INCH-POUND
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PERFORMANCE SPECIFICATION

TUBE ASSEMBLY METAL: SWAGED HYDRAULIC, (M1 TANK)

This specification is approved for use by the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC), Research, Development and Engineering Command (RDECOM), Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the performance, design, and test requirements for swaged hydraulic tube assemblies which provide hydraulic fluid, under pressure, to vehicle hydraulic system components. Tube assembly is swaged, separable, flareless type, and threaded one end to allow connection to standard fitting (see 6.2).

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract (see 6.2).

Comments, suggestions, or questions on this document should be addressed to U.S. Army RDECOM, Tank Automotive Research, Development and Engineering Center, ATTN: RDTA-EN/STND/TRANS MS #268, 6501 E. 11 Mile Road, Warren, MI 48397-5000 or emailed to DAMI_STANDARDIZATION@conus.army.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.daps.dla.mil.

AMSC N/A FSC 4710

AMERICAN SOCIETY FOR QUALITY (ASQ)

ANSI/ASQ Z1.4 - Sampling Procedures and Tables for Inspection by Attributes

(Copies of this document are available from www.asq.org or American Society for Quality, 600 North Plankinton Avenue, Milwaukee, WI 53203.)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B46.1 - Surface Texture (Surface Roughness, Waviness, and Lay)

(Copies of these documents are available online at http://www.asme.org or from American Society of Mechanical Engineers, Orders/Inquiries, P.O. Box 2300, Fairfield, NJ 07007-2300.)

ASTM INTERNATIONAL

ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Testing

(Copies of these documents are available from www.astm.org or ASTM International, P.O. Box C700, West Conshohocken, PA 19428-2959.)

SAE INTERNATIONAL

SAE AS33514 - Fitting End, Standard Dimension for Flareless Tube Connection and Gasket Seal
SAE AS33611 - Tube Bend Radii
SAE J514 - Hydraulic Tube Fittings

(Copies of these documents are available from www.sae.org or SAE Customer Service, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

2.3 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified (see 6.2), a sample shall be subjected to first article inspection in accordance with 4.2.

3.2 Materials. Materials used shall be in accordance with the manufacturer's materials specification for tube assemblies. The materials shall be capable of meeting all the operational and environmental requirements specified herein (see 4.7.1 and 4.7.2).

3.2.1 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible, provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.2.2 Tube. The tube shall be a corrosion-resistant material and meet the mechanical properties as specified in Table I (see 4.7.1 and 4.7.2).

TABLE I. Mechanical properties of tubing.

Nominal outside diameter		Nominal wall thickness		Ultimate tensile strength		Yield strength 0.2 percent offset		Elongation min (percent)	
inch	(cm)	inch	(cm)	psi	(MPa)	psi	(MPa)	Full section	Strip
0.188 and less (0.477)		0.016 and less (0.0406)		75,000 120,000 max	(516) (827)	---	---	35	---
		over 0.016		75,000 105,000 max	(516) (723)	30,000 min	(207)	35	---
Over 0.188 thru 0.500 (0.477 thru 1.27)		0.010 and less (0.0254)		75,000 115,000 max	(516) (792)	---	---	35	---
		over 0.010		75,000 105,000 max	(516) (723)	30,000 min	(207)	35	---
Over 0.500 (1.27)		All		75,000 100,000 max	(516) (689)	30,000 min	(207)	35	30

3.2.3 Fitting. The fitting shall be of a corrosion-resistant material (see 4.7.1 and 4.7.2).

3.3 Design.

3.3.1 Fitting and tube assembly. The fitting and tube assembly dimensions shall be as specified (see 6.2). The fitting configuration shall be in accordance with Figure 2 (see 4.7.2 and 4.7.5).

3.3.2 Fitting attachment. The fitting and the tube shall form a leak proof joint. If swaging is performed, it is recommended that the fittings be swaged on the tube by applying 5500 pounds per square inch (psi) (38 Megapascals (MPa)) hydrostatic pressure on swaging dies (see 4.7.2 and 4.7.6).

3.3.3 Tube insertion length. Before attachment, the length of the tube to be inserted into the fitting shall be in accordance with Table II (see 4.7.2 and 4.7.7).

3.3.4 Tube bend radii. Unless otherwise specified on the detailed part drawing, all tube bends shall be in accordance with SAE AS33611 (see 4.7.2 and 4.7.8).

3.3.5 Nut. The nut on the separable fitting shall have the same thread and hex size for corresponding tube sizes in accordance with SAE J514 and shall mate with fittings specified in SAE AS33514. The nut shall be captive and swivel freely on the assembly (see 4.7.2 and 4.7.9).

TABLE II. Tube insertion length.

Tube size O.D.		Tube insertion length			
		Minimum		Maximum	
(inch)	(cm)	(inch)	(cm)	(inch)	(cm)
1/4	(0.635)	0.615	(1.56)	0.915	(2.32)
3/8	(0.9525)	0.690	(1.75)	0.990	(2.51)
1/2	(1.27)	1.193	(3.03)	1.493	(3.79)
3/4	(1.905)	1.303	(3.31)	1.603	(4.07)
1	(2.54)	1.448	(3.68)	1.748	(4.44)

3.4 Performance.

3.4.1 Leakage.

3.4.1.1 Tube assembly. When mated with appropriately sized fittings (see SAE AS33514), the threaded and swaged assembly shall show no evidence of leakage or permanent deformation when subjected to hydrostatic pressures up to 1650 psig (11.37 MPa) (see 4.7.10).

3.4.2 Proof pressure. The tube assembly, when mated with appropriately sized fittings (see SAE AS33514) shall withstand a 3000 psig (20.7 MPa) minimum pressure for not less than 5 minutes. There shall be no evidence of external leakage or permanent deformation (see 4.7.11).

3.4.3 Burst pressure. The tube assembly, when mated with appropriately sized fittings (see SAE AS33514) shall withstand a minimum burst pressure of no less than 6000 psig (41.37 MPa). There shall be no evidence of external leakage or rupture at any pressure below the specified burst pressure. Assemblies used for verification of compliance to the burst pressure and endurance requirements shall be indelibly marked to prevent their use in functional systems (see 4.7.12).

3.4.4 Endurance. The tube assembly shall be capable of withstanding 200,000 impulse cycles without leakage or failure. The impulse rate shall be 65±5 cycles per minute. Each cycle shall consist of a rise from 0 pounds per square inch gage (psig) to surge pressure and back to 0 psig. The peak surge pressure shall be within a range from 2475 psig (17.06 MPa) to 2590 psig (17.85 MPa) (see 4.7.13).

3.4.5 Hydrostatic pressure resistance. Tubing shall be capable of withstanding an internal hydrostatic pressure P, without bulging, leakage, or other defects, except that any diametric permanent set shall be disregarded. Hydrostatic test pressure shall be calculated according to the following formula (see 4.7.14):

$$P = S \frac{D^2 - d^2}{D^2 + d^2}$$

where:

P = test pressure in psi (MPa)

S = 30,000 psi (206.8 MPa)

D = maximum permissible outside diameter (nominal OD plus tolerance), inch (cm)

d = maximum permissible inside diameter, inch (cm), (computed as D less twice the minimum permissible wall thickness)

3.4.6 Repeated assembly. The separable tube assembly shall be capable of repeated assemblies without leakage or failure utilizing the tightening requirements as specified herein (see 4.7.15).

3.4.6.1 Assembly tightening. Fittings shall be clean at time of assembly, do not lubricate. The ferrule, nut, and fitting seat shall be free from foreign materials, burrs, nicks and scratches. Figure 1 provides a visual inspection of the points that shall be in contact prior to final tightening (see 4.7.15).

3.4.7 Environmental conditions.

3.4.7.1 Operating temperature. The tube assembly shall be capable of withstanding an operating temperature of -65±2 degrees Fahrenheit (°F) (-54±1 degrees Celsius (°C)) to +275±5 °F (+135±3 °C) for no less than 4 hours and after exposure shall not leak or fail when subjected to a proof pressure test (see 4.7.11, 4.8.2 and 4.8.3).

3.4.8 Corrosion-resistance. The tube assembly shall not be damaged nor its performance impaired after exposure to salt fog. After exposure the assembly shall not leak or fail when subjected to the proof pressure test (see 4.9).

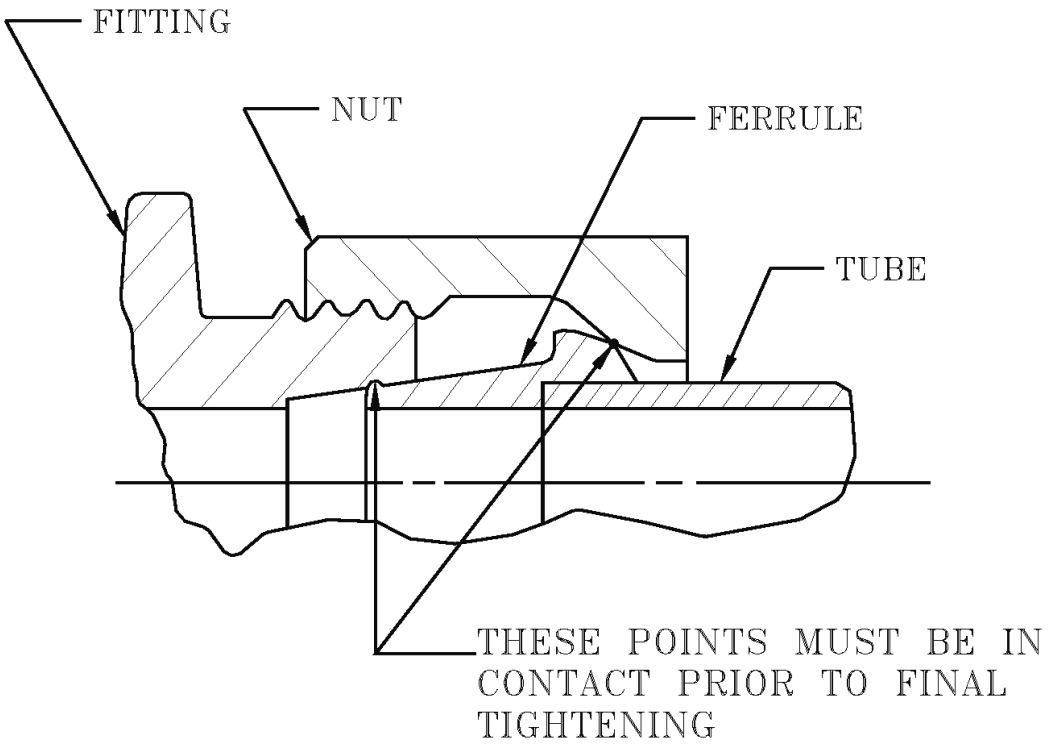


FIGURE 1. Assembly tightening.

3.4.9 Internal cleanliness. The internal tube and fitting surfaces shall meet cleanliness requirements as specified in Table III (see 4.10).

TABLE III. Particle cleanliness levels.

Level	Particle size, µm	Count per 1 ft^2	Count per 0.1 m^2	Count per liter
200	15	4189	4520	41890
200	25	1240	1340	12400
200	50	170	184	1700
200	100	16	17.3	160
200	200	1	1.08	10

3.5 Identification marking. Identification marking shall include, as a minimum, the following information permanently marked on the exterior of the tube assembly (see 4.7.2):

a. Manufacturer's identification
b. Serial number
c. Military part number
d. Federal stock number
e. Manufacturer's part number
f. Date of manufacture
g. Contract number

h. US.

3.6 Workmanship. Workmanship shall be of the quality necessary to produce tube assemblies free from defects which may affect their serviceability or reduce, limit, or compromise performance. Unless a finer finish is specified on drawings, sealing surfaces shall be smooth except that annular tool marks up to 100-microinch roughness height rating (RHR), as specified in ASME B46.1, will be acceptable. All other machined and bar stock flats shall be of uniform quality, condition, and shall not exceed 250 RHR (see 4.7.2).

3.7 Parts. Contractor shall supply a list and necessary data for replacement and spare parts. The contractor shall also assure that parts can be purchased using the contractors product drawing(s) and that the hardware can be built from the drawing package.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. First article inspection (see 4.2)
b. Conformance inspections (see 4.3)

4.2 First article inspection. Unless otherwise specified (see 6.2), first article inspection shall be performed on three tube assemblies when a first article sample is required (see 3.1). This inspection shall include the examinations of 4.4 (see Table IV and the tests of Table V).

TABLE IV. Classification of defects.

Category	Defect	Method of examination
Major		
101	Incorrect or faulty materials (see 3.2 thru 3.2.3)	Visual
102	Dimensions affecting interchangeability, not within tolerance (see 3.3 thru 3.3.5).	SIE 1/
103	Construction not within tolerance (see 3.3 thru 3.3.5).	SIE 1/
Minor		
201	Dimensions not affecting interchangeability, not within tolerance (see 3.3 thru 3.3.5).	SIE 1/
202	Incorrect or illegible marking (see 3.5).	Visual
203	Poor workmanship (see 3.6).	Visual

1/ SIE = Standard Inspection Equipment.

TABLE V. Classification of tests.

Title	Requirement	Test	First article 1/	Quality conformance	
				Acceptance (100%)	Control
First article	3.1	4.2	X	X	
Materials	3.2	4.7.1	X	X	
Tube	3.2.2	4.7.1	X	X	
Fitting	3.2.3	4.7.1	X	X	
Configuration	3.3.1	4.7.5	X	X	
Dimensions	3.3.1	4.7.5	X		
Fitting attachment	3.3.2	4.7.6	X		
Tube insertion length	3.3.3	4.7.7	X		
Tube bend radii	3.3.4	4.7.8	X		
Nut	3.3.5	4.7.9	X	X	X
Low operating temperature	3.4.7.1	4.8.2	X	X	X
High operating temperature	3.4.7.1	4.8.3	X	X	X
Corrosion resistance	3.4.8	4.9	X	X	
Internal cleanliness	3.4.9	4.10	X	X	
Leakage 2/	3.4.1	4.7.10	X	X	
Tube assembly	3.4.1.1	4.7.10	X	X	
Proof pressure	3.4.2	4.7.11	X		X
Burst pressure	3.4.3	4.7.12	X		X
Endurance	3.4.4	4.7.13	X		X
Repeated assembly	3.4.6	4.7.15	X		

1/ Place of manufacture.
2/ Leakage test (see 4.7.10) may be accomplished with proof pressure test (see 4.7.11).

4.2.1 Initial production conditions. Unless otherwise specified (see 6.2), two tube assemblies from the first 100 tube assemblies produced shall be selected for initial production inspection. This inspection shall include the examinations of 4.4 (see Table IV and the tests of Table V).

4.3 Conformance inspection. Conformance inspection shall include the examinations of 4.4 and the tests of 4.5 and 4.6.

4.4 Examination.

4.4.1 Sampling. Samples from an inspection lot for conformance inspection shall be selected in accordance with ANSI/ASQ Z1.4. Each sample selected shall be inspected as specified herein for the defects listed in Table IV. Conformance to a lot shall be accepted when zero (0) defects are found and rejected when one (1) or more defects are found.

4.5 Acceptance tests (100 percent). Each tube assembly shall be subjected to the tests specified in Table V. Failure of any test shall be cause for rejection.

4.6 Control tests. The control tests shall be conducted on one tube assembly from each lot of 50 units consecutively produced except that not more than one test shall be performed in a

two month period nor less than one test in a six month period. The tube assemblies shall be subjected to the tests specified in Table V.

4.7 Methods of inspection.

4.7.1 Materials. Conformance to 3.2 through 3.2.3 shall be determined by inspection of contractor records providing proof or certification that materials conform to requirements. Applicable records shall include drawings, specifications, design data, receiving inspection records, processing and quality control standards, vendor catalogs and certifications, industry standards, test reports, and rating data.

4.7.2 Defects. Conformance to 3.2 through 3.2.3, 3.3 through 3.3.5, 3.5 and 3.6 shall be determined by examination for the defects listed in Table IV. Examination shall be visual, tactile or by measurement with standard inspection equipment.

4.7.3 Inspection conditions. Unless otherwise specified herein (see 6.2), all examinations and tests shall be performed under the following conditions:

a. Air temperature: 73±18 °F (23±10 °C)
b. Barometric pressure: 28.5 +2,-3 inches of mercury (96.5 +6.77,-10.15 kilopascals (kPa))
c. Relative humidity: 50±30 percent

4.7.4 Inspection equipment. The following test equipment or equivalent is recommended for use in the performance of the inspections and tests specified herein:

a. Swage inspection profile gage - Deutsch, Number D12-9892.
b. Tube insertion tool - Deutsch, Number D9862.
c. Hydrostatic pressure supply unit capable of providing 0 - 10,000 psi (0 - 68.9 MPa) static pressure with instrumentation accuracy of 10 percent of the component tolerance.
d. Standard inspection equipment.

4.7.5 Tube assembly. To determine conformance to 3.3.1, the tube assembly shall be inspected for completeness of assembly, configuration, and dimensional features of the applicable tube drawing (see Figure 2).

4.7.6 Fitting attachment. The leakproof requirement of the joint shall be verified during leakage (see 4.7.10) and proof tests (see 4.7.11). To determine conformance to 3.3.2, inspection shall be performed during the swage operation utilizing the appropriate size profile gage (see 4.7.4.a) to verify the proper tube insertion (tube into fitting) length and outside diameter of the swage and for visual completeness of the operation. The swage equipment hydrostatic pressure force shall be recorded and verified for conformance to 3.3.2.

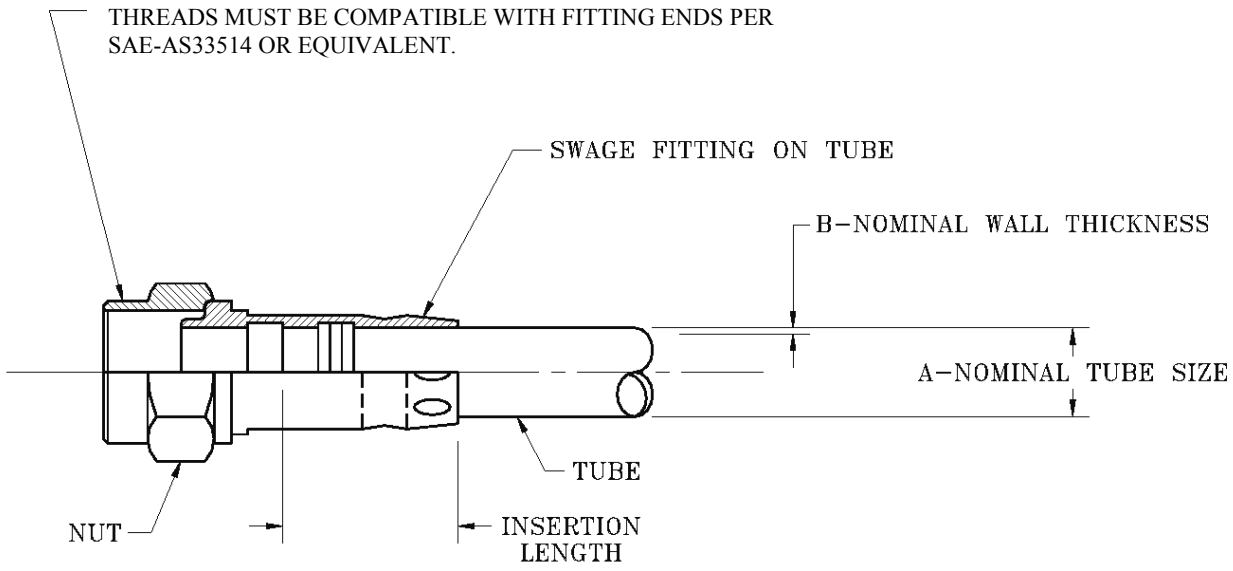


FIGURE 2. Separable fitting.

4.7.7 Tube insertion length. To determine conformance to 3.3.3, inspection shall be performed using the tube insertion tool (gage) (see 4.7.4b) to verify the tube insertion length into the fitting (see Figure 2) is as specified for the applicable tube size in Table II.

4.7.8 Tube bend radii. To determine conformance to 3.3.4, the tube assembly bend radii shall be inspected for conformance to requirements of SAE AS33611 unless otherwise specified on the detailed part drawing.

4.7.9 Nut. To determine conformance to 3.3.5, the nut shall be checked for thread size with an appropriate go/no go thread plug gage and a functional mating performed with the applicable fitting (see SAE AS33514). The connecting nuts of the assembly shall be examined for being captive yet have the ability to swivel freely.

4.7.10 Leakage. To determine conformance to 3.4.1.1, connect the tube assembly to a pressure supply unit (see 4.7.4.c). Utilizing an appropriately sized fitting (see SAE AS33514), tighten the connecting nuts. Fill the tube assembly with test fluid and cap the open end after all air is removed. Pressurize slowly from 0 psig to 1650 psig (0 MPa to 11.37 MPa) while monitoring the assembly from behind a protective enclosure. There shall be no evidence of external leakage or permanent deformation.

4.7.11 Proof pressure. To determine conformance to 3.4.2, connect the tube assembly to a pressure supply unit (see 4.7.4c), then tighten connecting nuts of the assembly. Fill the tube assembly with test fluid and cap the open end after all air is removed. Pressurize at one-third of rated pressure increase per minute until 3000 psig (20.7 MPa) proof pressure is attained. This pressure shall be maintained for a 5 minute period while monitoring the assembly from behind a protective enclosure. There shall be no evidence of external leakage or permanent deformation.

4.7.12 Burst pressure. To determine conformance to 3.4.3, a test shall be performed immediately after the proof pressure test of 4.7.11. Connect the tube assembly to a pressure supply unit (see 4.7.4.c). Utilizing an appropriately sized fitting (see MS33514), tighten the connecting nuts of the assembly. Fill the tube assembly with test fluid and cap the open end after all air is removed. Pressurize at one-third of rated pressure increase per minute for a 5-minute period while monitoring the assembly from behind a protective enclosure. There shall be no evidence of external leakage or rupture at any pressure below the specified minimum burst pressure. Assemblies used for verification of compliance to the burst pressure requirements shall be indelibly marked to prevent their use in functional systems.

4.7.13 Endurance. To determine conformance to 3.4.4, connect the tube assembly. Then connect the assembly to a high pressure impulse energy drive and subject it to 200,000 dynamic pressure impulse cycles at the pressures and rates specified in 3.4.4 and Figure 3. At the conclusion of impulse cycling, the assembly shall be subjected to the proof pressure test (see 4.7.11) and examined for leakage or failure. Any evidence of leakage or failure shall be cause for rejection.

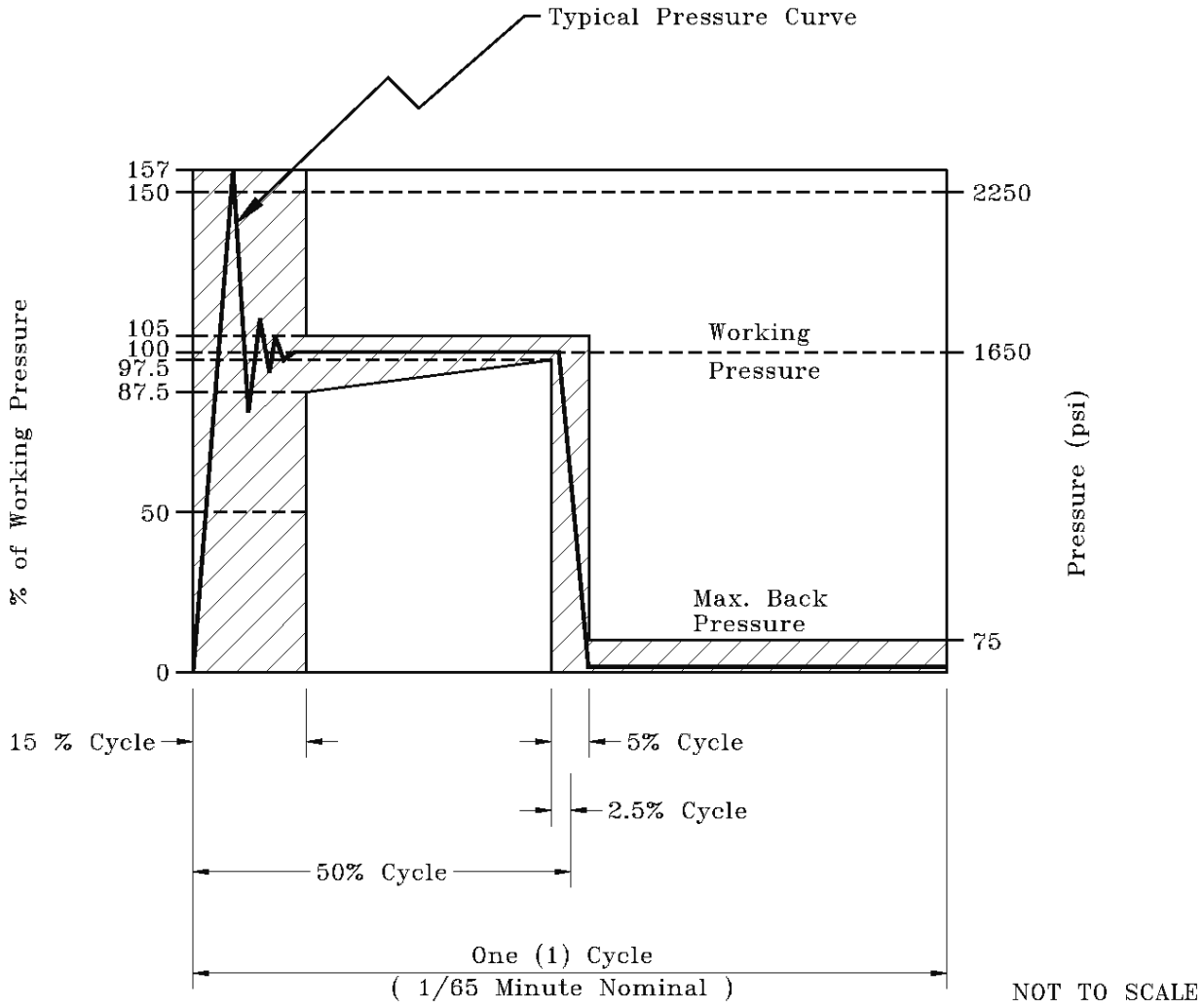
4.7.14 Hydrostatic pressure resistance. The determination of the hydrostatic pressure shall be as specified according to the formula in 3.4.5. The tubing shall be examined for bulging, leakage, and other defects or failures, except that any diametric permanent set shall be disregarded.

4.7.15 Repeated assembly. To determine conformance to 3.4.6 and 3.4.6.1, attach a non-lubricated mating fitting to each end of the tube assembly being tested. Tighten the connecting nut, then loosen the connecting nut and rotate the tube 90 degrees and retighten the connecting nut in the same manner. Repeat this procedure for eight cycles after which the assembly shall be subjected to the proof pressure test (see 4.7.11) and then the burst pressure test (see 4.7.12). Assemblies used for verification of compliance to the endurance requirements shall be indelibly marked to prevent their use in functional systems.

4.8 Environmental tests.

4.8.1 Environmental test conditions. Unless otherwise specified (see 6.2), conditions for environmental tests shall be as follows:

a. Assemblies undergoing initial production shall be subject to performance test (see Table V) prior to, during (when required in test method), and immediately following each environmental test.
b. Assemblies undergoing acceptance tests shall have passed all acceptance tests specified in Table V prior to environmental test. Tests shall be as specified herein.



NOTES:

1. The curve shown above represents a typical pressure-time cycle determined to be a proper severity for impulse testing. The actual pressure-time curve for impulse testing shall be confined to the shaded area indicated.

FIGURE 3. Dynamic pressure impulses.

4.8.2 Low operating temperature. To determine conformance to 3.4.7.1, the tube assembly shall be placed in an environmental test chamber and stabilized at low temperature operating conditions as specified for a period of not less than 4 hours. At completion of exposure and at the stabilized temperature, the tube assembly shall be subjected to and meet the requirements of the proof pressure test (see 4.7.11).

4.8.3 High operating temperature. To determine conformance to 3.4.7.1, the tube assembly shall be placed in an environmental test chamber and stabilized at high temperature operating conditions as specified for a period of not less than 4 hours. At completion of

exposure and at the stabilized temperature, the tube assembly shall be subjected to and meet the requirements of the proof pressure test (see 4.7.11).

4.9 Corrosion resistance. To determine conformance to 3.4.8, tube assemblies shall be subjected to a 96-hour salt spray in accordance with ASTM B117. The salt spray shall not use ozone depleting substances, such as 1,1,1 Trichloroethane. Alternative methods or solvents shall be used in place of ozone depleting substances.

4.10 Internal cleanliness. To determine conformance to 3.4.9, tube assemblies shall meet the cleanliness requirements in Table III and be subject to intermittent examinations during the manufacturer's cleaning process.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature which may be helpful, but is not mandatory.)

6.1 Intended use. The tube assembly is intended to provide a means for containing hydraulic fluid under pressure during transmission of the fluid between system components of the M1 tank.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.
b. If required, the specific issue of individual documents referenced (see 2.2).
c. If first article samples are furnished (see 3.1).
d. The fitting and tube assembly dimensions (see 3.3.1).
e. If first article inspection is not required (see 4.2).
f. If initial production inspection is not required (see 4.2.1).
g. Inspection conditions if other than as specified (see 4.7.3).
h. If environmental test conditions are other than specified (see 4.8.1)
i. Selection of applicable packaging requirements (see 5.1).

6.3 Subject term (key word) listing.

Fitting
Hydrostatic pressure

6.4 Changes from previous issue. The margins of this specification are marked with vertical lines to indicate where changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

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