



<i>Change Log</i>			
<i>Version</i>	<i>Latest Status</i>	<i>Date</i>	<i>Description of Change</i>
v1.2	Approved	07 Dec 2010	Section 1, paragraph 6
v1.1	Signed	12 Nov 2010	<p>Sentence starting "All Beryllium supplied shall be fully compliant with the requirement of this specification and..." has been modified as follows, "Beryllium supplied shall be fully compliant with the requirement of this specification and..."</p> <p>The word "All" has been removed as it implies all beryllium will be procured using this specification whereas two HC specifications will be available for Beryllium procurement</p>
v1.0	Signed	13 Sep 2010	<p>Section 11 Certification modified</p> <p>Number of tensile tests (Section 6.1 and 9) clarified.</p> <p>Radiographic examination (Section 7.2) clarified.</p> <p>Definition of a block added to Section 4</p> <p>Statement on pre qualification requirements added to Section 1.</p>

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**Contents**

- \* Difference (i.e. 100% - other elements)
- \*\* Proven method of measurement of Uranium content shall be proposed by Manufacturer of material and agreed with DA and IO.
- \*\*\* The content of other elements (e.g. Cr, Ni, Cu, Ti, Zr, Zn, Mn, Ag, Co, Pb, Ca, and Mo) shall be reported for information.

## 5.2 Density

The minimum bulk density shall be 99.0% of theoretical density.

Theoretical density is defined as:

$$\frac{100}{\frac{100 - \%BeO}{1.8477} + \frac{\%BeO}{3.009}} \text{ g/cm}^3$$

Method of testing is ASTM B311. The test shall be performed for each lot.  
Test specimen shall be taken from the position close to mechanical test specimens.

## 5.3 Grain size

The microstructural examination to determine grain size shall be performed in accordance with ASTM E112 using intercept method at 500 magnification. This grain size is determined on a test sample taken close to the mechanical test specimen. The average grain size shall not exceed 0.020 mm. One measurement per lot is required.

## 6 Mechanical Properties

Four specimens: 2 in longitudinal and 2 in transverse directions shall be tested at ambient temperature for each lot.

### 6.1 Tensile Properties

Tensile test should be performed according to ASTM E 8/E8M.

The material shall conform to the requirements for mechanical properties prescribed in Table 2.

**Table 2. Requirement for tensile properties**

Property	Value
Ultimate Tensile Strength, MPa, minimum	290
Yield Strength (0.2% offset), MPa, minimum	205
Elongation (in 4 diameter), %, minimum	3.0

Additional national standards and/or material supplier procedures can be applied if they are required. IO and DA shall be informed about these documents.

Other equivalent national or international standards and codes may be acceptable with prior written DA and IO approval, provided all equivalency criteria are satisfied.

### 3 Ordering Information

It is responsibility of the DA to specify the requirements for the material purchase order.

### 4 Manufacturing Process

The base material shall be produced by Vacuum Hot Pressing (VHP). The scheme of cut of the ordered beryllium blocks from original VHP billet shall be agreed between Manufacturer and Purchaser. The Supplier shall indicate longitudinal and transverse directions on the block or in documentation.

Definitions:

- Lot: entire billet, produced by hot pressing in one operation;
- Batch: several blocks of the same dimension cut from one lot
- Block: a single piece of material cut from a lot of predefined dimensions, (several blocks make up a batch)
- Directions:
  - o Longitudinal – direction parallel to moulding pressure
  - o Transverse - direction perpendicular to moulding pressure

### 5 Chemical Requirements and Physical Characteristics

#### 5.1 Chemical composition

The chemical composition obtained in accordance with ASTM E439 and other applicable standards shall comply with the requirement given in Table 1.

The chemical analysis shall be performed for each VHP billet.

Table 1. Chemical composition

Chemical element	Acceptance standard, % weight
Beryllium Assay, minimum *	99.0
Beryllium oxide, maximum	1.0
Aluminium, maximum	0.06
Carbon, maximum	0.10
Iron, maximum	0.08
Magnesium, maximum	0.06
Silicon, maximum	0.06
Uranium, maximum **	0.0030
Other metallic impurities, maximum	0.04

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## 5.2 Density

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## 6 Mechanical Properties

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### 6.1 Tensile Properties

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Ultimate Tensile Strength, MPa, minimum	290
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If this is not the case and the test specimen has a physical defect or if unsatisfactory test results are due to incorrect mounting of the specimen or testing machine malfunction, the test shall be repeated using another specimen. If the results of the second test are satisfactory, the lot shall be accepted; if not, the following paragraph shall apply.

Where unsatisfactory results cannot be attributed to any above mentioned causes, up to two retests may be performed for each unsatisfactory result obtained. These retests shall be carried out on a second set of test specimens, which shall be taken close to those which were defective. If the results of the retest are satisfactory, the lot shall be accepted, if not, it shall be rejected.

## 6.2 Location of specimen

Test specimens shall be cut of the remaining part of the VHP billet used for the supply of blocks for procurement. They shall be appropriately marked. Samples shall be cut in transverse and longitudinal directions. Identification of orientation shall be reported together with the test results.

The detailed scheme of specimens' fabrication shall be based on available practice and presented to DA and IO.

## 7 Non-destructive examination

### 7.1 Visual Examination

All external surfaces shall be examined by a visual examination in accordance with ASME Section V, Article 9. Cracks are not permissible.

### 7.2 Radiographic examination

Radiographic inspection to a penetrameter sensitivity of 2% shall be performed in accordance with ASTM E-1742, however exceptions are taken to the penetrameter contrast requirement and applicable area of penetrameter density ranges of +30% or -15% from the density at penetrameter location(s). Unless otherwise specified, accept/ reject decisions shall include areas directly beneath the penetrameter(s).

Material shall conform to the following requirements:

Maximum dimension	Maximum average dimension	Total combined defects in a volume of 25.4 x 25.4 x 25.4 mm <sup>3</sup>
0.75 mm	0.50 mm	Sphere diameter 1.25 mm

Detailed program for radiographic inspection shall be prepared and agreed with DA and IO. DA may accept some blocks with defects detected by radiographic inspection provided tiles are cut from outside the defect region. Should this be the case then a non conformance report (NCR) shall be raised.

## 8 Dimensions, Permissible Variations and Surface Finish

Blocks shall conform to the dimensions and dimensional tolerances as established by the purchase order and applicable procurement drawings. The main dimensions shall be recorded.

The longitudinal and transverse directions of the blocks shall be indicated.

The material shall be furnished with a machined surface. The surface finish shall be indicated in the purchase order or proposed by material Supplier.

## 9 Summary and Frequency of Required Tests

Each block shall be cut from billet which is fully characterised in terms of chemical composition, density, grain size, mechanical properties.

Table 3. Frequency of tests

Test	Frequency of test	Comments
Chemical composition	1 test per lot	
Density	1 test per lot	
Grain size	1 test per lot	
Tensile properties	4 tests per lot	2- longitudinal, and 2 – transverse  One set (Long + Trans) of specimens shall be taken from each end of the pressing
Visual surface examination	Per each block	
Radiographic examination	Per each block	
Dimensional check	Per each block	

## 10 Acceptance

Material Test Reports have to be provided to the Purchaser prior to delivery. Material and certification shall be in compliance with this specification. Material cannot be accepted if it does not comply with this specification.

## 11 Certification

An inspection certificate type 3.1 in accordance with EN10204:2004 shall be provided. The certificate specifies that the material was manufactured, sampled, tested and inspected in accordance with the material specification. The document is validated by the manufacturer's authorised inspection representative, independent of the manufacturing department.

## 12 Packaging and Marking

Each block shall be legibly identified with the following information. The marking shall be performed by acceptable means specified by purchaser.

- Manufacturer Name or Symbol
- Lot and Batch Number
- Serial Number of block in batch
- Specification Number
- X-Ray Number
- Purchase Order Number
- Warning Beryllium

Safety warnings (all safety warnings shall be translated into English) shall appear on each package. The supplier shall ensure that consignments comply with regulatory requirements applicable to the transport of beryllium in the home country and to the country of destination.

## 13 Material Test Report

The report shall contain the following information:

- Material designation and marking.
- Lot (billet) number
- Batch number
- Identification of order
- Result of chemical analysis
- Records of density measurement
- Records of microstructure examination and grain size
- Results of mechanical property tests
- Indication from where the specimens have been taken for all specified analysis
- Results of visual examination
- Results of radiographic inspection
- Packaging data

## 14 Quality Assurance Requirements

The quality assurance requirements for the supply of beryllium material shall be as defined in the ITER Procurement Quality Requirements (22MFG4).

## 15 Access of Inspectors

Representatives of the IO, DA and/or Third Party Inspector (TPI) shall at reasonable notice have the right to check at the Supplier's premises or at those of his sub-contractor the progress and status of the work forming the subject matter of the procurement and to witness specified tests.

The Supplier, via the concerned DA, shall hold at the disposal of the IO and TPI and make available to them such information and documents as are necessary to determine the progress and status of the work.