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Technical Requirements Specification

Tungsten heavy alloy WNiFe for TFW

This specification covers the supply of tungsten heavy alloy WNiFe for use by the TFW panels.

Approval Process			
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1 Scope

This specification covers the supply of tungsten (W) heavy alloy plates to be used as armour material for the ITER Temporary First Wall.

The supply covers the following items:

- a) Organisation of quality at works. Elaboration of all procedures required for the manufacturing, inspection (including analyses), packaging, storage and delivery, time schedules and documentation;
- b) Manufacture of plates;
- c) Performing of all the inspections and tests during and after manufacturing envisaged in this specification;
- d) Storage, packaging and delivery.

2 Referenced Documents

The following Codes and Standards shall be referred. The edition of Codes and Standards at the date of the contract enforced shall be used.

Other equivalent national or international Codes and Standards may be acceptable subject to the IO's written acceptance through the Deviation Request (DR). To this aim, the contractor shall provide the evidence that the proposed Codes and Standards are equivalent to the corresponding ones, which are specified below.

2.1 ASME Code Edition 2017

Section V, Article 9	Visual Examination.
Section V, Article 4	Ultrasonic Examination
Section V, Article 6	Liquid Penetrant Examination

2.2 ASTM Standards

ASTM B777-15	Standard Specification for Tungsten Base, High-Density Metal.
ASTM B760-13	Standard Specification for Tungsten Plate, Sheet, and Foil.
ASTM B311-17	Standard Test Methods For Density of Powder Metallurgy (PM) Materials Containing Less Than Two Percent Porosity.
ASTM E18-15	Standard Test Method for Rockwell Hardness of Metallic Materials.
ASTM E 8/8M-22	Standard Test Method for Tension Testing of Metallic Materials.

2.3 EN Standards

EN 10204:2004	Metallic products - Types of inspection documents.
EN ISO 6892-1:2016	Metallic materials — Tensile testing - Part 1: Method of test at room temperature

3 Ordering Information

It is responsibility of the Contractor to specify the requirements for the material purchase order, with taking into account the requirements of ASTM 777-15 and additional requirements due to the features of application.

4 Manufacturing Process

The high-density tungsten base metal is produced by consolidating metal powder mixtures, the composition of which is mainly tungsten. The raw materials shall be a mixture of loose metal powders consisting mainly of tungsten with combination of binder elements such as nickel, ion or the others. The material is produced by pressing and sintering of powders or liquid phase sintering. There are four classes for this materials as defined in table 1 of ASTM B777-15. The Class 4, standard alloy containing nickel and ion shall be supplied.

Definition of lot:

Synergy to tungsten materials produced by powder metallurgy (see Section 3 of ASTM B760-07(2013)), two (2) definitions of lot are implemented

- Chemical analysis lot;
- Manufacturing lot (in other word, inspection lot)

These definitions of lot shall be applied for the chemical analysis (chemical analysis lot) and for the other tests (manufacturing lot), described in this specification.

Sampling shall be done by one sample taken from the beginning of manufacturing lot and by another sample taken from the end of manufacturing lot, or by random sampling.

5 Chemical Requirements and Physical Characteristics

5.1 Chemical composition

The plates shall have the following chemical composition (Table 1) for Class 4 standard alloy as described in ASTM B777-15. The testing methods of chemical composition shall be reported to the IO.

The chemical composition analysis shall be done per the chemical analysis lot, and the check (product) analysis shall be done per the manufacturing lot with the purpose to verify the chemical composition of lot.

Table 1 - Chemical composition of the plates

Element	Composition, wt. %
W	≥ 97
Ni + Fe	balance
Co	≤ 0.050
Nb	≤ 0.10
Ta	≤ 0.01

Other elements can be reported by the Supplier based on their experience and internal specifications.

5.2 Density

The density shall be tested in accordance with ASTM B311-17 and shall be $\geq 18.5 \text{ g/cm}^3$.

5.3 Microstructure

The microstructure (x200) shall be reported. The microstructure shall be homogeneous.

5.4 Hardness

The plate shall be examined by the Rockwell hardness test at the plane perpendicular to the deformation direction (at minimum 3 mm away from the plate surfaces).

The Rockwell hardness test shall be performed in accordance with ASTM E18-15.

The Rockwell hardness HRC of the delivered material shall be ≤ 35 .

5.5 Mechanical properties

Tensile test at room temperature shall be performed according to ASTM E 8/8M (or EN ISO 6892-1).

	At Room temperature
Tensile Strength, MPa min	689
Yield Stress (at 0.2% offset), MPa, min	517
Total Elongation, %, min	2

6 Dimensions and Permissible Variations

The requirements specified in the purchase order are applicable.

6.1 Surface conditions

The finished material shall be free of visible oxide, scale, splits, laps, cracks, seams, protrusions, gall marks, inclusions and any other kind of defects.

6.2 Straightness

The plates shall meet the requirements of ASTM B760-07(2013) or alternative requirements as agreed between the Contractor and IO.

7 Non-destructive examination

7.1 Visual Examination

All external surfaces of plates shall be examined by a visual examination in accordance with ASME Section V, Article 9.

The surfaces shall be plane, uniform and free from wrinkles, buckles, blowholes, tears, cracks and inclusions.

7.2 Liquid Penetrant Examination

Liquid penetrant test shall be performed for each product in accordance ASME Section V, Article 6. The applied standard shall be reported to the IO. The dye penetrant shall meet the requirements specified in the ITER Vacuum Handbook (ITER_D_2EZ9UM v2.5) and the updates.

Indications of cracks, tears, laps, seams or chain-like porosity are unacceptable.

7.3 Ultrasonic Examination

Ultrasonic test shall be performed in accordance with ASME Section V, Article 4.

Defect indication larger than Flat Bottom Hole (FBH) 2 mm is not acceptable.

8 Number and Content of Tests / Sampling

8.1 Test frequency

Test	Number of test samples
Chemical analysis	1 / chemical analysis lot Check analysis: 1/ manufacturing lot
Density	2 / manufacturing lot
Microstructure	2 photographs in 2 directions / manufacturing lot
Hardness test	3 / manufacturing lot
Mechanical properties test	2 / manufacturing lot

8.2 Non destructive tests – frequency

Test	Inspection
Dimensional check	Start, middle and end of each plate
Visual examination	100 %
Liquid penetrant test	100 %
Ultrasonic test	100 %

9 Acceptance

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

10 Documentation

The Supplier shall provide the Inspection Certificate “type 3.1” in accordance with EN 10204, which includes at least the following information:

- Description of the material designation and marking,
- Lot number,
- Report of the measurements of the dimensions and geometrical tolerances of each product,
- Report of the measurements of the chemical composition,
- Report of the measurements of the density of each lot,
- Report of the measurements of hardness of each lot,
- Report of the measurements of mechanical properties of each lot,
- Report on microstructural examination of each lot,
- Visual examination report of each product,
- Ultrasonic examination report of each product,
- Penetrant test report of each product.

All documents shall be in the English language and all measures shall be given in the metric system SI. Each document shall be provided as an electronic file in PDF format.

11 Packaging and marking

The plates shall be properly packed in order to prevent any kind of damages and properly fixed inside a box. This box shall be rigid enough in order not to deform appreciably under the tungsten weight.

The plates shall be suitable protected for transport and storage by use of PVC bags.

Each plate shall be legibly identified with information specified by the purchaser such as the following example.

- Supplier name,
- Material's name,
- Dimensions,
- Condition (stress relieved),
- Lot No.

12 Quality Assurance Requirements

The Supplier should have an ITER approved QA Program or an ISO 9001 accredited Quality Assurance System.

The Supplier shall ensure that the quality of services meet the requirements. In case of any questions, the Supplier shall ask the purchaser for clarification prior to proceeding with the work.

A list of the documentation associated with the ITER Quality Requirements is given in the Table below.

The Suppliers who supply materials that are custom made for this contract, shall submit the Quality Plan, Manufacturing and Inspection Plan (MIP) and reports including all required information for the IO approval.

The Suppliers who supply materials that are off-the-shelf or production by order, shall submit the reports including all required information.

Table 3 IO Quality requirements

IO Quality Requirements	Associated IO Quality Documents
Prior to contract implementation: <ul style="list-style-type: none"> ▪ Obtain IO acceptance of a dedicated “Quality Plan” 	“Quality Plan” (ITER_D_22MFMW)
Prior to start of manufacturing: <ul style="list-style-type: none"> ▪ Obtain IO acceptance and mark up of a “Inspection Plan” (Manufacturing and Inspection Plan; MIP) 	“ Inspection Plan” (22MDZD), “Inspection Plan Template” (QV7GQF).
During manufacture: <ul style="list-style-type: none"> ▪ Notify IO representatives of any Inspection Points as marked up on the “MIP” ▪ Complete the relevant entries in the “MIP” as work progresses. 	
During contract implementation – issue as necessary: <ul style="list-style-type: none"> ▪ “Deviation Request” ▪ “Non-Conformance Reports” 	Procedure for the management of Deviation Request (2LZJHB). Procedure for management of Nonconformities (22F53X).

The Supplier shall implement, in compliance with its Quality Assurance System, the monitoring activities including the quality audits and any inspections to verify the compliance with the requirements.

The IO reserves the right to perform the visits to any premises where the ITER related work is being performed.

Documentation developed as the result of this supply shall be retained by the Contractor for a minimum of 5 years from the completion of this supply.