de Havilland Inc.

Material Specification

TITLE:	**HYDRAULIC TUBING, CORROSION RESISTANT STEEL (21Cr-6Ni-9Mn)**
SPECIFICATION NUMBER:	**DHMS M2.16**
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1 SCOPE

This specification covers the requirements for ARMCO 21-6-9 or equivalent seamless or welded and drawn corrosion resistant steel, round tubing, for use in aircraft high pressure hydraulic systems designed to meet the requirements of F.A.R., Part 25.

2 APPLICABLE SPECIFICATIONS

The following specifications and publications shall form a part of this specification to the extent specified herein.

AMS 2243	Tolerances: Corrosion and Heat Resistant Steel Tubing
ASTM E45-63	Determining the Inclusion Content of Steel
Federal Test Method Standard No. 151	Metals: Test Method
Fed. Std. No. 183	Continuous Identification Marking of Iron and Steel Products
ASA B46.1	Surface Texture (Surface Roughness, Waviness and Lay)
MS 33584	Tubing End - Standard Dimensions for Flared
MIL-STD-163	Steel Mill Products, Preparation for Shipment and Storage
MIL-STD-271	Nondestructive Testing Requirements for Metals

3 REQUIREMENTS

3.1 Material

The raw material used to fabricate tubing to this specification shall meet the requirements of AMS 5595.

3.2 Grain Size

Two specimens selected from each lot of tubing shall be prepared and tested in accordance with Method 311 (Comparison Procedure) of Fed. Test Method Std. 151.

The average grain size for three fields of view on each specimen, in the weld area of the tube, shall be No. 6 or finer.

3.3 Cleanliness

Two specimens from each lot of tubing shall be prepared and tested in accordance with ASTM E45 Method A, to determine the inclusion content using JERNKONTORET Chart, Plate 1 as a comparison standard.

The inclusion content of the tube shall not exceed the limits of Table II.

Table I

Type	Thin		Heavy	
	Average	Worst Field	Average	Worst Field
A	1.5	2.5	1.0	2.0
B	2.5	3.0	1.5	2.5
C	1.5	2.5	1.0	2.0
D	2.5	3.0	1.5	2.5

3.4 Condition

The tubing shall be supplied in the non-stress relieved condition having had a 15% cold reduction after the final heat treatment. After the cold reduction the tubing shall be descaled and passivated.

3.5 Manufacturing Process

The steel shall be produced by the air melted electric furnace process. Vacuum degassing may be utilized if necessary to meet the requirements of this specification.

3.6 Mechanical Properties

Samples shall be tested as a full-tube specimen with a test section of not less than 6 inches between plugs as required by Figure 1, Method 211 of Federal Test Method Standard No. 151. Tests shall comply with the applicable requirements of Method 211.

Tube samples selected per Table III shall conform to the mechanical properties given in Table IV.

Table III - Sampling Plan

Tubing Lot Size in Feet	No. of Samples
1 - 300	2
301 - 1000	3
1001 - 3000	5
3001 - 10000	9

Table IV - Mechanical Properties

Property	Test Requirements	Nominal Figures
Ultimate Yield Strength	136 ksi (min.)	142 ksi
Yield Strength at .2% offset	125 ksi (min.)	131 ksi
Elongation in inches	20% (min.)	23%

3.7 Bending

Two specimens of suitable length selected from each lot of tubing shall be bent cold 180 degrees around a mandrel with centre line bend radius (R) as follows:

.25 inch O.D. tubing R=3 x O.D.

.375 inch O.D. and larger tubing R= 4 x O.D.

3.7 Bending ... continued

Flattening after bending shall not exceed 4% of the nominal O.D. The tubing shall not develop cracks, tears, breaks, wrinkles or waves or other defects detrimental to high pressure hydraulic applications.

3.8 Corrosion Resistance

Two specimens of full tube section taken from separate pieces of tubing from each lot, shall be tested for susceptibility to intergranular corrosion in accordance with Method 821.1 of Fed. Test Method Std. 151. Specimens of the as received tubing shall be treated for 48 hours in a boiling copper sulphate, sulfuric acid solution. After the exposure the specimen shall be flattened at room temperature between parallel plates by gradually applied load normal to the axis of the tubing until the distance between the pressure plates is not greater than six times the nominal wall thickness. Any detectable weld shall be placed in the maximum fold area on flattening. The specimen shall be examined at a magnification of 20X. There shall be no evidence of cracks due to intergranular attack.

3.9 Surface Condition

(a) The tubing shall have a smooth, grey metallic appearance and be free from surface films, scale, flakes or loose adhering particles on it.

(b) Specimens, each approximately one foot long and taken fro separate pieces of tubing shall be selected from each lot according to Table V, and split lengthwise. The inner and outer surfaces of both halves shall be examined for surface waviness and lay per ASA B46.1.

Surface roughness shall not exceed an arithmetical average roughness rating (RHR) 63 on the inside and (RHR) 32 on the outside surface.

Table V

Tubing Lot Size in Feet	No. of Samples
1 - 3000	1
3001 - 6000	2
6001 - 9000	3

3.9 Surface Condition - continued

(c) One half of each sample length of tubing used in (b), shall be immersed in an aqueous solution of 15% nitric acid and 3% hydrofluoric acid by volume @ 100 - 120°F, for 15 minutes. After immersion, the specimen shall be washed and dried. The appearance of the two halves shall be compared. Variations in colour and appearance, other than minor changes in shade and texture in the pickled tubing shall be cause for rejection.

(d) Each tube shall be visually inspected to ensure that the tube is free from cracks, seams, laps, laminations, tears, pits and other detrimental defects. Tubing containing any of the above stated discontinuities, including those tests made in sub-paragraphs (b) and (c), that are greater than 5% of the wall thickness, shall be rejected.

3.10 Hydrostatic Pressure Testing

(a) Samples, of approximately 1 foot length, taken from separate pieces of tubing shall be selected from each lot according to Table III. Samples shall be flared to the respective dimensions of MS33584, assembled per and 10064 and subjected to an internal pressure of 12,000 psi., for tube diameters and their corresponding wall thicknesses listed in Table VI.

Table VI

Nominal Tube Diameter in Inches	Nominal Wall Thickness in Inches
0.250	0.016
0.375	0.020
0.500	0.025
0.625	0.033
0.750	0.039

(i) There shall be no leaks in the fitting area.

(ii) The tubing shall show no bulging, leakage, or other defects, except that a diametric permanent set of 0.002" per inch of diameter is acceptable.

(b) The sample shall then be pressurized at a rate not exceeding 25000 psi. per minute, to burst. Failure of any sample at pressures of less than 120000 psi. is cause for rejection of the lot.

3.11 Tolerances

Tubing selected per Table VII shall be examined for compliance with dimensional requirements in accordance with the latest issue of AMS 2243.

Table VII

No. of Tubes in Lot	Sample Size
1 - 25	3
26 - 100	13
101 - 200	25
201 - 500	59

(i) Wall thickness variations shall not exceed +15/-0 percent of the nominal wall thickness.

(ii) The maximum curvature shall not exceed 0.020 inches per foot.

(iii) (Flattening) ovality shall not exceed 1% of the nominal O.D.

3.12 Ultrasonic Inspection

The tubing shall be subjected to a 100% ultrasonic inspection in accordance with MIL-STD-271.

Tubing containing surface and internal defects greater than 5% of the wall thickness shall be rejected. Individual surface defects having a depth of less than 5% of the wall thickness, shall be removed by light belt polishing and buffing, provided that the final dimensions are within the specified tolerances. Defects having a large root radius plainly visible to the unaided eye, whose surfaces blend smoothly into the normal surfaces need not be removed. Passivation treatment shall follow any surface polishing or buffing operation. Centerless grinding and grit blasting of outer or inner surfaces is not acceptable. Tubing shall not be sized by metal removal methods.

4 REPORTS

The supplier shall furnish with each lot of tubing three copies of a test report showing actual test data conformance to Sections 3.1, 3.2, 3.3, 3.6, 3.7, 3.8, 3.10. The report shall include the purchase order number, this specification number, heat number, size and wall thickness and quantity.

A lot of tubing is defined as one size and wall thickness of tubing from one heat of steel, manufactured and inspected at the same time.

5 IDENTIFICATION

Each tube shall be identified per Fed. Std. No. 183, and the following additional information; (1) DHMS M2.16, (2) outside diameter and wall thickness, (3) heat number, (4) lot number.

6 TESTING

All testing shall be performed in accordance with Federal Test Method Standard No. 151, supplemented by information in each appropriate paragraph of Section 3.

7 ORDERING DATA

Procurement documents should specify the following:

- Title, number, issue and amendment number of this specification.

- Condition (see Para. 3.4.).

- Outside diameter and wall thickness.

- Tube shall be ordered in random mill lengths between 12 and 16 ft., or longer when specifically requested.

8 REJECTION

Failure of a specimen to meet the test requirements of Sections 3.1, 3.2, 3.3, 3.6, 3.7, 3.8, 3.9, 3.10, 3.12, shall be cause for rejection of the lot. A retest is permitted provided that 5 additional specimens are tested for each failed specimen of the original sample. If one of the retest specimens fail, the lot shall be rejected with no further retesting permitted. Failure of any tube to meet any other requirement of this specification shall result in the rejection of the individual tube, provided each individual tube of the lot is tested in the non-conforming category.

9 QUALITY ASSURANCE PROVISIONS

The purchaser reserves the right to perform any of the tests set forth in this specification to assure that the material meets specification requirements.

Material not meeting the requirements of this specification per Paragraph 8, will be returned to the vendor at vendor's expense.

10 PACKING

Tubing shall be preserved, packaged, packed and marked for shipment in accordance with applicable requirements of MIL-STD-163.