SAE Aerospace
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AEROSPACE STANDARD

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Hose Assembly, Tetrafluoroethylene, Lightweight, 204 °C, 21 000 kPa Hydraulic, Metric

RATIONALE

This document has been reaffirmed to comply with the SAE 5-Year Review policy.

1. SCOPE:

This specification covers lightweight hose assemblies intended for use in high-temperature, 204 °C, high-pressure, 21 000 kPa (210 bar) aircraft hydraulic systems, also for use in pneumatic systems which allow some gaseous diffusion through the PTFE wall.

2. APPLICABLE DOCUMENTS:

The following documents of the issue in effect on date of invitation for bids or request for proposals, form a part of this specification to the extent specified herein.

2.1 Specifications:

2.1.1 Federal:

QQ-W-423	Wire, Steel, Corrosion-Resisting
P-D-680	Dry Cleaning Solvent
QQ-S-763	Steel Bars, Wire Shapes, and Forgings, Corrosion-Resisting
TT-I-735	Isopropyl Alcohol

2.1.2 Military:

MIL-C-5501	Caps and Plugs, Protective, Dust and Moisture Seal, General Specification for
MIL-F-8815	Filter and Filter Elements, Fluid Pressure, Hydraulic Lines, 15 Micron Absolute and 5 Micron Absolute, Type II Systems
MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance
MIL-H-8446	Hydraulic Fluid, Nonpetroleum Base, Aircraft
MIL-H-83282	Hydraulic Fluid, Fire-Resistant, Synthetic, Hydrocarbon Base, Aircraft

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2.1.2 (Continued):

MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-T-8504	Steel, Corrosion-Resisting (304) Aerospace Vehicle Hydraulic Systems, Annealed, Seamless and Welded
MIL-T-8808	Tubing, Steel, Corrosion-Resistant (18-8 Stabilized), Aircraft Hydraulic Quality
MIL-T-27602	Trichloroethylene, Oxygen Propellant Compatibility

2.2 Standards:

2.2.1 Military:

DOD-STD-100	Engineering Drawing Practices
MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-831	Test Reports, Preparation of

Copies may be obtained from the procuring activity or as directed by the contracting officer.

2.3 Other Publications:

American Society for Testing and Materials:

ASTM A 262	Detecting Susceptibility to Intergranular Corrosion on Stainless Steel
ASTM D 412	Rubber, Determination of Tension Characteristics
ASTM D 571	Rubber Hose for Automotive Hydraulic Brake Systems
ASTM D 792	Specific Gravity and Density of Plastics by Displacement
ASTM D 1457	TFE - Fluorocarbon Resin Molding and Extrusion Materials

Copies may be obtained from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

Society of Automotive Engineers:

AMS 3380	Hose, Polytetrafluoroethylene, TFE Fluorocarbon Resin, Wire Braid Reinforced
AMS 5556	Steel Tubing, Seamless or Welded, Corrosion and Heat-Resistant 18 Cr - 11 Ni - (Cb + Ta) (SAE 30347) Hydraulic
AMS 5557	Steel Tubing, Seamless and Welded, Corrosion and Heat-Resistant 18 Cr - 11 Ni - Ti (SAE 30321) Hydraulic
AMS 5567	Steel Tubing, Seamless and Welded, Corrosion Resistant 19 Cr - 10 Ni (SAE 30304) Hydraulic, Solution Treated
AMS 5570	Steel Tubing, Seamless, Corrosion and Heat-Resistant 18.5 Cr - 10.5 Ni - 0.40 Ti (SAE 30321)
AMS 5571	Steel Tubing, Seamless, Corrosion and Heat-Resistant 18 Cr - 11 Ni - 0.70 (Cb + Ta) (SAE 30347)
AMS 5575	Steel Tubing, Welded, Corrosion and Heat-Resistant 18 Cr - 10.5 Ni - 0.70 (Cb + Ta) (SAE 30347)

2.3 (Continued):

AMS 5639	Steel Bars, Forgings, Tubing and Rings, Corrosion-Resistant 19 Cr - 10 Ni (SAE 30304)
AMS 5643	Steel Bars, Forgings, Tubing and Rings, Corrosion Resistant 16.5 Cr - 4.0 Ni - 4.0 Cu
AMS 5644	Steel Bars and Forgings, Corrosion and Heat Resistant 17 Cr - 7 Ni - 1 Al
AMS 5645	Steel Bars, Forgings, Tubing, and Rings, Corrosion and Heat Resistant 18 Cr - 10 Ni - 0.40 Ti (SAE 30321)
AMS 5646	Steel Bars, Forgings, Tubing, and Rings, Corrosion and Heat Resistant 18 Cr - 11 Ni - 0.60 (Cb + Ta) (SAE 30347)
AMS 5689	Steel Wire, Corrosion and Heat Resistant 18 Cr - 9.5 Ni - Ti (SAE 30321) Solution Heat-Treated
AMS 5690	Steel Wire, Corrosion and Heat-Resistant 17 Cr - 12 Ni - 2.5 Mo (SAE 30316)
AMS 5697	Steel Wire, Corrosion-Resistant 19 Cr - 9.5 Ni (SAE 30304)
AMS 5743	Steel Bars and Forgings, Corrosion and Moderate Heat-Resistant 15.5 Cr - 4.5 Ni - 2.9 Mo - 0.10 N, Solution Heat-Treated, Subzero Cooled, Equalized, and Oven Tempered
ARP611	Tetrafluoroethylene Hose Assembly Cleaning Methods
ARP1153	Method for Determining Relative Specific Gravity, PTFE Tubing
ARP1835	Preparation for Delivery, General Requirements for Hose Assemblies
AS1055	Fire Resistance, Fire Test and Performance Requirements for Flexible Hose and Rigid Tube Assemblies
AS1072	Sleeve, Hose Assembly, Fire Protection
MA1370	Screw Threads, Controlled Radius Root with Increased Minor Diameter; General Specification for
MA2002	Impulse Testing of Hydraulic Hose Assemblies, Tubing and Fittings
MA2005	Tube Fittings, Fluid Systems, Separable, General Specification for
MA2011	Fitting End, Standard Dimensions for Flareless Tube Connection and Gasket Seal
MA2014	Fitting End, Flareless Acorn, Standard Dimensions for
MA2019	Fitting End, Standard Dimensions for Flared Tube Connection and Gasket Seal

Copies may be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001.

3. REQUIREMENTS:

3.1 Qualification:

The hose assemblies furnished under this specification shall be products which are qualified by meeting all the requirements covered by this document.

3.2 Material:

The hose assembly materials shall be uniform in quality, free from defects, consistent with good manufacturing practice and shall conform to applicable specifications and the requirements specified herein. All materials not specifically described herein shall be of the highest quality and suitable for the purpose intended.

3.2.1 Metals: Metals used in the hose and fittings shall be corrosion-resistant and shall conform to the applicable specifications as follows:

Bars and Forgings:

QQ-S-763	Class 304 - Condition A and Condition B (AMS 5639)
QQ-S-763	Class 321 - Condition A (AMS 5645)
QQ-S-763	Class 347 - Condition A (AMS 5646)
AMS 5643	17-4 PH
AMS 5644	17-7 PH
AMS 5743	AM-355

Tubing:

MIL-T-8504	Composition 304 (AMS 5567)
MIL-T-8808	Type I or Type II, Composition 321 (AMS 5570 or AMS 5557)
MIL-T-8808	Type I or Type II, Composition 347 (AMS 5571 or AMS 5575, AMS 5556)

Wire:

QQ-W-423	Composition 305 (AMS 5691)
QQ-W-423	Composition 304 (AMS 5697)
QQ-W-423	Composition 316 (AMS 5690)
AMS 5689	Composition 321 (QQ-W-423, Form 1, Composition 321)

3.3 Construction:

The hose assembly shall consist of a seamless tetrafluoroethylene inner tube, corrosion-resistant steel-wire reinforcement, and corrosion-resistant steel end fittings are required to meet the construction and performance requirements of this specification, and as required for its intended use.

3.3.1 Inner Tube: The inner tube shall be of a seamless construction of virgin tetrafluoroethylene resin of uniform gage. It shall have a smooth bore and shall be free from pitting or projections on the inner surface. Additives may be included in the compound from which the tube is extruded.

3.3.2 Reinforcement: The reinforcement shall consist of corrosion-resistant steel wires conforming to the applicable specifications listed in 3.2.1. The wires shall be so arranged over the inner tube as to provide sufficient strength to ensure conformance with the requirements specified herein. Broken reinforcing wires shall be cause for rejection. Crossed-over reinforcing wires shall not be cause for rejection of the hose assembly.

3.3.3 Fittings: All fittings shall be proven to meet the requirements herein. Standard hose assemblies shall have flared fittings to mate with MA2019 or flareless fittings according to MA2014 to mate with MA2011. Fitting hex portions shall fit standard wrench openings.

3.3.3.1 Insert Fittings: Standard insert fittings shall be of one piece construction. Welded and redrawn tubing per MIL-T-8504 or MIL-T-8808 may be used.

3.3.3.2 Nonstandard Fittings: Nonstandard fitting nipples shall be of one piece construction to the maximum extent possible. Those made with other than one piece construction can use welded and redrawn tubing per MIL-T-8808 and shall employ a butt-weld joint method.

3.3.3.3 Crimped or swaged sockets of 304 steel shall pass testing per ASTM A 262 practice E prior to crimping or swaging.

NOTE: This requirement does not apply to sockets of 321, 347 or 304L corrosion resistant steel.

3.4 Dimensions:

The hose assembly dimensions, except for length, shall be as specified in Figure 6 and Table 6.

3.4.1 Hose Weight: Hose consisting of inner tube and reinforcement as outlined in 3.3.1 through 3.3.3 shall not exceed the maximum hose weights covered in Table 1.

TABLE 1 - Physical Requirements of Hose Assemblies and Weight of Hose

Hose Size	/1/ Hose Weight Maximum	Operating Pressure	Proof Pressure	Burst Pressure Room Temperature Minimum	Burst Pressure High Temperature Minimum	Bend Radius at Inside of Blend Minimum	Volumetric Expansion Minimum
	kg/m	kPa	kPa	kPa	kPa	mm	cm^3/m
DN06	.16	21 000	42 000	110 000	82 700	38	2.6
DN10	.27	21 000	42 000	96 000	72 400	63	3.3
DN12	.36	21 000	42 000	96 000	72 400	73	5.3
DN16	.48	21 000	42 000	84 000	62 000	82	6.7
DN20	.82	21 000	42 000	84 000	62 000	101	11.8
DN25	1.52	21 000	42 000	84 000	62 000	127	29.5

/1/ Hose weight shall be determined on a minimum length of 300 mm.

3.5 Performance:

The hose assembly shall meet the following performance requirements:

3.5.1 Tube:

3.5.1.1 Tube Roll: The tube shall not leak, split, burst, or show any evidence of malfunction, when tested through the sequence as specified in 4.6.2.1.

3.5.1.2 Tube Proof Pressure: The tube, without reinforcing wires, shall not leak, burst or show any evidence of malfunction when held for one (1) minute at the proof pressure values as specified in Table 4 and under 4.6.2.1.

3.5.1.3 Tensile Strength: The longitudinal tensile strength for all sizes of tubes shall be 15 100 kPa minimum at 25 °C ± 1 °C when tested in accordance with 4.6.2.2. The transverse tensile strength for sizes DN16 and larger shall be 12 400 kPa minimum at the same temperature. For sizes under DN16, the transverse strength need not be tested.

3.5.1.4 Elongation: Elongation at 25 °C ± 1 °C shall be a minimum of 200 percent when tested in accordance with 4.6.2.3.

3.5.1.5 Specific Gravity: The apparent specific gravity of the hose inner tube shall not exceed 2.155, the relative specific gravity shall not exceed a value of 2.210 when tested as specified in 4.6.2.4.

3.5.2 Hose Assembly: The hose, complete with reinforcing wires and assembled with end fittings, shall meet the following performance requirement.

3.5.2.1 Proof Pressure: The hose assembly shall withstand the proof pressure listed in Table 1 without malfunction or leakage, when tested as specified in 4.6.3.

3.5.2.2 Elongation and Contraction: The hose assembly shall not change in length by more than 2% of hose length, when subjected to the operating pressure in Table 1 for a minimum of 5 minutes. Hose assemblies shall be tested in accordance with 4.6.4.

3.5.2.3 Volumetric Expansion: The volumetric expansion of the hose assemblies, when tested in accordance with 4.6.5, shall not exceed the limits specified in Table 1.

3.5.2.4 Leakage: The hose assembly shall not leak when subjected to two (2) pressure cycles of 70 percent of minimum room temperature burst pressure, when tested in accordance with 4.6.6.

3.5.2.5 Room Temperature Burst Pressure: The hose assembly shall not leak nor burst at any pressure below the burst value specified in Table 1, when tested in accordance with 4.6.7.

3.5.2.6 Thermal Shock: The hose assemblies shall not leak nor show any evidence of malfunction when pressure tested from -54 °C to 204 °C as specified in 4.6.8.

3.5.2.7 Impulse: The hose assemblies shall be capable of withstanding 250,000 impulse cycles when tested in accordance with 4.6.9.

3.5.2.8 Assembly Flexibility: The hose assembly shall not leak when flex cycle tested from -54 °C to 204 °C as specified in 4.6.10. Any leakage from the hose or fittings, hose burst, fitting blow-off, or any other evidence of malfunction during the test shall constitute failure.

3.5.2.9 Stress Degradation: When tested in accordance with 4.6.11, the hose assembly shall not exceed an average effusion rate of 78 cm^3/m/min for any size.

3.5.2.10 Pneumatic Surge: The inner tube of the hose assembly shall not collapse nor show evidence of degradation when tested in accordance with 4.6.12.

3.5.2.11 Pneumatic Effusion: The hose assemblies, when tested in accordance with 4.6.13, shall not exceed a total effusion rate of 26 cm^3/m of hose for any size.

3.5.2.12 Repeated Assembly: The fitting shall withstand, without leakage or failure, the repeated assembly test as described under 4.6.14. There shall be no leakage, galling or other malfunction in proof testing, or pneumatic testing after the last assembly cycle.

3.5.2.13 Conductivity: When tested as specified in 4.6.15, hose assemblies of sizes DN06 through DN12 shall be capable of conducting a direct current equal to or greater than six (6) microamperes, and sizes DN16 through DN25 a current equal to or greater than twelve (12) microamperes, with a test potential of 1000 volts, direct current.

3.6 Screw Threads:

Fitting threads shall be in accordance with AS1370. Fitting nut thread tolerance increase of 10 percent during assembly or testing shall not be cause for rejection of the hose assembly.

3.7 Length:

Hose assembly length shall be specified in the following increments only:

Under 500 mm, not less than 5 mm
500-1000 mm, not less than 10 mm
1000-1500 mm, not less than 20 mm
Over 1500 mm, not less than 30 mm

NOTE: Flareless hose assembly lengths shall be measured from “gage point” to “gage point.”

Tolerances on hose assembly lengths shall be as follows:

±3 mm for lengths under 500 mm
±7 mm for lengths from 500 to 900 mm
±13 mm for lengths from 900 to 1300 mm
±1% for lengths over 1300 mm

3.8 Part Numbering of Interchangeable Parts:

All parts having the same manufacturer’s part number shall be functionally and dimensionally interchangeable. The item identification and part number requirement of DOD-STD-100 shall govern the manufacturer’s part numbers and changes thereto.

3.9 Identification of Product:

Equipment, assemblies, and parts shall be marked for identification in accordance with MIL-STD-130. The following special marking shall be added:

3.9.1 Fittings: The manufacturer's name or trademark shall be permanently marked on all end fittings.

3.9.2 Assembly: A permanent marking on the fitting or a permanent band on the hose shall be used. The band shall be no wider than 25 mm and shall not impair the flexibility or the performance of the hose. The marking on the fitting or band shall include the following information:

a. Assembly manufacturer's name or trademark, and specification number (MA2007)
b. Complete hose assembly part number
c. Operating pressure "21 000 kPa," as applicable
d. Operating temperature "204 °C," as applicable
e. Pressure test symbol "PT"
f. Date of hose assembly manufacture expressed in terms of month and year
g. Hose manufacturer's federal code number (Handbook H4-1)

3.10 Workmanship:

The hose assembly, including all parts, shall be constructed and finished in a thoroughly workmanlike manner. All surfaces shall be free from burrs. All sealing surfaces shall be smooth, except that annular tool marks up to 2.5 micrometers will be acceptable.

3.10.1 Dimensions and Tolerance: All pertinent dimensions and tolerances, where interchangeability, operation, or performance of the hose assembly may be affected, shall be specified on all drawings.

3.10.2 Cleaning: All hose assemblies shall be free from oil, grease, dirt, or other foreign materials both internally and externally. Unless otherwise specified, hose assemblies shall be cleaned to Class 0 of ARP611.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the procuring activity. The purchaser reserves the right to perform any of the inspections set forth in the specification, where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of Inspections:

The examining and testing of hose assemblies shall be classified as:

a. Qualification inspections (4.3)
b. Quality conformance inspections (4.4)

4.3 Qualification Inspections:

4.3.1 Qualification Test Samples: Test samples shall consist of the number of samples and lengths specified in Table 2 for each method of fitting attachment, permanent and reusable. The procedure used shall be as specified in Table 3. The end fitting outlet design for the samples shall have flared fittings to mate with MA2019 or flareless fittings according to MA2014 to mate with MA2011.

TABLE 2 - Length of Hose Assemblies for Test (mm)

Hose Assembly Size	Six Assemblies for Impulse Test (4.6.9)	Two Assemblies for Flex Test (4.6.10)	Six Assemblies for Other Tests /2/
DN06	300	400	500
DN10	400	500	500
DN12	500	500	500
DN16	500	600	500
DN20	600	700	500
DN25	800	800	500

/2/ One additional sample of each size in lengths as shown in Figure 5 shall be used for examination and conductivity tests (sample No. 20 of Table 3).

TABLE 3 - Qualification Test Schedule

	PTFE Tube	Hose Assemblies									
Sample No.	1 /3/	2	3	4	5	6	7	8	9	10 through 15 /4/	16
Paragraph 4.6.-	1.1 .2	1.2 .3 .4 .10 .14	1.2 .3 .4 .10 .14	1.2 .3 .5 .13 .7	1.2 .3 .5 .13 .7	1.2 .3 .6 .8	1.2 .3 .6 .8	1.2 .3 .11 .12	1.2 .3 .11 .12	1.2 .3 .9	1.2 .15

NOTE: All assemblies to have a flared fitting on one end and a flareless fitting on the other, except /4/.

/3/ Production lot records may be used to verify conformance to 4.6.1 and 4.6.2 when the tube being used is an established production item.

/4/ These samples shall have a 90° elbow fitting on one end of the hose, and a straight-type fitting on the other end of the hose. If approval is being sought for both the bent-tube and the forged-elbow configuration, then one-half of the samples (3) shall use one type of configurated elbow, while the other half of the samples use the other half.

4.3.2 Test Report, Test Samples, and Data for the Purchaser: When the tests are conducted at a location other than the laboratory of the purchaser, the following shall be furnished to that activity:

a. Test report. Three (3) copies of a test report in accordance with MIL-STD-831, which shall include a report of all tests and outline description of the tests and conditions.

b. Test sample. The sample which was tested, when requested by the purchaser.

c. Three (3) sets of engineering data in the form of detail and assembly drawings. The assembly drawings shall have a cut-away section showing all details in their normal assembly position and shall carry part numbers of all details and subassemblies.

d. List of sources of hose or hose components, including source's name and product identification for inner tube, hose, and assembly.

NOTE: Log sheets, containing required test data, shall remain on file at the source test facility and are not to be sent to the qualifying activity unless specifically requested.

4.3.3 Qualification Inspections: Qualification inspections shall consist of all the examinations and tests specified under 4.6.

4.4 Quality Conformance Inspections:

Quality conformance inspections shall be sampled in accordance with the procedure in MIL-STD-105 and shall consist of the following tests:

a. Individual tests - 4.4.1 (100% inspection)
b. Sampling tests - 4.4.2
c. Periodic control tests - 4.4.3

4.4.1 Individual Tests: Each hose assembly shall be subjected to the following tests:

a. Examination of product - 4.6.1
b. Proof pressure test - 4.6.3

NOTE: Production samples that are proof pressure tested with water should be air dried prior to capping (see cleaning requirements, 3.10.2).

4.4.2 Sampling Tests: The following inspections or tests shall be performed in the order indicated on eight (8) hose assemblies, selected at random from each inspection lot. The inspection lot shall consist of no more than 3000 hose assemblies, all of one dash number size, manufactured under essentially the same conditions. One (1) hose assembly tested from each lot of 375 hose assemblies is also permitted.

a. Internal cleanliness (ARP611, Class 0)
b. Leakage tests - 4.6.6
c. Room - temperature burst pressure test - 4.6.7
d. Specific gravity tests (apparent and relative) - 4.6.2.4

4.4.3 Periodic Control Tests: The following inspections and tests shall be performed as indicated on eight (8) hose assemblies manufactured from bulk hose lengths selected at random from each inspection lot. The inspection lot shall consist of not more than 6000 m of hose, all of one dash number size, manufactured under essentially the same conditions. Two (2) hose assemblies manufactured and tested from each lot of 1500 m of hose is also permitted.

4.4.3.1 Four (4) hose assemblies (or one (1) hose assembly from a lot of 1500 m) in accordance with Table 2 shall be subjected to the following tests in the order indicated:

a. Elongation and contraction - 4.6.4
b. Impulse test - 4.6.9

4.4.3.2 Four (4) hose assemblies (or one (1) hose assembly from a lot of 1500 m) in accordance with Table 2 shall be subjected to the following tests in the order indicated:

a. Stress degradation test - 4.6.11
b. Conductivity test - 4.6.15

4.4.4 Rejection and Retest: Where one or more items selected from a lot fails to meet the specification, all items in the lot shall be rejected.

4.4.4.1 Resubmitted Lots: Once a lot (or part of a lot) has been rejected by a procuring activity (government or industrial), before it can be resubmitted for tests, full particulars concerning the cause of previous rejection and the action taken to correct the defects in the lot shall be furnished, in writing, by the contractor.

4.4.5 Changing Inspection Procedures: Changing inspection severity levels (for example, from normal to tightened inspection) shall be in accordance with MIL-STD-105. All inspection plans shall be single sample plans with an AQL of 1.0 percent at special inspection level S-2.

4.4.6 Destructive Test Sample: Prior to testing, a letter “D” shall be impression-stamped on each end fitting of those assemblies used for destructive tests (4.4.2 and 4.4.3).

4.5 Test Conditions:

4.5.1 Fitting Ends: Qualification tests shall be conducted on assemblies using straight type swivel ends (flared on one end, flareless on the other), except the samples 14 through 19 shall have a 90° elbow fitting on one end. Satisfactory qualification tests on these hose assemblies shall constitute qualification approval on hose assemblies using other fittings that have an identical hose attachment method and design.

4.5.2 Preparation of Sample:

4.5.2.1 Unless otherwise specified, the length of sample assemblies shall be in accordance with Table 2.

4.5.2.2 The test hose assemblies may be made up with one end having a flared fitting to mate with parts in accordance with MA2019, and the other end having a flareless fitting in accordance with MA2014 to mate with parts in accordance with MA2011. However, if the test samples are all flared type end fittings, and qualification approval is desired also for flareless style fittings, the following procedures are required: two (2) additional assemblies having flareless style fitting ends of the size to be qualified shall be subjected to the following tests, in the sequence indicated:

a. Examination of product - 4.6.1
b. Proof pressure test - 4.6.3
c. Leakage test - 4.6.6
d. Repeated assembly test - 4.6.14
e. Room temperature burst pressure test - 4.6.7

4.5.2.3 Oil Aging: In all the tests using oil aged samples, the hose assemblies shall be filled with a high temperature test fluid and soaked in an air oven at a temperature of 204 °C for seven (7) days. All air shall be excluded from the bore of the assembly during the test. No pressure shall be applied to the assembly during the aging period.

4.5.2.4 Air Aging: Air aged samples shall be kept in air at a temperature of 204 °C for seven days.

4.5.2.5 Unaged Samples: Unaged assemblies shall be as manufactured.

4.5.3 Test Fluids: Unless otherwise specified, the pressure test fluid shall be hydraulic or MIL-H-83282 oil conforming to MIL-H-5606, or water. For 204 °C testing, the test fluid shall be MIL-H-8446 hydraulic fluid, or equivalent, unless otherwise specified by the user.

4.5.4 Temperature Measurements: Unless otherwise specified, temperature measurements shall be taken within 150 mm of the hose assemblies under test. Unless otherwise specified, all temperatures shall have a tolerance of +8 °C, -3 °C.

4.5.5 End Connections: Except as otherwise noted, each hose end shall be connected to a steel male fitting end in accordance with MA2019 or MA2011, lubricated with either MIL-H-5606 fluid or the test fluid, with the installation torque range specified in MA2005.

4.5.6 Pressure Measurements: Unless otherwise specified, all pressures shall have a tolerance of ±500 kPa.

4.6 Inspection Methods:

4.6.1 Examination of Product:

4.6.1.1 Inner Tube: Each length of tubing shall be examined to determine conformance to this specification with respect to material, size, workmanship, and dimensions.

4.6.1.2 Hose Assembly: All hose assemblies shall be visually inspected to determine conformance to this specification and inspected for broken or missing reinforcing wires or any evidence of malfunction which shall be cause for rejection. Crossed over reinforcing wires shall not be cause for rejection.

4.6.2 Tube Tests:

4.6.2.1 Tube Roll and Proof Pressure Test: Each length of tubing shall be subjected to a tube roll and proof pressure test in accordance with AMS 3380, except that the flattening gap, rounding gap, and proof pressure shall be as specified in Table 4. The test fluid shall be air or water. See 3.5.1.1.

TABLE 4 - Tube Roll Gap and Proof Pressure

Size	Flattening Gap Maximum mm	Rounding Gap Minimum mm	Proof Pressure kPa
DN06	5	6	2600
DN10	7	8	1900
DN12	8	11	1500
DN16	8	14	1200
DN20	8	17	900
DN25	8	21	700

4.6.2.2 Tensile Strength: Size DN12 tube, and under, shall be subjected to tensile strength tests in accordance with ASTM D 412, except that the separation speed shall be 51 mm per minute. Tubes larger than DN12 shall be tested in accordance with ASTM D 1457. See 3.5.1.3.

4.6.2.3 Elongation: The tube shall be subjected to the elongation in accordance with the ASTM methods specified in 4.6.2.2. See 3.5.1.4.

4.6.2.4 Specific Gravity of the Tube:

4.6.2.4.1 Apparent Specific Gravity: Apparent specific gravity shall be determined in accordance with ASTM D 792, method A-1, at 25 °C ± 1 °C. Two (2) drops of wetting agent shall be added to the water. When test samples are prepared from braided hose, the braid impressions must be removed prior to testing. See 3.5.1.5.

4.6.2.4.2 Relative Specific Gravity: Relative specific gravity shall be determined in accordance with the ARP1153 method for all sizes and types of tubes. See 3.5.1.5.

4.6.3 Proof Pressure Test: All hose assemblies shall be pressure tested to the values specified in Table 1 for not less than 30 seconds and not more than five (5) minutes. The test fluid may be either water or hydraulic oil conforming to MIL-H-5606 for tests conducted at room temperature. All assemblies used for the tests described in this specification shall have this proof pressure test applied to them. Any evidence of leakage from hose or fittings, or any other evidence of malfunction shall constitute failure. Proof pressure test of hose assemblies having firesleeves shall use water as the test medium. Proof pressure shall be held for a minimum of two (2) minutes, during which time the firesleeves shall be pulled back from the end fittings. See 3.5.2.1.

4.6.4 Elongation and Contraction Test: Two (2) hose assemblies of each size shall be subjected to the elongation and contraction test. The hose shall not change in length by more than 2% for 250 mm of length when subjected to the operating pressure shown in Table 1 for not less than five (5) minutes. With the hose held in a straight position, unpressurized, a minimum gage length of 250 mm shall be marked off on the hose and the hose then pressurized. After five (5) minutes, while still pressurized, the gage length shall be measured and the change in length calculated in % of the initial gage length. See 3.5.2.2.

4.6.5 Volumetric Expansion Test: Two (2) assemblies of each size shall be tested in accordance with ASTM D 571. The volumetric expansion of the test assemblies shall be in accordance with the values shown in Table 1. This test shall be performed at operating pressure. See 3.5.2.3.

4.6.6 Leakage Test: Two (2) assemblies of each size shall be pressurized to 70 percent of the minimum room temperature burst pressure shown in Table 1 and held for five (5) minutes minimum. The pressure shall then be reduced to zero (0), after which it shall again be raised to 70 percent of the minimum room temperature burst pressure for a final five (5) minute check. Any evidence of leakage from the hose or fitting, hose burst, fitting blow-off, or any other evidence of malfunction shall constitute failure. See 3.5.2.4.

4.6.7 Room Temperature Burst Pressure Test: Two (2) hose assemblies of each size shall be subjected to a pressure sufficient to burst the assemblies with a rate of pressure rise equal to 140 000 kPa ± 30 000 kPa per minute. The assemblies shall be observed throughout the test. The type of failure and the pressure where failure occurred shall be recorded. The assemblies shall not leak or show other evidence of malfunction at any pressure below the specified pressure listed in Table 1. See 3.5.2.5.

4.6.8 Thermal Shock Test: The thermal shock test shall be as follows (see 3.5.2.6):

a. Two (2) hose assemblies of each size shall be subjected to this test. One (1) assembly shall be air aged and one (1) assembly shall be unaged. The assemblies shall be subjected to the proof pressure specified in Table 1 for a minimum of five (5) minutes.

b. The test assemblies shall then be mounted, empty, in a high temperature test fixture (typical setup shown in Figure 1), and the ambient temperature reduced to -54 °C ± 1 °C for a minimum of two (2) hours. At the end of this period, while still at this temperature, high temperature test fluid at a temperature of 204 °C shall be suddenly introduced at a minimum pressure of 350 kPa. Immediately after the hot oil has filled the assembly, the pressure shall be raised to the proof pressure specified in Table 1 for a minimum of five (5) minutes. Not more than 15 seconds shall elapse between the introduction of the high temperature oil at 350 kPa and the raising of the pressure to proof pressure.

c. The test assemblies shall then be filled with one of the high temperature test fluids at a pressure of 500 ± 150 kPa and soaked with ambient, and fluid temperature maintained at 204 °C for one (1) hour. At the end of this period, the assemblies shall be pressurized to the proof pressure specified in Table 1 for a minimum of five (5) minutes. The pressure shall then be released; and while still maintaining the 204 °C, the pressure shall then be increased at the same rate of rise as specified in 4.6.7 until failure is obtained. The hose assemblies shall be under continuous observation during the preceding test, and the pressure where the failure occurred and the type of failure shall be recorded.

d. Any evidence of leakage from the hose or fittings, fitting blow-off, or any other evidence of malfunction prior to final burst per c. above, shall constitute failure.

4.6.9 Impulse Test: Impulse testing shall be performed as follows on six (6) straight-to-90° elbow hose assemblies of each size. The impulse test equipment shall conform to MA2002. See 3.5.2.7.

a. Two (2) assemblies shall be oil aged, two (2) shall be air aged, and two (2) shall be unaged. The assemblies shall then be subjected at room temperature to the proof pressure specified in Table 1 for a minimum of five (5) minutes.

b. The hose assemblies shall then be pressurized to 21 000 kPa while maintaining this pressure at room temperature, the hose assemblies shall be immersed in a 3.5% ± 0.1% NaCl solution for 8 to 10 minutes, then allowed to air dry for the remainder of one (1) hour. This subsequent immersion and air drying process shall be repeated no less than fifty (50) times.

NOTE: The NaCl solution shall contain a dry basis of not more than 0.1% sodium iodine and 0.5% total impurities.

c. The test assemblies shall be connected to rigid supports and bent in a U-shape with a bend radius at the apex of the bend as specified in Table 1.

4.6.9 (Continued):

d. The impulse pattern shall be as specified in MA2002, with peak pressures of 150 percent measured at the inlet manifold. Impulsing shall occur at a rate of 70 ± 10 cycles per minute. The test fluid shall be one of the high-temperature test fluids. Fluid temperature shall be maintained at 204 °C and measured at the test manifold. Ambient temperature shall be 204 °C, measured at a point within 15 cm from the hose assemblies.

e. Impulse testing shall be run in such a manner that the assemblies are temperature-cycled from room temperature to specified fluid and ambient air temperatures a minimum of two (2) times, with a minimum of eighty percent (80%) of the impulse cycles at 204 °C.

Any evidence of leakage from the hose or fittings prior to the completion of 250 000 impulse cycles shall constitute failure.

NOTE: It is preferred that testing be continuous with a minimum number of shutdowns to accommodate shift schedules and maintenance.

4.6.10 Assembly Flexibility Test: Two (2) hose assemblies of each size shall be mounted in the assembly flex test setup as illustrated on Figure 2 and subjected to the following test sequence. The assemblies shall be filled with oil as specified in 4.5.3. Temperature indicated is both fluid and ambient. Flexing shall occur at a rate of 70 ± 10 cycles per minute during portions c., d., and e. See 3.5.2.8.

a. The test assemblies shall be soaked with no pressure of flexing at a temperature of -54 °C ± 1 °C for a minimum of one (1) hour.

b. With no flexing, the test assemblies shall be pressurized to the proof pressure as specified in Table 1 with the temperature still at -54 °C for a minimum of five (5) minutes (first cycle only).

c. Flexing shall begin while the test assemblies are pressurized to the operating pressure as specified in Table 1 with the temperature still at -54 °C for a minimum of 4000 flex cycles.

d. With the pressure reduced to zero (0), flexing shall continue to 1000 flex cycles at -54 °C.

e. Increase the temperature to 204 °C and flex for 1000 cycles with pressure at zero (0). The pressure shall then be increased to the operating pressure specified in Table 1 with the temperature held at 204 °C. Flexing shall continue until an accumulated total of 80 000 cycles is reached.

f. Steps a., c., d., and e. shall be repeated for a total of five (5) test sequences (i.e., 400 000 flexing cycles).

g. After completion of step f., and with no flexing, the test assemblies shall be pressurized to the proof pressure specified in Table 1 with the temperature still at 204 °C for a minimum of five (5) minutes (last cycle only).

4.6.11 Stress Degradation Test: Two (2) hose assemblies of each size shall be subjected to the following test sequence (see 3.5.2.9):

a. The hose assemblies shall be filled with a high-temperature test fluid and placed in an oven which shall be maintained at a temperature of 204 °C. Precautions shall be taken to assure that the hose assemblies do not come in contact with part of the oven that are at higher temperatures. A pressure equal to the operating pressure specified in Table 1 shall be applied to the hose assemblies.

b. After a minimum of 20 hours at 204 °C, the pressure shall be gradually released and the assemblies removed from the oven, drained, and cooled to room temperature.

c. The hose assemblies shall then be filled with fluid conforming to MIL-H-5606. A pressure equal to the operating pressure specified in Table 1 shall be applied and held for a minimum of two (2) hours at room temperature.

d. The procedure specified in steps a., b., and c. shall be repeated a total of three (3) times.

e. After the final two (2) hour pressurization period, the hose assemblies shall be drained and flushed with trichloroethylene, conforming to MIL-T-27602, and placed in an oven for one (1) hour. The temperature of the oven shall be maintained at 70 °C ± 5 °C.

f. The hose assemblies shall be removed from the oven, cooled to room temperature, and then subjected to an air under water test. To conduct this test, the hose assemblies shall be installed in an apparatus constructed similar to that shown in Figure 3.

g. The apparatus with the hose assembly installed, shall be immersed in water containing no wetting agent. A pressure equivalent to the operating pressure specified in Table 1 shall be applied for 15 minutes to allow any entrapped air in the hose to escape.

h. The pressure shall be held an additional five (5) minute period, during which time the effused gas shall be collected from the test sample, including the juncture of the hose and the fitting, but not including the fitting nut. After the five (5) minute period of pressurization, the average rate of effusion from the hose and two (2) fittings shall be measured and computed into $cm^3/m/min$.

4.6.12 Pneumatic Surge Test: Two (2) hose assemblies that were subjected to the stress degradation (4.6.11) shall be used for this test. The hose assemblies shall be installed in a setup as shown in Figure 4. The assemblies shall be tested at room temperature with gas at the operating pressure specified in Table 1, for 25 minutes. After this period of pressurization, the exhaust valve shall be opened within 50 milliseconds to permit rapid depressurization. After five (5) minutes, the valve shall be closed and the assemblies repressurized. This sequence of 25 minutes at operating pressure and 5 minutes at zero (0) pressure shall be repeated a total of 16 times. At the end of this period, the hose shall be sectioned and examined for evidence of tube collapse, sponging of the inner tube, or other defects. The filter downstream of the hose shall be examined for evidence of inner tube degradation. See 3.5.2.10.

4.6.13 Pneumatic Effusion Test: Two (2) hose assemblies of each size shall be used for this test. The assemblies shall be subjected to the operating pressure specified in Table 1 for one (1) hour at room temperature. Air effusion shall be collected, using the water displacement method and an air collecting device similar to that shown in Figure 3. The total amount of effusion through the hose and the two (2) fittings shall be collected over the last 1/2 hour of testing. See 3.5.2.11.

4.6.14 Repeated Assembly Test: Specimens shall be screwed together and unscrewed eight times. Each of the eight cycles shall include the complete removal of the hose fitting from the manifold union. Fitting nuts shall be tightened to the torques specified in MA2005, one half shall be tested to the minimum, one half to the maximum tightening torques. Following the first, fourth and eighth installation, proof tests shall be conducted. Following the eighth installation the hose fittings shall be pressure tested with air or nitrogen for five minutes at the nominal system pressure. See 3.5.2.1.2.

4.6.15 Conductivity Test: The conductivity test shall be conducted as follows (see 3.5.2.1.3.):

a. The test specimen shall be a length of hose (with braid and one end fitting) as shown in Figure 5. The inner surface of the tube shall be washed first with solvent conforming to P-D-680, and then with isopropyl alcohol conforming to TT-I-735, to remove surface contamination, and thoroughly dried at room temperature. The wire braid shall flare out as shown in Figure 5 to prevent contact with the end of the tetrafluoroethylene tube. One steel adapter of appropriate size shall be assembled to the hose end fitting as shown on Figure 5.

b. The test specimen shall then be arranged vertically as shown on Figure 5. The relative humidity shall be kept below 70 percent and room temperature between 16 °C and 32 °C. One thousand (1000) Volts, direct current shall be applied between the upper electrode and (salt-solution or mercury) the lower adapter electrode. The salt water solution shall have a maximum of 450 grams of sodium chloride (NaCl) in one liter of chemically pure water.

c. The current shall be measured with an instrument with a sensitivity of at least one (1) microampere (1×10^{-6} ampere). The current measured shall be equal to or greater than, six (6) microamperes for sizes DN06 through DN12 and equal to or greater than twelve (12) microamperes for sizes DN16 through DN25.

5. PREPARATION AND DELIVERY:

5.1 Preservation and Packaging:

All openings shall be sealed with caps or plugs conforming to MIL-C-5501. The gross weight of each pack shall be limited to approximately 90 kg. Containers shall be closed and strapped. They shall be provided with a case liner and shall be sealed. Packaging methods per ARP1835 shall be used unless otherwise specified by the purchaser.