de Havilland Inc.

Material Specification

TITLE:	**18% NICKEL (300) MARAGING STEEL BAR (VACUUM MELTED)**
SPECIFICATION NUMBER:	**DHMS M2.18**
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1 SCOPE

This specification covers the requirements for high strength, 300 grade, 18% nickel maraging steel.

2 APPLICABLE SPECIFICATIONS

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

AMS 2251	Tolerances
AMS 2248	Chemical Check Analysis Limits Wrought Heat and Corrosion Resistant Steels and Alloys
ASTM E112-63	Estimating the Average Grain Size of Metals
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
DHMS MI-1	Ultrasonic Inspection of Maraging Steel
MIL-STD-163	Steel Mill Products, Preparation for Shipment and Storage

3 REQUIREMENTS

3.1 Chemical Composition - Chemical composition shall conform to the requirements given below, when tested per section 6.3.

Element	Weight Percent
Nickel	18.0 - 19.0
Molybdenum	4.6 - 5.2
Cobalt	8.5 - 9.5
Titanium	.5 - .8
Aluminum	.05 - .15
Boron	0.006 max.
Zirconium	0.02 added
Calcium	0.05 added
Carbon	0.03 max.
Manganese	0.10 max.
Phosphorous	0.010 max.
Sulphur	0.01 max.
Silicon	0.10 max.

3.2 Condition

3.2.1 Bars - shall be available in the fully annealed condition unless otherwise specified.

3.2.2 All forms of this material may be furnished in one of the following conditions as specified.

(1) As rolled.

(2) Pickled or blast cleaned.

(3) Rough turned.

(4) Cold drawn.

(5) Centerless ground.

3.3 Manufacturing Process

3.3.1 The steel shall be consumable electrode vacuum melted.

3.3.2 All billets shall be forged prior to rolling or drawing.

3.3.3 Decarburization control is not needed on maraging steel because of the low carbon content.

3.4 Grain Size - The average grain size shall be No. 5 or finer for cross-sectional areas up to 25 sq. inches, when tested per section 6.2. Grain size on larger cross-sectional areas shall be negotiated.

3.5 Mechanical Properties

3.5.1 Solution Annealed Condition - The material shall be solution annealed by the producer at 1500°F ± 25°F for one hour per inch of thickness and air cooled to room temperature to the following MINIMUM mechanical properties:

Mechanical Properties	Requirement
U.T.S.	140 KSI Min.
Yield at .2% offset	100 KSI Max.
Elongation in 2 Inches	12% Min.
Reduction of Area	60% Min.
Rockwell "C" Hardness	34 Max.

3.5.2 Aged Condition - Subsequent aging performed by the fabricator at 900°F ± 25°F for 3 to 6 hours followed by air cooling to produce the following MINIMUM mechanical properties:

NOTE: Aging curves over the temperature range 875°F to 925°F and times 1 to 6 hours are to be supplied.

3.5.2 Continued

Mechanical Properties	Requirement
U.T.S.	280 KSI Min. 305 KSI Max.
Yield at .2% offset	275 KSI Min. 300 KSI Max.
Elongation in 2 Inches	6% Min.
* Notch Tensile Strength (Kt = 9)	400 KSI Min.
Reduction of Area	30% Min.
Rockwell "C" Hardness	53 - 56

3.5.3 Tensile specimens selected per section 6.3 shall conform to the mechanical properties given in Para. 3.5.1 and 3.5.2.

3.5.4 The material shall maintain a good dimensional stability throughout the aging process.

3.6 Cleanliness - Inclusion content of the material shall not exceed the limits stated in Table I when tested in accordance with section 6.4.

Table I

Inclusion Type	Thin	Heavy	Worst Field
A	X		1.5
A		X	1.0
B	X		1.5
B		X	1.0
C	X		1.0
C		X	1.0
D	X		1.5
D		X	1.0
E	X		2.5
E		X	1.5

* Notch tensile values shall not form a basis for rejection of material.

3.7 Nondestructive Testing - Ultra sonic inspection results shall conform to the discontinuity limits stated in DHMS MI-1 for Class III material when tested in accordance with section 6.5.

3.8 Workmanship

The product shall be uniform in quality, free of alloy segregation, sound and free from foreign materials and from internal and external defects detrimental to fabrication or to performance of parts.

3.9 Tolerances

Tolerances of the bar stock shall be in accordance with the limits stated in the latest issue of AMS 2251.

4 REPORTS

The vendor shall furnish with each shipment three copies of a test report with actual test data showing conformances with Sections 3.1, 3.4, 3.5, 3.6 and 3.7 of this specification.

This report shall include the purchase order number, heat number, material specification number, thickness, size and quantity from each heat.

A lot is defined as material of one size, from one heat of steel, having had the same thermal treatment and inspected at one time.

5 IDENTIFICATION

The material shall be identified per Fed. Std. No. 183 and the following additional information: (1) DHMS M2.18, (2) heat number.

The marking fluid shall be capable of being removed in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect on the material or its performance. The characters shall be sufficiently stable to withstand ordinary handling.

6 TESTING

6.1 Chemical Analysis - The chemical composition shall be tested in accordance with Method 111.1 or 112.1 of Federal Test Method Standard No. 151. The chemical composition shall be as specified in Para. 3.1 and the analysis variations shall be within the limits stated in the latest issue of AMS 2248, except that the check limits for molybdenum shall be .10 over max. and .10 under min. The analysis check shall be made on one sample taken from each heat in the shipment.

6.2 Grain Size - One specimens selected from each lot of bar stock shall be prepared and tested in accordance with ASTM E112-63, Comparison Procedure. The average grain size for three fields of view on each specimen shall be No. 5 or finer.

6.3 Tensile Test Method - One longitudinal tensile specimen selected from the centre of a bar from each lot, shall be prepared and tested in accordance with method 211 of Federal Test Method Standard No. 151. The test results shall conform to requirements stated in Para. 3.5.1 and 3.5.2.

6.4 Micro-Inclusion Test - The producer of the material shall prepare radial specimens approximately 0.28 sq. ins. in surface area, cut from mid-radius and representing material from the top and bottom of each ingot. These specimens shall be solution annealed and aged. The specimens shall be polished on a face parallel to the longitudinal axis for micro-inclusion rating in accordance with the Jerkontoret chart in ASTM E-45-63. No sample shall exceed the limits laid down in Table I.

6.5 Ultrasonic Inspection - The bar stock shall be 100% inspected with an ultrasonic inspection technique by the supplier to the procedures and limitations outlined in DHMS MI.1.

7 ORDERING DATA

Procurement documents should specify the following:

- Title, number and issue of this specification.
- Condition (3.2).
- Size and Shape.
- Exact lengths of length tolerances if manufacturer cannot comply with AMS 2251.

8 REJECTIONS

Failure of a specimen to meet the requirements of Sections 3.1, 3.4, 3.5, and 3.6 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 bar to meet the requirements of Section 3.7 shall result in rejection of the individual bar.

Failure of any bar to meet any other requirements of this specification shall result in rejection of the individual bar, provided each bar is tested individually for the non-conforming attribute.

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 will be returned to the Vendor at the Vendor's expense.

10 PACKING

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