de Havilland Inc.

Material Specification

TITLE:	**250 MARAGING STEEL ROD, BAR, AND FORGING**
SPECIFICATION NUMBER:	**DHMS M2.03**
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1 SCOPE

This specification covers the requirements for high strength, 18% nickel maraging steel rod, bar and forgings.

2 INTRODUCTION

The clauses of this specification are written under the following headings:

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3 APPLICABLE SPECIFICATIONS

3.1 Standards

AMS 2251C - Tolerances (Bar Stock)

DHMS MI-1 - Ultrasonic Inspection of Maraging Steel

AMS 2808 - Identification of Forgings

4 REQUIREMENTS

4.1 Composition

Maraging steel shall be composed of the following elements in percentage (%) by weight:

Nickel	17.0 - 19.0
Molybdenum	4.6 - 5.1
Cobalt	7.0 - 8.5
Titanium	0.30 - 0.50

4.1 Composition (Continued)

Aluminum	0.05 - 0.15
Boron	0.003 added
Zirconium	0.02 added
Calcium	0.06 added
Carbon	0.03 max.
Manganese	0.10 max.
Phosphorous	0.01 max.
Sulphur	0.01 max.
Silicon	0.10 max.

4.2 Condition

4.2.1 Bars & Forgings - shall be available in the fully annealed condition unless otherwise specified.

4.2.2 All forms of this material may be furnished in one of the following conditions as specified:

1. As forged or rolled
2. Pickled or blast cleaned
3. Rough turned
4. Cold drawn
5. Centerless ground

4.3 Manufacturing Process

4.3.1 The steel shall be consumable electrode vacuum melted.

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

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

4.3.4 The grain size shall be 5 or finer for cross-sectional areas up to 25 sq.ins. Grain size on larger cross-sectional areas shall be negotiated.

4.3.5 The material shall be solution annealed by the producer at 1500°F - 1650°F for one hour per inch of thickness and air cooled to room temperature to produce a Rockwell "C" hardness of 34 max., having also the following MINIMUM mechanical properties:

	Long.	Trans.
U.T.S. KSI	140	140
Yield at .2% offset (KSI max)	100	100
Elongation %	12	12
Reduction of Area %	60	60

4.3.6 Subsequent aging performed by the fabricator at 900°F ± 25°F for 3 - 6 hours followed by air cooling produces a Rockwell "C" hardness of 49 - 54, having also the following MINIMUM mechanical properties:

	Long.	Trans.
U.T.S. KSI	240 Min.	240 Min.
	270 Max.	270 Max.
Yield at .2% offset (KSI)	230 Min.	230 Min.
	260 Max.	260 Max.
Elongation %	7	5
Reduction of Area %	40	30
* Notch Tensile Stg. (KSI) (K_t=9)	350	350
Grain Size	5 & finer	

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

4.3.7 Test pieces shall be selected as directed in para. 7.

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

4.4 Analysis

An analysis check shall be made on one sample taken from each melt conforming to AMS 2248. Check limits for Molybdenum shall be .10 over max. and .10 under min.

4.5 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.

4.6 Tolerances

Tolerances shall be in accordance with those laid down in AMS 2251C unless otherwise specified.

5 REPORTS

5.1 Unless otherwise specified, the vendor of the product shall furnish with each shipment, three copies of a report of the results of tests for chemical composition of each heat in the shipment and the results of tests on each thickness from each heat to determine conformance to the technical requirements of this specification. This report shall include the purchase order number, heat number, material specification number, thickness, size and quantity from each heat.

5.2 Unless otherwise specified, the vendor of finished or semi-finished parts shall furnish with each shipment, three copies of a report showing the purchase order number, material specification number, contractor or other direct supplier of material, part number and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

5.3 If forgings are supplied the Part Number and size of stock used to make the forgings shall also be included.

6 IDENTIFICATION

6.1 Unless otherwise specified, individual pieces or bundles shall have attached a metal tag stamped with DHMS M2.03, the purchase order number, nominal size and heat number or shall be boxed and the box marked with the same information.

In addition to the above information, flats 2 in. and larger in both dimensions and other bars 2 in. and over in diameter or distance between parallel sides shall be stamped with heat number within 2 in. of one end.

The characters shall not be less than 3/8" in height, shall be applied using a suitable marking fluid, and 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.

6.2 Forgings shall be identified in accordance with the latest issue of AMS 2808.

7 TESTING

7.1 Rectangles having one dimension greater than 3 in. and the other dimension less than 3 in. test specimens should be removed in the long transverse direction at the centre position. If both dimensions exceed 3 in. transverse test specimens shall be removed as in Fig. 1.

NOTE: Mechanical test specimens for forgings shall be taken as indicated by drawing. Where the drawing does not specify the location of test specimens, samples shall be taken from a forging in the longitudinal direction and in a section where the least reduction takes place.

7.2 Micro Inclusion Test:
The producer of the material shall prepare radial specimens approximately .28 sq. ins. in surface area, cut from mid-radius and representing the material from the top and bottom of each ingot. The 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 Jernkontoret Chart in ASTM #E45-51. No sample shall exceed the limits laid down in Table 1.

7.3 Ultrasonic Inspection:

Ultrasonic inspection shall be done by the supplier to limits as agreed upon between the supplier & De Havilland Aircraft of Canada, Limited.

8 ORDERING DATA

8.1 Procurement documents should specify the following:

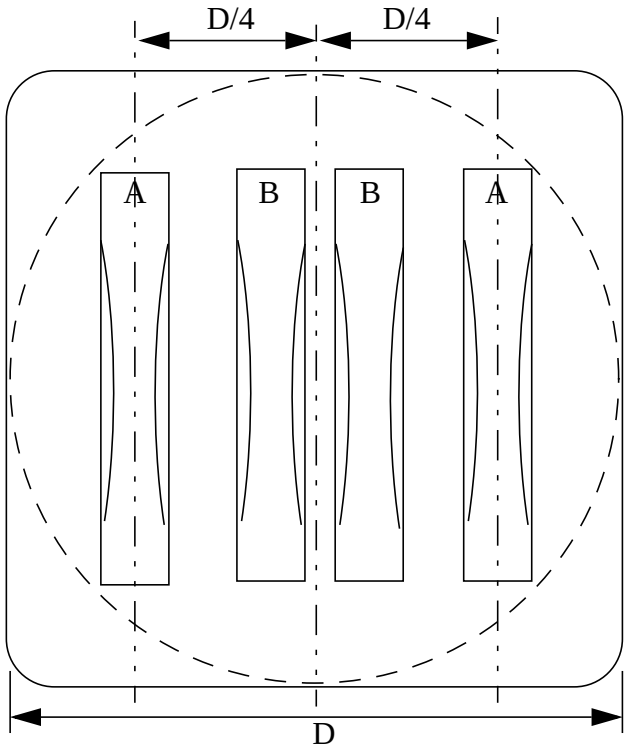
- Title, number and issue of this specification.
- Condition (4.2).
- Size and Shape.
- Exact lengths of length tolerances if manufacturer cannot comply with AMS 2251.

9 REJECTIONS

9.1 Material not conforming to this specification or to authorized modifications will be subject to rejection.

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



A - Mid-radius
B - Center

Fig. 1 Location of transverse tensile specimens.