

MIL-F-45764B(MI)
28 June 1974

SUPERSEDING
MIL-F-45764A
9 December 1965

MILITARY SPECIFICATION

FLUID LINES AND FITTINGS FOR MISSILES AND RELATED GROUND EQUIPMENT: FABRICATION AND INSTALLATION OF

This specification is approved for use by all Departments and agencies of the Department of Defense.

1. SCOPE

1.1 This specification covers the fabrication, assembly and installation of metal fluid lines and connecting fittings for missiles and related ground equipment.

1.2 The tubing assemblies covered by this specification shall be of the following classes as specified (see 6.3).

Class 1 - Tubing assemblies using flared tube fittings.

Class 2 - Tubing assemblies using flareless tube fittings.

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

FEDERAL

GGG-W-686	Wrench, Torque
WW-T-700/4	Tube, Aluminum Alloy, Drawn, Seamless, 5052
WW-T-700/6	Tube, Aluminum Alloy, Drawn, Seamless, 6061

FSC 1410

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MIL-C-5501	Cap and Plug, Protective, Dust and Moisture Seal
MIL-F-5509	Fittings, Flared Tube, Fluid Connection
MIL-T-6845	Tubing, Steel, Corrosion - Resistant (304), Aerospace Vehicle Hydraulic System, 1/8 Hard Condition
MIL-T-7081	Tube, Aluminum Alloy, Seamless, Round Drawn, 6061, Aircraft Hydraulic Quality.
MIL-T-8504	Tubing, Steel, Corrosion - Resistant, (304) Aerospace Vehicle Hydraulic Systems, Annealed, Seamless and Welded
MIL-T-8808	Tubing, Steel, Corrosion - Resistant (18-8) Stabilized, Aircraft Hydraulic Quality (ASQ).
MIL-D-9898	Drawing, Tube Bend
MIL-M-9950	Missile Components, Liquid Oxygen Nitrogen, Gaseous Oxygen, Instrument Air, Helium and Fuel Handling Systems, Cleaning and Packaging for Delivery
MIL-F-18280	Fitting, Flareless Tube, Fluid Connection
MIL-H-25475	Hydraulic System, Missile, Design, Installation Tests, and Data Requirements, General Requirements For

STANDARDS

MILITARY

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes.
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MIL-STD-1247	Marking, Functions and Hazard Designations of Hose, Pipe and Tube Lines for Aircraft Missile and Space Systems
MIL-STD-1250	Corrosion Prevention and Deterioration Control in Electronics Components and Assemblies.
MS20819	Sleeve, Flared Tube Fitting
MS21921	Nut, Sleeve Coupling, Flareless
MS21922	Sleeve, Coupling, Flareless
MS33583	Tubing End, Double Flare, Standard Dimensions For
MS33584	Tubing End, Standard Dimensions For Flare
MS33611	Tube Bend Radii
MS150451 thru MS150500	Ball, Steel, Grade 1 (Asg)
Air Force - Navy Aeronautical	
AN818	Nut Coupling
AND10064	Fitting, Installation of Flared Tube, Straight Threaded Connectors

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Material.

3.1.1 Tubing. Tubing used in the fabrication, assembly and installation of fluid lines for missiles and ground equipment shall conform to MIL-T-6845, MIL-T-7081, MIL-T-8504, MIL-T-8808, WW-T-700/4 and WW-T-700/6 and the applicable design drawings.

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3.1.2 Fittings. Material used in the manufacture of fittings for class 1 and class 2 assemblies shall be in accordance with MIL-F-5509 or MIL-F-18280 as applicable.

3.1.3 Special fitting. Special fittings shall be subject to approval by the procuring activity (see 6.3).

3.1.4 Nut, sleeve, and tube combination. Unless otherwise specified on the design drawing, steel nuts and sleeves shall be used on steel tubing. Aluminum nuts and sleeves shall be used with aluminum tubing. Dissimilar metals are defined and grouped in MIL-STD-1250 and shall be used accordingly.

3.2 Construction.

3.2.1 Fabrication of tubing assembly.

3.2.1.1 Forming. Tubing bend radii and the angle of the bend shall be as specified on the design drawing and are subject to the bend radii limitations specified in MIL-D-9898.

3.2.1.2 Tubing end preparation. Prior to flaring class 1 tubing assemblies or presetting the sleeve of class 2 tubing assemblies, the tubing end shall be cut square within 1/2 degree and all burrs shall be removed from inside and outside of the tube ends. The break or chamfer on either the inside or outside diameter shall not exceed 25 percent of the tube wall thickness.

3.2.1.3 Flaring. Class 1 tubing, size 3/8 and under of material conforming to WW-T-787, shall be flared in accordance with MS33583, unless otherwise stipulated on the design drawing. Other material shall be flared in accordance with MS33584, unless otherwise stipulated on design drawing.

3.2.1.4 Presetting of sleeves. The sleeves of class 2 tubing assemblies must be preset on the tubing before assembly with the fitting. The three approved presetting methods in order of their preference are machine presetting, hand tool presetting, and hand presetting, using steel fittings. The tubing end shall be firmly seated against the shoulder in the presetting tool or fitting before applying a setting force to the sleeve. (Use of a mandrel is optional in all methods except when hand presetting thin wall tubing of the following sizes).

3/8 dia x .020 wall

1/2 dia x .025 wall

5/8 dia x .025 wall

3/4 dia x .025 wall

1 dia x .035 wall

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3.2.1.4.1 Presetting procedure. Tubing ends shall be cut in accordance with 3.2.1.2. Slide the nut and then the sleeve on the tubing. The pilot of the sleeve must point toward the seat of the connector. The sleeve, working surfaces, the threads of the fitting should be lubricated, except for oxygen lines, with the approved lubricant (see table VIII). Bottom the tubing firmly on the seat of the connector. Tighten the nut on the connector until the cutting edge of the sleeve grips the tubing. This can be determined by slowly turning the tubing with the fingers while tightening the nut. When the tube can no longer be turned by the fingers, it is ready for final tightening. Tighten nut one more turn for aluminum tubing up to and including 1/2 inch diameter. All stainless steel tubing and aluminum tubing over 1/2 inch diameter should be preset by tightening the nut one and one sixth turns.

3.2.1.5 Assembly of tubing and fittings. The assembly of tubing and fitting shall be in accordance with the design drawing and as specified by the procuring activity (see 6.3.)

3.3 Cleaning and protective sealing.

3.3.1 Particle size limitation. Oxygen, nitrogen, helium and fuel handling tubing used in missiles and ground support equipment shall be cleaned in accordance with MIL-M-9950. Hydraulic and pneumatic systems lines shall be cleaned to comply with the limits specified herein. Particles of contamination per square foot of component surface area shall not exceed the following limits:

- (a) No particle greater than 2,500 microns in any dimension.
- (b) One particle between 700 and 2,500 microns.
- (c) Five particles between 175 and 700 microns.

3.3.2 Nonvolatile residue content.

3.3.2.1 Oxygen systems. The nonvolatile residue contamination on the significant surfaces of tubing assemblies used in oxygen system shall be not greater than .001 g. per square foot of surface area as determined in analysis of the solution extracted in the reliability test of the system checkout.

3.3.2.2 Fuel system. No volatile residue requirements.

3.3.2.3 Pneumatic and hydraulic systems.

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3.3.2.3.1 Onboard systems. The cleaning procedure shall be as specified on the design drawing.

3.3.2.3.2 Ground support equipment. The nonvolatile residue contamination on the significant surfaces of tubing assemblies used in ground support equipment pneumatic systems shall not be greater than .001 g. per square foot of surface area as determined in analysis of the solution extracted in the reliability test of the system checkout.

3.3.3 Rinsing. Cleaned tubing shall be rinsed, as applicable, to remove cleaning and preparation chemicals. The cleaned and rinsed tubing surfaces shall register a pH value within a range from 6.0 to 8.0.

3.3.4 Drying. Tubing shall be thoroughly dried as evidenced by no moisture pickup in the prefiltered drying gas passed through the tubing.

3.3.5 Protection. If the tubing assembly is not being used immediately the ends shall be capped in accordance with MIL-C-5501.

3.4 Installation of tubing.

3.4.1 Fit of tube assemblies. Tubing shall be aligned so as to have a firm seat on the fitting. The nut shall be started with no tubing strain in any direction.

3.4.2 Thread lubricant. Thread lubricant, when required to prevent seizure and galling during assembly or installation of fluid lines and fittings, shall be applied in accordance with the design drawing or as recommended in paragraph 6.5. Generally, the male threads of the fitting and the sleeve should be lubricated with a thin film of lubricant. The fitting shall not be over-lubricated, and lubricant shall not be allowed to enter the interior of the tube.

3.4.3 Tightening.

3.4.3.1 Tightening requirements. Unless otherwise specified in the design drawing, the nut shall be started on the fitting and turned until the flare is firmly seated. A wrench should never be used until the nut is finger tight.

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Table I. Wrench Torque for Tightening AN818 Nuts

Tube diameter (inches)	Aluminum 52S0* (in-lbs)		Aluminum 61ST6* (in-lbs)		Stainless Steel (in-lbs)	
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
1/8	20	25			60	80
3/16	25	35	30	70	90	100
1/4	40	65	70	120	135	150
5/16	60	80	70	120	180	200
3/8	75	125	130	180	270	300
1/2	150	250	300	400	400	500
5/8	200	350	430	550	650	700
3/4	300	500	650	800	900	1000
1	500	700	900**	1100**	1200	1400
1-1/4	600	900	1200**	1450**	.	
1-1/2	600	900	1550**	1850**		
1-3/4	700	1000	2000**	2350**		
2	800	1100	2500**	2900		

* Caution - See applicable design drawing for tubing material before applying These torque values.

** These values normally are not applicable for missile use.

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Table II. Installation Wrench Torque (in-lbs) Flareless Fittings (MS20819, MS21922, and MS21921)

Size	TUBING OD (inches)	Wall Thickness (Inches)	ALUMINUM		ANNEALED STAINLESS		STAINLESS			
			Min.	Max.	Min.	Max.	Min.	Max.		
3	3/16	.016	80	90			90	110		
		.018					90	110		
		.020								
4	1/4	.016	100	110	90	110	110	140		
		.020					110	140		
		.035					140	170		
5	5/16	.020	125*	180*			100	120		
	.035									
6	3/8	.020	145	175			170	230		
		.028	145	175			200	250		
		.035					145	175		
		.042							145	175
8	1/2	.020	270	330	300	400	300	400		
		.028					400	500		
		.035					270	330	500	600
		.049					320	380	500	600
10	5/8	.020	360	440			300	400		
		.028					500	600		
		.035					360	440	600	700
		.042					360	440	700	850
.049	425	525								
12	3/4	.028	380	470			650	800		
		.035					800	960		
		.049								
16	1	.020	750	900	750	900	800	950		
		.035					1600	1750		
		.065								

*For dry lubed nuts.

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3.4.3.2 Torque requirements for class 1. Tubing shall be aligned so as to have a firm seat on the fittings, a torque wrench shall be used to tighten it to the proper torque value in accord with the design drawing, table I or AND 10064. Use a second wrench on the hex of the body to counteract the torque of the wrench on the nut. When a torque wrench can not be used, tighten with a wrench until a distinct increase in torque occurs, then tighten the nut an additional one-sixth to one-third turn. Do not tighten more than one-third turn beyond the sharp torque rise position.

3.4.3.3 Torque requirements for class 2. Tubing shall be assembled and preset in accordance with 3.2.1.4.1. Torque requirements shall be in accordance with design drawing or table II.

3.4.4 Support of tubing. Fluid lines shall be supported or tied in accordance with the design drawing, table III or MIL-H-25475. This requirement is to prevent vibration and chafing after installation.

Table III. Maximum Hydraulic Line Support
Spacings Between (Measured Along
the Tubes)

Nominal Tube O.D. (inches)	Aluminum Alloy (inches)	Steel (inches)
1/8	9-1/2	11-1/2
3/16	12	14
1/4	12-1/2	16
5/16	15	18
3/8	16-1/2	20
1/2	19	23
5/8	22	25-1/2
3/4	24	27-1/2
1	26-1/2	30
1-1/4	28-1/2	31-1/2
1-1/2	29-1/2	32-1/2

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3.4.5 Color coding. Fluid lines shall be permanently marked in accordance with MIL-STD-1247. Lines shall be conspicuously marked between each bulkhead in order that each run of line may be traced and identified.

3.5 Performance and product characteristics.

3.5.1 Hydrostatic pressure resistance. Unless otherwise specified in the design drawing, the tube assembly shall be capable of withstanding an internal hydrostatic pressure as specified in tables IV, V or VI, as applicable, without exhibiting any leakage, burst or other abnormal effects.

Table IV. Proof Pressure (Aluminum Alloy Tubing) PSI

Wall Thickness Inches	Tubing - sizes and outside diameter							
	3	4	5	6	8	10	12	16
	3/16	1/4	5/16	3/8	1/2	5/8	3/4	1
.016	4000	4000						
.020	6000	4000	4000	3000	1500	1500	1500	
.028	6000	6000	6000	4000	3000	1500	1500	1500
.035		6000	6000	6000	4000	3000	3000	1500
.042			6000	6000	4000	4000	3000	1500
.049				6000	6000	4000	4000	3000
.058					6000	6000	4000	3000
.065					6000	6000	4000	4000
.072						6000	6000	4000
.083						6000	6000	4000
.095							6000	6000
.109							6000	6000

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Table V. Proof Pressures (Annealed Stainless Steel) PSI

Wall Thickness Inches	Tubing - size and outside diameter							
	3	4	5	6	8	10	12	16
	3/16	1/4	5/16	3/8	1/2	5/8	3/4	1
.016	4000	3000	1500	1500	1500	1500		
.020	6000	4000	3000	3000	1500	1500		
.028	6000	6000	4000	4000	3000	1500	1500	1500
.035		6000	6000	4000	4000	3000	1500	1500
.042		6000	6000	6000	4000	3000	3000	1500
.049			6000	6000	4000	4000	3000	1500
.058				6000	6000	4000	4000	3000
.065					6000	6000	4000	3000
.072						6000	4000	4000
.083						6000	6000	4000
.095						6000	6000	4000
.109							6000	6000

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Table VI. Proof Pressures (Stainless Steel) PSI

Wall Thickness Inches	Tubing - size and outside diameter							
	3	4	5	6	8	10	12	16
	3/16	1/4	5/16	3/8	1/2	5/8	3/4	1
.016	6000	6000	6000	4000	4000	3000		
.020	6000	6000	6000	6000	4000	4000	3000	
.028	6000	6000	6000	6000	6000	6000	4000	3000
.035	6000	6000	6000	6000	6000	6000	6000	4000
.042			6000	6000	6000	6000	6000	4000
.049				6000	6000	6000	6000	6000
.058					6000	6000	6000	6000
.065						6000	6000	6000
.072							6000	6000
.083							6000	6000
.095								6000

3.5.2 Tube capacity. The tubing assemblies shall be capable of allowing a steel ball of a nominal size, as specified in table VII, and in conformity to MS150451 through MS150500, to pass freely through the tubing after flaring or presetting and forming.

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Table VII. Tube Capacity and Ball Diameter

Material	OD (inch)	Wall Thickness (inch)	Ball diameter (inch)
CRES	.125	.020	.625
CRES	.250	.020	.1875
AL ALLOY	.250	.035	.1562
CRES	.312	.028	.2188
AL ALLOY	.312	.042	.1875
CRES	.375	.028	.2812
AL ALLOY	.375	.049	.2500
CRES	.500	.035	.4062
AL ALLOY	.500	.065	.3438
CRES	.625	.042	.5000
AL ALLOY	.625	.083	.4062
CRES	.750	.049	.5938
AL ALLOY	.750	.095	.5312
AL ALLOY	1.00	.049	.8125
AL ALLOY	1.250	.065	1.0312

3.6 Finish.

3.6.1 Tubing. Finishes of interior and exterior surfaces of the tubing shall conform to the design drawing, MIL-T-6845, MIL-T-7081, MIL-T-8504, MIL-T-8808, MS33611, or MS33584, as applicable.

3.6.2 Fittings. The fittings shall be finished in accordance with the design drawing, MIL-F-5509 or MIL-F-18280, as applicable.

3.7 Product marking.

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3.7.1 Tube stamping. There shall be no impression stamped on the tubing for any purpose.

3.7.2 Marking and stamping of AN and MS fittings. All standard (AN and MS) fittings shall be marked and stamped in accordance with MIL-F-5509 and MIL-F-18280.

3.7.3 Marking and stamping of special fittings. Special fittings manufactured to AN standards, but manufactured of alternate materials, shall not receive any identifying color markings.

3.8 Workmanship. Uniformity of shapes and dimensions shall permit interchangeability of tube assemblies of the same design. The interior and exterior surfaces of the tubing and fittings shall be clean, smooth, and free from corrosion, scale, splits, cracks, pits, die or toolmarks, "orange peel" appearance, nicks, scratches or similar mechanical damages which may adversely affect the performance, strength or endurance of the tube assembly.

4. QUALITY ASSURANCE PROVISIONS

4.1 The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examination and tests shall be kept complete and available to the Government as specified in the contract or order. The Government 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 Lot. When this specification is used in conjunction with a procurement order for fittings, tubing, tubing assemblies or end articles in which these are installed, the lot for purposes of acceptance shall be as established for the items in the procurement order. When not thus established, a lot shall consist of all the items in a single production order which are submitted for inspection at one time in accordance with the same drawing, drawing revision, specification, and specification revision.

4.3 Sampling. Unless otherwise specified in the contract or order or applicable item procurement specification, inspection shall be 100 percent. Any sampling procedure used (less than 100% inspection) shall be approved by the procuring activity and shall be in accordance with MIL-STD-105 or other Government approved documents.

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4.4 Inspection.

4.4.1 Examination.

4.4.1.1 Tubing. Prior to fabrication, all tubing shall be visually examined to determine compliance with requirements of 3.1.1.

4.4.1.2 Fittings. All fittings prior to assembly shall be inspected in accordance with MIL-F-5509 and MIL-F-18280. All special fittings prior to assembly shall be visually examined to determine compliance with the requirements of 3.1.3 and 3.6.2 of this specification and the applicable design drawings.

4.4.1.3 Inspection of construction. All fabrication of tubing assemblies, cleaning of tubing and the installation of tubing shall be visually and dimensionally examined for assurance of conformance to the requirements of 3.2.3.3., 3.4 and the applicable design drawings.

4.4.1.4 Finish. All tubing and fittings shall be examined to determine compliance with the finish requirements of 3.6.

4.4.1.5 Product marking. The marking of all tubing and fittings shall be examined for compliance with the requirements of 3.7.

4.4.1.6 Workmanship. Visual examination shall be made of complete tube assemblies to verify compliance with the requirements of 3.8.

4.4.2 Test procedure.

4.4.2.1 Torque. Torque requirements of 3.4.3.1 shall be tested by an applicable and accurately calibrated torque wrench conforming to GGG-W-686 and in accordance with a test method specified in the contract or order.

4.4.2.2 Steel ball test. After flaring or presetting, a steel ball as specified in table VII and conforming to MS150451 through MS150500, shall be passed through the tubing in accordance with 3.5.2. Assemblies failing to pass the test shall be rejected.

4.4.2.3 Hydrostatic pressure. Unless exceptions are made in the contract or order, no part of a hydraulic system shall fail, take any permanent set, or be damaged in any manner, when subjected to applicable proof pressure. The hydrostatic testing equipment shall have the approval of the Government inspector prior to use.

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5. PREPARATION FOR DELIVERY

There are no applicable requirements.

6. NOTES

6.1 Intended use. Tube assemblies covered by this specification are intended for use in missiles and related ground equipment. For the purpose of this specification, the installation of this material is limited to tubing assemblies as defined in 6.2.2.

6.2 Definitions.

6.2.1 Fitting. The term "fitting" as used in this specification includes standard AN fittings, such as nuts, sleeves, unions, and special fittings to which the fluid lines are connected. However, it does not include fluid components with moving parts such as check valves and other types of valves.

6.2.2 Tubing assembly. The term "tubing assembly" as used in this specification refers to the tubing and the connecting fittings which become integral with the tubing.

6.3 Ordering data. Procurement documents should specify:

(a) The title, number, and date of this specification.

(b) If special fittings, other than as specified on the design drawing, are required (3.1.3), and the title, number, and date of applicable specifications for nonstandard items.

(c) Class of assembly required (see 1.2 and 3.2.1.5).

(d) Color coding required (see 3.4.5).

6.4 Lubricants, which may be used during installation of fluid lines, (see 3.4.2), are noted in table VIII.

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Table VIII. Lubricant for Gasket and Fittings

Service	Name	Source*	Type
Liquid oxygen	AR-1F	1	Grease
	Lox Lube	2	Grease
Nitrogen tetroxide	Molykote Z	3	Dry Powder
	Electrofilm 1000	9	Dry Film
	Teflon	-	-
Hydrogen peroxide	Fluorolube T-45	4	Oil
	Fluorolube LG	4	Grease
	UCON-LB-135	11	Oil
U-Deta	DC 200 Fluid (350cs)	5	Oil
UDMH	Apiezon L	7	Grease
JP-4,JP-5, or RP-1	Parker Sealube	6	Grease
	QC-2-0026	5	Grease
Alcohol	Apiezon L	7	Grease
	Versilube F-50	12	Grease
	Apiezon M	7	Grease
Hydrazine	Apiezon L	7	Grease
	Apiezon M	7	Grease
	Dow-Corning High Vacuum Grease	5	Grease
Pneumatic-General	DC-4 Dimethyl Silicon Grease	5	Grease
Pneumatic Propellant Pressurization	Same as system being pressurized		

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