

Technical Specifications (In-Cash Procurement)

**Technical Specification of Furnace for Thermal Cycling
and Atmospheric Baking of Big Diagnostic Port Plug
Components in the ITER Port Integration Facility**

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Diagnostic Port Plug Components in the ITER Port Integration Facility

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1 Preamble

This Technical Specification must be read in conjunction with the General Management Specification for Service and Supply (GM3S) – [Ref 1], which forms an integral part of the technical requirements.

2 Introduction

This technical specification defines the design, operational, and performance requirements for a large-scale thermal cycling and baking furnace intended for big metallic components and structures of the Diagnostic Port Plugs (Diagnostic Shielding Modules, Port Plug Structures, etc...). These components are critical for the integration of diagnostic systems and must comply with ultra-high vacuum (UHV) conditions during operation. To achieve this, thermal cycling and baking are implemented as part of the cleaning process, serving as a compensatory measure for the removal of hot helium leak testing.

The manufacturing of these components is distributed across multiple suppliers and domestic agencies worldwide. Current fabrication specifications include the requirement for thermal baking cycles; however, manufacturers consistently report significant challenges in accessing facilities with the necessary size and technical capabilities to perform these processes. Establishing similar large-scale installations at each supplier site would be inefficient, costly, and logistically complex.

To address these constraints, an alternative approach is proposed. Instead of requiring thermal cycling at the point of manufacture, stricter standards for cleaning and surface finishing will be enforced upon delivery. Furthermore, a centralized facility will be provided to perform thermal cycling and baking for all components during their assembly at the Port Integration Facility. This solution ensures uniformity in processing, reduces multiplication of resources, and guarantees compliance with UHV requirements.

This document specifies the technical, functional, and design requirements for the construction, installation, and commissioning of this centralized thermal cycling and baking system. It includes details on capacity, temperature control, safety measures, operational procedures, and integration with existing assembly workflows.

3 Acronyms & Definitions

3.1 Acronyms

The following acronyms are the main one relevant to this document.

Abbreviation	Description
CAD	Computer Assisted Design
CRO	Contract Responsible Officer
DA	Domestic Agency
FAT	Factory Acceptance Tests
GM3S	General Management Specification for Service and Supply
HMI	Human-Machine Interface
IO	ITER Organization
PIA	Protection Important Activity

PIC	Protection Important Component
PID	Proportional-Integral-Derivative
PLC	Programmable Logic Control
QA	Quality Assurance
QC	Quality Control
SAT	Site Acceptance Tests
UHV	Ultra-High Vacuum

3.2 Definitions

Contractor: shall mean an economic operator who have signed the Contract in which this document is referenced.

Other definitions can be examined in the section 2.1 of the GM3S Ref [1] and may be required to ensure proper understanding of the document.

4 Applicable Documents & Codes and standards

4.1 Applicable Documents

It is the responsibility of the Contractor to identify and request for any documents that would not have been transmitted by IO, including the below list of reference documents.

This Technical Specification takes precedence over the referenced documents. In case of conflicting information, this is the responsibility of the contractor to seek clarification from IO.

Upon notification of any revision of the applicable document transmitted officially to the contractor, the contractor shall advise within 4 weeks of any impact on the execution of the contract. Without any response after this period, no impact will be considered.

Ref	Title	IDM Doc ID	Version
1	General Management Specification for Service and Supply (GM3S)	82MXQK	1.4
2	ITER Procurement Quality Requirements	22MFG4	5.1
3	Procurement Requirements for Producing a Quality Plan	22MFMW	4.0
4	Software qualification policy	KTU8HH	2.0
5	Procedure for ITER CAD Data Exchanges	2NCULZ	4.2
6	ITER Vacuum Handbook	2EZ9UM	2.5

4.2 Applicable Codes and Standards

The thermal cycling and baking cycle parameters shall be fully aligned with the requirements specified in the ITER Vacuum Handbook and its appendices and attachments - Ref [6]. All operational settings, including temperature ranges, ramp rates, and hold times (described in this Technical Specification), must comply with the standards outlined in the handbook to ensure consistency, safety, and compatibility with ITER vacuum system specifications.

In addition, the furnace shall conform to the following European Directives and Standards:

- 2006/42/EC – Machinery Directive
- 2014/35/EU – Low Voltage Directive
- 2014/30/EU – Electromagnetic Compatibility Directive
- 2014/68/EU – Pressure Equipment Directive (for gas circuits)
- EN 746-1, EN 746-2, and EN 746-3 – Industrial Thermoprocessing Equipment Safety Standards
- EN 60204-1 – Safety of Electrical Equipment of Machines
- EN ISO 12100 – Machinery Safety – Risk Assessment
- Ecodesign Directive (2009/125/EC)
- Other specific European and ISO Standards pointing to the different technical aspects of the equipment and mentioned in the sections hereafter.

5 Scope of Work

This section defines the specific scope of work for the service, in addition to the contract execution requirement as defined in Ref [1].

The scope includes the design, manufacture, supply, installation, and commissioning of an industrial thermal cycling furnace intended for the treatment of large metallic components made of stainless steel.

The furnace shall be capable of performing low-temperature thermal cycling operations under controlled atmosphere conditions, providing precise and uniform temperature distribution across the entire working volume. The system shall comply with all applicable European Union regulations and standards concerning safety, performance, and energy efficiency.

5.1 Equipment to be Supplied

The furnace shall be a horizontal, electrically heated, atmosphere-controlled chamber furnace suitable for the thermal cycling of large metallic parts.

It shall include a movable floor-mounted loading platform, designed to slide longitudinally for convenient loading and unloading by overhead crane. The platform shall be designed to accommodate heavy loads and ensure stable, repeatable positioning during operation.

The furnace chamber shall be gas-tight and constructed to allow operation both in air and under an inert argon atmosphere. The design shall ensure optimal temperature uniformity, reliable control, and safe handling of large metallic parts weighing up to fifty tonnes.

The equipment shall be of modular design, easily maintainable, and prepared for continuous industrial operation.

Main dimensional and functional parameters:

- Useful internal dimensions: 6.0 m (L) × 3.0 m (W) × 3.5 m (H)
- Maximum load capacity (on sliding platform): 50 metric tons
- Maximum operating temperature: 250 °C
- Maximum heating rate: 5 °C/hour
- Maximum controlled cooling rate: 5 °C/hour

- Temperature uniformity: ± 2 °C (verified according to EN ISO 23693 or AMS 2750 Class 2 equivalent)
- Atmosphere: Air or inert argon
- Location of operation: European Union territory

5.2 Furnace Construction

The furnace structure shall be fabricated from high-quality materials suitable for repeated thermal cycling. The internal chamber shall be constructed from stainless steel grade 304 or 316, ensuring resistance to oxidation and corrosion under process conditions.

Thermal insulation shall be composed of multi-layer, high-performance ceramic fiber and microporous insulation materials compliant with EN 14303, designed to minimize heat loss and maintain stable thermal conditions. The outer casing shall be made of painted carbon steel or stainless-steel panels, adequately ventilated to limit external surface temperatures in accordance with EN ISO 13732-1.

The furnace shall include a hermetically sealed door, operated vertically, with heat-resistant seals and mechanical locking mechanisms. The door system shall include interlocks preventing it from being opened during operation or when the furnace is under argon atmosphere.

The sliding loading platform shall move along precision-ground rails or rollers and shall be capable of supporting the full rated load with appropriate structural reinforcement. The platform movement shall be smooth and controlled, either manually assisted or motor-driven, and provided with mechanical stops, safety locks, and position indicators. The design shall ensure gas-tight sealing between the platform and the furnace body during operation.

5.2.1 Heating and Temperature Control

The furnace shall be heated by electrical resistance elements made of nickel-chromium (NiCr) or equivalent high-temperature alloys conforming to EN 60115-1. Heating elements shall be distributed symmetrically within the furnace walls and ceiling to provide homogeneous temperature distribution throughout the working chamber.

The heating system shall be divided into independently controlled zones to achieve the required temperature uniformity. Each zone shall be equipped with a separate thermocouple and power regulation circuit.

Temperature control shall be achieved using Proportional-Integral-Derivative (PID) controllers integrated in a programmable logic control (PLC) system.

The furnace shall maintain a maximum temperature deviation of ± 5 °C from the setpoint across the usable volume. Control accuracy shall be demonstrated by means of a uniformity test in accordance with EN 60584-1 (thermocouples) and EN ISO 23693 (temperature uniformity survey).

The furnace shall operate safely and reproducibly within the following limits:

- Maximum working temperature: 250 °C
- Maximum heating rate: 5 °C/hour

- Maximum controlled cooling rate: 5 °C/hour
- Temperature uniformity: ± 2 °C across entire load volume

5.2.2 Cooling System

Controlled cooling shall be achieved by natural or forced convection, depending on the selected configuration. For forced convection, the furnace shall incorporate circulation fans constructed from high-temperature-resistant alloys and designed to operate under both air and argon atmospheres.

The control system shall regulate fan speed and airflow direction to ensure homogenous cooling and compliance with the specified cooling rate of up to 5 °C/hour. Cooling sequences shall be programmable and automatically managed through the main control system.

5.2.3 Atmosphere Control System

The furnace shall be designed to operate under a controlled atmosphere, allowing complete purging of air and replacement with argon gas to reduce oxygen content inside the chamber.

The system shall include gas inlet and exhaust manifolds, valves, pressure regulators, and safety devices designed in accordance with EN ISO 14113 (industrial gas systems) and EN 746-3 (industrial thermoprocessing equipment safety).

The purge process shall be automated, with adjustable flow and pressure parameters. Continuous monitoring of oxygen concentration shall be provided by an oxygen sensor complying with EN 50104, ensuring safe operation. Automatic interlocks shall halt heating if the oxygen concentration exceeds allowable limits.

All piping, valves, and fittings shall be of stainless-steel construction suitable for argon service, with connections designed to minimize leakage and ensure long-term reliability.

5.2.4 Control and Automation

The furnace shall be equipped with a PLC-based control system integrated with a touchscreen human-machine interface (HMI). The control system shall allow programming, execution, and monitoring of complex thermal cycles consisting of multiple heating, holding, and cooling stages.

The system shall provide real-time monitoring and recording of all critical process parameters including temperature, atmosphere composition, gas flow rates, and safety alarms. Data logging shall be continuous, with automatic storage in electronic format for traceability, in compliance with EN ISO 9001:2015 quality management requirements.

The HMI shall permit:

- Creation and storage of user-defined thermal cycle recipes
- Real-time graphical visualization of temperature curves and system status
- Alarm display and acknowledgment
- Password-protected access levels for operator, supervisor, and maintenance personnel

Data shall be exportable in CSV or PDF format and accessible via Ethernet or OPC-UA for integration with the plant's supervisory control system.

5.2.5 Safety, Certification and Compliance

The furnace shall conform to the following European Directives and Standards:

- 2006/42/EC – Machinery Directive
- 2014/35/EU – Low Voltage Directive
- 2014/30/EU – Electromagnetic Compatibility Directive
- 2014/68/EU – Pressure Equipment Directive (for gas circuits)
- EN 746-1, EN 746-2, and EN 746-3 – Industrial Thermoprocessing Equipment Safety Standards
- EN 60204-1 – Safety of Electrical Equipment of Machines
- EN ISO 12100 – Machinery Safety – Risk Assessment

The equipment shall be CE marked and supplied with a Declaration of Conformity.

Safety features shall include overtemperature protection, emergency stop buttons, door interlocks, gas safety valves, and audible and visual alarms. An oxygen monitoring and alarm system shall ensure safe argon operation. The system shall include emergency venting to prevent overpressure in the chamber.

5.2.6 Energy Efficiency

The furnace design shall prioritize energy efficiency in accordance with the Ecodesign Directive (2009/125/EC). Insulation materials and heating control systems shall minimize energy losses and optimize heat recovery.

The supplier shall provide evidence of energy performance, including thermal losses and power consumption data under typical operating conditions, verified according to EN 746-2.

5.3 Installation, Commissioning, and Training

The supplier shall be responsible for delivery, installation, alignment, and commissioning of the furnace at the customer's site: Port Integration Facility in the Building 55 of the ITER Organization premises.

Site acceptance testing (SAT) shall include verification of temperature uniformity, functional testing of the atmosphere system, and full safety system validation in accordance with EN 746-1.

Operator and maintenance training shall be conducted in English and include both theoretical and practical instruction on operation, safety, and troubleshooting. Training materials shall be provided in printed and electronic formats.

6 Documentation, Deliverables and Payments Schedule

The supplier shall provide a complete set of documentation in English, including:

- General arrangement and assembly drawings
- Electrical, pneumatic, and gas schematics

- Operation and maintenance manuals
- Calibration certificates for thermocouples and controllers
- Temperature uniformity and gas tightness test reports
- CE Declaration of Conformity and compliance certificates
- Recommended spare parts list and preventive maintenance plan

All documentation shall conform to **EN ISO 82079-1** (Preparation of Instructions for Use).

The supplier shall adhere to the following project schedule, including associated payment milestones. All payments shall be made upon completion of the corresponding deliverable and formal acceptance by the IO.

Phase	Description of the Deliverable	Target Completion	Payment (% Contract Value)	Acceptance Criteria
1	Detailed engineering design, general arrangement drawings, control architecture, and documentation for purchaser approval	T0 + 2 months	10%	Approval of design documents
2	Procurement of main components (heating elements, insulation materials, control system, gas systems) and start of manufacturing	T0 + 4 months	20%	Inspection report confirming materials compliance
3	Completion of furnace fabrication and internal Factory Acceptance Test (FAT)	T0 + 6 months	35%	FAT report approved
4	Delivery to site and completion of installation (mechanical, electrical, and control systems)	T0 + 7 months	15%	Visual inspection and installation checklist approved
5	Site Acceptance Test (SAT), calibration, and demonstration of full operation including uniformity and atmosphere tests	T0 + 7 months	15%	SAT report signed and approved
6	Final documentation, training completion, and warranty activation	T0 + 8 months	5%	Delivery of all documents and training certificate

(*) T0 = Commencement Date of the contract; X in months.

Supplier is requested to prepare their document schedule based on the above and using the template available in the GM3S Ref [1] appendix II.

7 Quality Assurance requirements

The Quality class under this contract is 2, Ref [1] GM3S section 7 applies in line with the defined Quality Class. The organisation conducting these activities should have an ITER approved QA Program or an ISO 9001 accredited quality system.

The general requirements are detailed in ITER Procurement Quality Requirements Ref [2].

Prior to commencement of the task, a Quality Plan must be submitted for IO approval giving evidence of the above and describing the organisation for this task; the skill of workers involved

in the study; any anticipated sub-contractors; and giving details of who will be the independent checker of the activities Ref [3].

Documentation developed as the result of this task shall be retained by the performer of the task or the DA organization for a minimum of 5 years and then may be discarded at the direction of the IO. The use of computer software to perform a safety basis task activity such as analysis and/or modelling, etc. shall be reviewed and approved by the IO prior to its use, in accordance with Software qualification policy Ref [4].

8 Safety requirements

The scope under this contract does not cover for PIC and/or PIA.

9 Specific General Management requirements

Requirement for Ref [1] GM3S section 6 applies completed/amended with the below specific requirements.

9.1 CAD design requirements

This contract does not imply CAD activities. Contractor may receive CAD data for information purpose only from IO-TRO following rules and guidelines given in Ref [5].