

Technical Requirements Specification

Bulk tungsten for TFW

This specification covers the supply of bulk tungsten for use by the TFW panels

Approval Process			
	Name	Action	Job Title / Affiliation
Author	Hirai T.	14 Aug 2025:signed	Divertor Outer Target Officer
Co-Authors			
Reviewers	Barabash V.	25 Sep 2025:recommended	Materials & Standards Coordinator
	Chen L.	18 Aug 2025:recommended	Blanket Officer
	Kushchin A.	22 Sep 2025:recommended	Quality Engineer
Approver	Hunt R.	25 Sep 2025:approved	Project Leader
Information Protection Level: Non-Public - Unclassified			
RO: Chen Lei			
Read Access	LG: Blanket add right persons, LG: Blanket Assembly Section Team, AD: ITER, AD: External Collaborators, AD: IO_Director-General, AD: OBS - Configuration Management Section (CMS), AD: External Management Advisory Board, AD: IDM_Controller, AD: OBS - Configuration Management Section (CMS) - EXT, AD: N...		

#drn#

<i>Change Log</i>			
Bulk tungsten for TFW (DUDN9C)			
<i>Version</i>	<i>Latest Status</i>	<i>Issue Date</i>	<i>Description of Change</i>
v0.0	In Work	03 Jun 2025	
v1.0	Approved	14 Aug 2025	first version

Table of Contents

1	<i>Scope.....</i>	<i>2</i>
2	<i>Referenced Documents.....</i>	<i>2</i>
2.1	ASME Code Edition 2017.....	2
2.2	ASTM Standards.....	2
2.3	EN Standards.....	2
3	<i>Ordering Information.....</i>	<i>2</i>
4	<i>Manufacturing Process</i>	<i>3</i>
5	<i>Chemical Requirements and Physical Characteristics.....</i>	<i>3</i>
5.1	Chemical composition.....	3
5.2	Density.....	3
5.3	Grain size and microstructure	4
5.4	Hardness	4
6	<i>Dimensions and Permissible Variations.....</i>	<i>4</i>
6.1	Surface conditions	4
6.2	Straightness.....	4
7	<i>Non-destructive examination</i>	<i>4</i>
7.1	Visual Examination.....	4
7.2	Liquid Penetrant Examination	5
7.3	Ultrasonic Examination.....	5
8	<i>Number and Content of Tests / Sampling.....</i>	<i>5</i>
8.1	Test frequency	5
8.2	Non destructive tests – frequency	5
9	<i>Acceptance</i>	<i>5</i>
10	<i>Documentation.....</i>	<i>5</i>
11	<i>Packaging and marking.....</i>	<i>6</i>
12	<i>Quality Assurance Requirements.....</i>	<i>6</i>

1 Scope

This specification covers the supply of tungsten (W) 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 tungsten 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 B760-07 (2013)	Standard Specification for Tungsten Plate, Sheet, and Foil.
ASTM E112-13	Standard Test Methods For Determining Average Grain Size.
ASTM B311-17	Standard Test Methods For Density of Powder Metallurgy (PM) Materials Containing Less Than Two Percent Porosity.
ASTM E92-17	Standard Test Method for Vickers Hardness and Knoop Hardness of Metallic Materials.

2.3 EN Standards

EN 10204:2004	Metallic products - Types of inspection documents.
EN ISO 6507-1:2018	Metallic materials - Vickers hardness test - Part 1: Test method

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 B760-07 (2013) and additional requirements due to the features of application.

4 Manufacturing Process

The tungsten used in plate production is processed according to the classical methods normally used in powder metallurgy, such as pressing, sintering, forging, rolling and/or swaging and drawing/straightening as well as a final mechanical or chemical surface treatment or the alternative methods such as hot isostatic pressing.

The heat treatment ensures that the specified physical and mechanical properties are attained. The tungsten plates have to be supplied in the stress relieved condition.

Definition of lot:

In accordance with Section 3 of ASTM B760-07(2013), there are two (2) definitions of lot:

- Chemical analysis lot;
- Manufacturing 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 tungsten plates shall have the following chemical composition (Table 1) as described in ASTM B760-07 (2013). 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 tungsten plates

Element	Composition max, wt. %	Permissible variation in Check analysis, wt. %
C	0.010	±0.002
O	0.010	+10% relative
N	0.010	+0.0005
Fe	0.010	+0.001
Ni	0.010	+0.001
Si	0.010	+0.001

The minimum tungsten content shall be 99.94%.

For other impurities, max 0.05 wt.% Co, max 0.10 wt. % Nb and max 0.01 wt.% Ta.

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 $\geq 19.0 \text{ g/cm}^3$.

5.3 Grain size and microstructure

The grain size shall be measured in accordance with ASTM E112-13 using the basic magnification $\times 100$. A micrographic examination with the photographs must be made parallel and perpendicular to the deformation direction.

The tungsten plate shall have the following grain size shown in Table 1. The microstructure must be homogeneous.

Table 1 – Grain size of tungsten plate

Plate thickness [mm]	Grain size [ASTM number] Samples must be cut perpendicular to the rolling direction
≥ 10	3 or finer

5.4 Hardness

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

The Vickers hardness test shall be performed in accordance with ASTM E92-17 or EN ISO 6507-1:2018.

The Vickers hardness HV30 of the delivered material shall be $\text{HV30} \geq 410$.

6 Dimensions and Permissible Variations

Requirements of ASTM B760-07(2013) shall be fulfilled, unless the specific requirements related to plate manufacture for ITER Temporary First Wall.

6.1 Surface conditions

The finished tungsten plates 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 tungsten 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 tungsten 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 tungsten plate in accordance with 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
Grain size	2 / manufacturing lot
Microstructure	2 photographs in 2 directions / manufacturing lot
Hardness test	3 / 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 plate,
- Report on main deformation direction and grain orientation for each plate,
- 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 grain size of each lot,
- Report on microstructural examination of each lot,
- Visual examination report of each plate,
- Ultrasonic examination report of each plate,
- Penetrant test report of each plate.

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

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

- Supplier name,
- Material's name,
- Dimensions: plate thickness, width and length,
- 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 Supplier and Contractor for a minimum of 5 years from the completion of this supply.