	0.250	20	26	39	57									
-5	7.94	0.312	16	20	29	42	60								
-6	9.52	0.375	13	16	24	33	46	55							
-8	12.70	0.500		12	17	24	32	37	45	51					
-10	15.88	0.625		9	13	18	24	28	34	38	44	50			
-12	19.05	0.750		8	11	15	20	23	27	30	34	39	42		
-14	22.23	0.875		7	9	13	17	19	22	25	29	32	34	44	
-16	25.40	1.000		6	8	11	14	17	19	22	24	27	29	37	54
-18	28.58	1.125			7	10	13	15	17	19	21	24	25	32	46
-20	31.75	1.250			7	9	11	13	15	17	19	21	22	28	40
-24	38.10	1.500				7	9	11	12	14	15	17	18	23	32
-28	44.45	1.750				6	8	9	11	12	13	15	15	19	26
-32	50.80	2.000				5	7	8	9	10	11	13	13	16	23
-36	57.15	2.250				5	6	7	8	9	10	11	12	14	20
-40	63.50	2.500				4	6	6	7	8	9	10	11	13	18
-48	76.20	3.000				4	5	5	6	7	7	8	9	11	14

SAENORM.COM : Click to view the full PDF of J1065 - 200909