Part A(II-1)
Scope of Supply & Works, Technical Specifications for EC MHVPS

GeM Bid No.	GeM Bid No.: GEM/2025/B/6267679
Title	Part A(II-1): Scope of Supply & Works, Technical Specifications for EC MHVPS

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1 Introduction

The ITER Electron Cyclotron Heating and Current Drive (EC H&CD) excites the electrons in the plasma with a high-intensity microwave beam corresponding to the electron resonant frequency along a vertical plane near the plasma axis. The electrons in turn transfer the absorbed energy to the ions by collision.

ITER EC H&CD foresees 20 MW of power injected into the plasma, in continuous operation (CW) at 170 GHz, using 1MW gyrotrons sources of electromagnetic waves. The EC system draws the required power from the ITER 22kV pulsed power electrical network (PPEN) through its power supply (PS) system that adjusts and controls the RF output power.

Main High Voltage Power Supply (MHVPS) applied to the gyrotron cathode w.r.t collector will deliver most of the MW electrical power required to generate the electron beam and the RF power.

Present inquiry describes the scope, roles and responsibility for detail design, manufacturing, component testing, supply, installation and acceptance testing of 4 numbers of PSM based MW level MHVPSs. Following annexures to the present document details specific requirements as mentioned below:

Annexure-A	*Management Specifications*	*Including legal regulatory requirements, accepted sound project management practices, safety and QA requirements*
Annexure-B	*Technical Specifications*	*Including Design, testing and interfaces*
Annexure-C	*Quality and site Specification*	*Including Quality & site specifications*

2 Extent of Supply

The scope of work for providing the MHVPS includes the supply as following:

Table 1: Extent of supply

	Rating	Quantity
MHVPS*	(-)55kVDC, 110A	4 nos. viz. Unit-1 to 04

*Inclusive of

1. 22kV Soft charging system
2. MV Cables (22kV AC)
3. Multi Secondary Transformers
4. LV Cables (AC)
5. SPS Modules (Switching modules)
6. High Voltage Rack
7. Output DC Filter
8. DC Co-axial Cable
9. HV Relays (HV side / LV side)
10. Equipment Control Cubicles (Inclusive of monitoring and protection equipment)
11. Instrumentation, hydraulic circuit, relay blocks for transformer protection, associated cable works, etc. shall be the integral part of the MHVPS.

Also includes Short Pulse dummy load, short circuiting device for testing purpose, spare parts covering 1-year operational life, any specific handling tool, test zigs. If needed some of the components may be sourced from local supply at site, such provisions/arrangements to be identified during manufacturing design.

In addition to the supply of the above-mentioned items, the scope of work shall also include activities consisting of (in consultation with ITER-India);

- Detailed design, justification and manufacturing design approval
- Preparation of the procedure specifications for tests and inspections
- Preparation of procurement specifications for EC MHVPS components and execution, as part of the sub contracted activities
- Management of the sub contracts if any
- Supervision of the Sub Suppliers during all the phases of design, manufacture, and testing
- Production of the Technical and Quality Documentation required at various gate review defined by IO
- Supervision of Installation, site testing of the component objects of the contract, following approved procedure specification for assembly and tests
- Acceptance test of the EC MHVPS, in accordance with approved procedures.

All the components shall be designed, manufactured and tested according to the applicable standard and Quality System.
The main boundaries between the MHVPS and PURCHASER's SITE - ITER Organization, France are summarized below. This list indicates the equipment which are not included in the Contract and are provided at PURCHASER's SITE:

- The infrastructures needed to accommodate the MHVPSs device. This includes all civil works in addition to the buildings where the MHVPS system and the relevant control systems will be located and more in general for every civil work needed for proper installation of the electric devices.
- The 22 kV AC distribution
- The 400V AC distribution, both normal and uninterruptible
- Grounding Grid (buildings)
- Compressed air distribution system;
- The EC H&CD Controller & Gyrotron controller
- The cooling water system and HVAC
- Fire protection, detection and intervention systems
- Utilities during installation, commissioning and testing
- Interlock key system
- Cable Trays including for Medium voltage cables, Output Coaxial cables & control cables.

A dedicated 22kV feeder facility and other interfaces to simulate actual site conditions (at PURCHASER's SITE) is established at ITER-India lab, Gandhinagar to demonstrate assembly/integration, performance specifications of various ITER supplies before the equipment is dispatched to PURCHASER's SITE.

3 Scope of Work

The scope of work includes detailed design, manufacturing, component testing, supply, installation and acceptance testing of 4 nos. of Main High Voltage Power Supply (MHVPS) rated for (-)55kVDC, 110A at PURCHASER's SITE - ITER Organization, France according to the terms and conditions and specifications defined in the inquiry. CONTRACTOR/SUPPLIER owes the full responsibility for the performance of the MHVPSs complying to the Technical Specifications as outlined in Table 1 of *Tender Part A(II-1), Annexure B: Technical Specifications for EC MHVPS*.
Roles and responsibility under the contract shall be followed as:

- ✓ Design & manufacturing
  - o CONTRACTOR/SUPPLIER to perform detailed design, manufacturing, factory testing of 4 nos. of Main High Voltage Power Supply (MHVPS).

- ✓ Supply
  - o CONTRACTOR/SUPPLIER to offer 4 nos. of MHVPSs complete in all aspects with export sea worthy packing and required documentation.
  - o CONTRACTOR/SUPPLIER to deliver MHVPSs on FCA [Supplier's site].
  - o *ITER-India to assume transportation from Supplier's site & unloading at PURCHASER's SITE - ITER Organization, France.*

- ✓ Installation and acceptance testing at PURCHASER's SITE
  - o CONTRACTOR/SUPPLIER shall provide prescription of equipment storage & preservation, site preparation, installation of various equipment, standalone testing, integrated testing.
  - o *ITER-India to engage service provider to support the services required for site preparation, installation, standalone testing, integrated testing of MHVPSs, in compliance with IO (here, ITER) safety norms*
  - o CONTRACTOR/SUPPLIER shall remain responsible for fulfilment of Health, Safety and Environment (HSE) requirements, to ensure that installation is performed in line with the requirements of the MHVPS at PURCHASER's SITE - ITER Organization, France.
  - o CONTRACTOR/SUPPLIER shall remain responsible for standalone testing of the equipment, integrated testing and final acceptance of MHVPSs on Dummy load at PURCHASER's SITE - ITER Organization, France.

However, if the CONTRACTOR/SUPPLIER anticipates constraints in conducting the Factory Acceptance Test (FAT) due to interface requirements, under the responsibility of CONTRACTOR/SUPPLIER, the first MHVPS unit (here Unit-1) shall be assembled and tested at ITER-India Lab, Gandhinagar on the dummy load. The test of first MHVPS at ITER-India Lab shall be considered as ***extension of factory acceptance test (Extended FAT)***. CONTRACTOR/SUPPLIER remains responsible for supervision of works including the availability of OEMs if needed during installation and standalone testing of Transformers and SPS modules. The terms for utilizing the ITER-India lab facility shall be agreed upon.

After successful Factory Acceptance Test, MHVPS Unit-1 shall be transferred to ITER-India lab, Gandhinagar. CONTRACTOR/SUPPLIER shall provide the prescription for equipment storage & preservation, site preparation, installation of various equipment, standalone testing and integrated testing. The Power supply shall be demonstrated for installation, assembly/integration and operations perspective as per the prescription at ITER-India lab.

For the purposes of demonstration at ITER-India lab, Gandhinagar, complete scope of works including transportation, installation, assembly/integration, standalone testing and integrated testing shall be the responsibility of CONTRACTOR/SUPPLIER. After the successful demonstration, the CONTRACTOR/SUPPLIER shall dismantle, repack and transfer this unit back to Supplier's site and refurbish as required.

Components of all units of MHVPS shall be consolidated at Supplier's site from where all MHVPSs to be dispatched to PURCHASER's SITE.

CONTRACTOR/SUPPLIER shall confirm following along with the offer that work should be performed in accordance with the statutory and legal requirements associated with ITER-India Lab and PURCHASER's SITE - ITER Organization, France.

4 Interface Boundaries

CONTRACTOR/SUPPLIER will be responsible for interfacing the MHVPS with the following systems made available at PURCHASER's SITE:

- Building and respective facilities
- 22 kV PPEN network
- 400 V/230 V SSEN auxiliary supply
- Grounding system
- The component cooling water system (CCWS) and HVAC
- EC Plant Controller along with safety and Interlock
- EC gyrotrons for interface functions
- Cable Trays

5 Technical Specifications

EC MHVPS rating are summarized in Table 2. However, the CONTRACTOR/SUPPLIER shall consider the detailed specifications as mentioned in Tender Part A(II-1), Annexure B: Technical Specifications for EC MHVPS.

Table 2: MHVPS Ratings

Power Supply	Rating	Reference document
MHVPS	(-)55kVDC, 110A	Tender Part A(II-1), Annexure B: Technical Specifications for EC MHVPS

6 Spares/Accessories

During the detailed design stage, list of spares is to be proposed covering 1 year of equipment operational life. These spare parts can be used during warranty period to ensure a high availability by a faster repair of the equipment. In addition to the above, vendor shall propose as an option at the final design review a detailed list of spare parts that will cover 5 years of equipment operational life, beyond the warranty period.

Typically, the spare includes SPS modules, signal conditioning cards, controller cards, measuring units, CWS hoses and its associated instrumentations, cables (HV, LC & Fibre) and others associated with each MHVPS units. Detailed list to be updated based upon failure analysis.

7 Acceptance tests

Equipment manufactured by the CONTRACTOR/SUPPLIER/sub-vendor shall conform to specified requirements and applicable IEC standards.

MHVPSs shall have component testing as well as test on complete assembled MHVPS unit/s.

It is assumed that MHVPS units will utilized identical components/equipment, in this case the Factory acceptance test will be performed on the first unit of completely assembled MHVPS. For the remaining MHVPSs component testing is acceptable.

7.1 Component Testing

For COTS item, Manufacturer's Test Certificate (TC) will be the acceptable document.

The non-COTS components, viz. Multi-Secondary Transformer, SPS Modules, and dummy load will be inspected at various manufacturing stages at manufacturer's site based on detailed manufacturing and inspection plan (MIP). These tests will include Routine, type and special tests prescribed by the relevant IEC Recommendations. In particular, IEC 60076-11 and IEC 61378-1 specify the test for the transformers; IEC 60146 series specifies the test for the converters. Type Test conducted on the components should comply with the validity requirements set by the authorized body.

7.2 EC MHVPS Factory Acceptance Test (FAT/Extended FAT)

The Factory test will be performed on complete assembled unit of MHVPS at Supplier's site. Procedure to be prepared by the CONTRACTOR/SUPPLIER and approved by ITER-India before starting the tests. The acceptance tests shall demonstrate that the performance specifications are met.

The Acceptance tests shall include:

- End to End Interface checks
- Voltage to Ground Withstand Test
- Functional tests under MHVPS controller to verify the performance specifications on Dummy Load.
- Wire Burn Test
- Shut Down & Restart Test

Integrated Factory acceptance will be effective upon successful testing as above and delivery of all relevant documentations.

More detailed prescription for these tests are specified in the section 5.2 of *HVPS Tender Part A(II-1) – Annexure B: Technical Specifications for EC MHVPS*.

However, if the CONTRACTOR/SUPPLIER anticipates constraints in conducting the Factory test due to interface requirements, under the responsibility of CONTRACTOR/SUPPLIER, the first MHVPS unit shall be assembled and tested at ITER-India Lab, Gandhinagar on the dummy load. The test of first MHVPS at ITER-India Lab shall be considered as ***extension of factory acceptance test (Extended FAT)***. The first unit once installed and tested with dummy load at ITER-India Lab, shall be dismantled, refurbished as required, repacked and transported to PURCHASER's SITE - ITER Organization, France.

7.3 Assembly/Integration demonstration of Unit-1

After successful Factory Acceptance Test, MHVPS unit-1 shall be transferred to ITER-India lab, Gandhinagar. CONTRACTOR/SUPPLIER shall provide the prescription for equipment storage & preservation, site preparation, installation of various equipment, standalone testing and integrated testing. The Power supply shall be demonstrated for installation, assembly/integration and operations perspective as per the prescription at ITER-India lab.

Assembly/Integration demonstration shall be complete upon successful testing and delivery of all relevant documentations as above.

More detailed prescription for these tests are specified in the section 5.3 of *HVPS Tender Part A(II-1) – Annexure B: Technical Specifications for EC MHVPS*.

8 Document deliverables

A project review gate is a decision point at the end of each phase where a formal review or phase review gate is held to determine the success of the last phase. The purpose of each review is to evaluate the design against its requirements in order to verify that the system is being built correctly and that the right system is being built. A successful review will establish the baselines and solidify the design. Phase review gates directly corresponded to the end of each phase they are linked to.

CONTRACTOR/SUPPLIER has to produce necessary documents (as per agreed input data package) for review & approval during the following gate reviews;

1) Final Design Review (FDR)
2) Manufacturing Readiness Review (MRR)
3) Delivery Readiness Review (DRR)
4) Construction Readiness Review (CRR)
5) Construction Completion Review (CCR)

8.1 Documents considered during Final Design Review (FDR)

Following is the tentative non-exhaustive list of documents;

- Design Report including electrical & seismic analysis.
- RAMI analysis report.
- I&C analysis and design report as defined in the Plant Control Design Handbook.
- Electrical Single Line Diagram (SLD), Process Flow Diagram (PFD), Process and Instrumentation Diagram (P&ID).
- Factory and Site Test Plan.
- Spare parts and storage requirements.
- Installation and Assembly procedure.
- CAD exchange according to DCIF.
- Design Change Requests and Non-Conformity / Deviation Reports if any

8.2 Documents to be submitted for Manufacturing Readiness Review (MRR)

Manufacturing Readiness Review is a set of verification activities to be performed before the start of manufacturing activities in order to assure that required activities are adequately and ready to be effectively performed according to approved documents and the relevant technical criteria of the components to be manufactured are specified in the documents.

Following is the tentative non-exhaustive list of documents;

- Quality Plan
- Manufacturing & Inspection Plan
- Updated I&C deliverables
- Factory test procedure
- Specifications for Handling and Transportation
- Final Site Installation Plan
- Final Site Commissioning Plan
- Final spare parts list and storage requirements
- Revised CAD exchange
- Manufacturing and Inspection Plan

8.3 Documents to be submitted for Delivery Readiness Review (DRR)

This gate review process is to ensure the required and relevant documentation and data has been provided in accordance with the contractual requirements and associated procedures; such as having a unique identifier for each item-type, matching part numbers on goods and packing list, preservation & storage requirements, that the Delivery Report and Contractor Release Note (manufacturing dossier) are reviewed and approved, etc. Furthermore, the part numbers physically on the goods and the packing list also need to match the as-designed and as-manufactured BOMs (Bill of Materials). Further detailed list to be exchanged later.

8.4 Documents to be submitted for Construction Readiness Review (CRR)

CRR is a key step to verify that all the conditions are satisfied to execute a related scope of construction on PURCHASER's SITE - ITER Organization, France. Accordingly, the CRR constitutes a "Hold Point" that must be satisfactorily completed prior to instruct the works contractor to be mobilized on ITER site and to start construction execution. This stage shall establish if engineering is consistent with the Baseline & sufficiently mature for construction preparation against a confirmed scope and shall identify any issues related to material availability (e.g. delivery date delay, material non-compliance, etc.) and work site conditions (e.g. access difficulties, co-activity, etc.) which may impact the commencement / execution of the works.

Following is the tentative non-exhaustive list of documents;

- Draft instruction manual on the installation, assembly and operation procedures

8.5 Documentation to be submitted for Construction Completion Review (CCR)

Following is the tentative non-exhaustive list of documents;

- Operation and maintenance manuals
- Site acceptance test report
- Final design report
- Final instruction manual on the installation, assembly and operation procedures

The final documentation shall include all the documentation described as above, covering both the "as built" configurations and all the revisions performed during the installation, the tests and the commissioning.

The documentation shall be provided in English language in electronic version. The electronic version shall be based on standard formats, as Microsoft Word, Excel, PowerPoint, Portable Document Format (PDF) and CATIA models/drawings.

9 Warranty

CONTRACTOR/SUPPLIER shall provide a warranty on each unit of EC MHVPS for the scope of supply covering repair or replacement up to 2.5 years after delivery at FCA Supplier's site or up to 1 year after Final Acceptance at PURCHASER's SITE whichever event occurs earlier.

10 Delivery period

Required delivery period is mentioned in table below.

Table 3: Delivery milestones

Important milestones	**Expected Finish Duration**
Contract Award	T0
Kick Off Meeting	T1 = T0 + 0.5 months
Detailed Design review	T2 = T1 + 2months
Manufacturing Readiness Review	T3 = T2 + 4months
Manufacturing & Component level Testing of All units of MHVPSs	T4 = T3 + 26months
Unit -1 Factory Test on Dummy load	T5 = T3 + 20months
Unit- 1 Assembly/integration demonstration at ITER-India lab, Gandhinagar	T6 = T5 + 6months
Delivery Readiness Review	T7 = (T4, T6) + 1month
Delivery of 4 nos. of MHVPS	T8 = T7 + 1month

10.1 Consolidation of Supplies

Components of MHVPSs, all four units must be consolidated under the responsibility of CONTRACTOR/SUPPLIER (at supplier's site) to organise the logistics related to transport to PURCHASER's SITE. The equipment must be offered for export sea worthy packing, documentation including declarations. MHVPS components must be stored in a controlled indoor environment.

- Clean and dry location free from direct sunlight and corrosive fumes.
- Ambient temperature range of -20 °C to 35 °C
- Relative humidity < 90% and non-condensing

- Area with rapid changes in temperature must be avoided and equipment not to be placed directly on the ground.
- The site should be spacious enough to accommodate handling tools.
- Stored components must be adequately insured.

11 Contractor Release/DRR

Contractor Release note (CRN) will be effective upon successful testing as per section 7.1, 7.2, 7.3 and availability of agreed number of EC MHVPS units complete in all aspects. Contractor Release Note shall be prepared based upon successful review and approval of all relevant documentation. DRR (as per section 8.3) shall be performed and deliveries in multiple batches is also envisaged depending upon the availability of site, logistics, resources for the complete scope. Having CRN/DRR does not relieve CONTRACTOR/SUPPLIER from the obligations under the Contract.

12 Packing and Transport requirements

Details related to packing & transport, refer section 8 of '*Tender Part A(II-1), Annexure – C: Quality & Site specification for EC MHVPS*'.

13 Site Installation and Testing period

Site Installation at Purchaser's site shall begin typically 3 months after the delivery, includes possibility of early start. Complete duration of Site installation and Acceptance test for all MHVPS units is considered as 15 months.

Table 4: Site Installation key milestone

Important milestones	**Expected Finish Duration**
Delivery of 4 nos. of MHVPS to PURCHASER's SITE - ITER Organization, France *(to be organised by ITER-India)*	T0
Installation of all units of MHVPS at PURCHASER's SITE in sequence	T1 = T0 +9 months
Acceptance Test of all unit of MHVPS with dummy Load (in sequence).	T2 = T0 + 18 months
Final documentation approval.	T3 = T2 + 3months

14 Acceptance at PURCHASER's SITE

MHVPS shall be installed and commissioned at PURCHASER's SITE - ITER Organization, France . The tests will be done according to the Site Test Procedure to be prepared by the CONTRACTOR/SUPPLIER and approved by ITER-India before starting the tests. The acceptance tests shall demonstrate that the performance specifications are met.

The acceptance tests shall include:

- End to End Interface checks
- Voltage to Ground Withstand Test
- Functional tests with MHVPS controller to verify the performance specifications on Dummy Load.
- Wire Burn Test
- Shut Down & Restart Test

Final acceptance will be effective upon successful testing as above on Dummy Load and delivery of all relevant documentation.

More detailed prescription for these tests are specified in the Section 5.4 of *Tender Part A(II-1): Annexure-B Technical Specifications for EC MHVPS*.

15 Maintenance Support

After delivery/ final acceptance, if it is deemed necessary, CONTRACTOR/SUPPLIER should be able to provide maintenance support directly or indirectly. A separate arrangement shall be agreed for this purpose.

16 Training

CONTRACTOR/SUPPLIER shall provide training for the working staff concerning the operation, maintenance and
troubleshooting of the systems in the Procurement.
The training shall be realized in four forms:

1. Preparation of an "Operation and Maintenance Manual" adequate to allow the on-site technical staff to get a good understanding of the equipment, of its operating modes and of the procedures to carry out settings and checks of protections, control loops, maintenance interventions, etc.
2. Informal instruction during the execution of the Contract, especially during the factory and site testing and commissioning. When the ITER-India or its representatives are present, they will be allowed to ask a reasonable number of questions and to seek clarifications without unduly delaying the activities.
3. A formal presentation to the on-site technical staff lasting up to 2 days. CONTRACTOR/SUPPLIER shall give the presentation, unless differently agreed.

CONTRACTOR/SUPPLIER shall be available to provide additional training, at additional expenses, if requested within one year from the acceptance of the system.

17 Reference documents

References appearing in Annexures can be found in zip folder on ITER-India website as per below link under Public/Global Tender Category.

https://www.iterindia.in/tenders

Part A(II-1), Annexure A: Management Specifications for EC MHVPS

GeM Bid No.	**GEM/2025/B/6267679**
Title	**Part A(II-1), Annexure A: Management Specifications for EC MHVPS**

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Acronyms & Abbreviations

CE	: Conformité Européenne, meaning "European Conformity"
EC	: Electron Cyclotron
FDR	: Final Design Review
HP	: Hold Point
HVPS	: High Voltage Power Supply
ITER	: International Thermonuclear Experimental Reactor
IO	: ITER Organization
MHVPS	: Main High Voltage Power Supply
MIP	: Manufacturing and Inspection Plan
NP	: Notification Point
PS	: Power Supply
QA	: Quality Assurance
QP	: Quality Plan

1 Introduction

This document defines the management specifications in order to comply with the legal regulatory requirements, accepted sound project management practices, safety and ITER-India QA requirements for the manufacturing, testing and supply of Main High Voltage Power Supplies (MHVPS).

2 Planning and Scheduling

Contractor/Supplier shall prepare detailed manufacturing and delivery schedule on Primavera (latest version) and shall submit monthly schedule progress updates. CONTRACTOR/SUPPLIER can use other planning and scheduling software after the written approval of ITER-India.

3 Procurement Execution

The execution does not foresee any R&D or prototyping phase. The scope of work includes detail design, manufacturing, component testing, supply, installation and acceptance testing of 4 (Four) nos. of Main High Voltage Power Supplies (MHVPSs), each rated for (-)55kVDC, 110A at Purchaser's site (ITER Organization (IO), France).

This contract shall be executed in three phases:

- **Phase I: Engineering Work and pre-manufacture Phase;** This phase comprises the Design (details & manufacturing), Call for Tender and Award of the Sub-supplier for MHVPS Sub components.

- **Phase II: Manufacturing, factory acceptance, Assembly/Integration demonstration at ITER-India Lab, and Consolidation of the Items;** This phase comprises the manufacture of the MHVPS components, and factory acceptance. First MHVPS unit shall be demonstrated for installation, assembly/integration and operations perspective at ITER-India lab. The first unit once demonstrated at ITER-India Lab, shall be dismantled, refurbished as required, packed and transported back to SUPPLIER's SITE. Components for the other three MHVPS shall be consolidated at SUPPLIER's SITE from where all four MHVPSs to be dispatched to PURCHASER's SITE.

- **Phase III: Installation and Final Acceptance Tests of the Items;** This phase comprises the installation and final acceptance of four MHVPSs units with dummy load at PURCHASER's SITE - ITER Organization, France.

4 Procurement Process

The procurement responsibilities for all the components of MHVPSs shall be undertaken by CONTRACTOR/SUPPLIER. CONTRACTOR/SUPPLIER shall procure the major components (Multi-secondary transformers, SPS modules) through OEMs by standard methodology with following phases.

- **Phase 1 – Tender notice and issue of tender document:**
  Interested suppliers, who meet the eligibility criteria[1] given in the Tender notice, shall be issued the tender document.
- **Phase 2 - Pre-Bid meeting:**

[1] *Eligibility Criteria for procurement of Multi-secondary transformers and SPS modules are detailed in Section 7 of 'ITER_D_G4QVU5 - EC MHVPS Procurement Description Document'.*

During this phase, CONTRACTOR/ITER-India shall explain the overall scope of work, schedule requirements and any technical queries. All the parties are allowed to put up their questions/clarifications. This meeting shall clarify the scope of works and address technical issues.
Following this meeting suppliers can submit their bid in the specified format.

- **Phase 3 - Bid evaluation and contract award:**
  Bid evaluation and contract award to technically acceptable lowest supplier. CONTRACTOR/ITER-India reserves the right to award or cancel the contract in case of single bid.
  CONTRACTOR/SUPPLIER shall provide ITER-India with an advance notification of 15 (fifteen) calendar days prior to evaluation meetings in order to give the ITER-India the opportunity to participate in an advisory role in such meetings.

ITER-India reserves the right to observe and advise in the procurement tendering process used under the contract. However, the parties shall mutually agree on the contents of the procurement tendering process which shall be placed for ITER-India's advice before the Call of Tender.

5 Monitoring, Evaluation and Verification

Figure 1 shows major activities and milestones with corresponding Notification Points and Hold Points. A Notification Point (NP) is a milestone where CONTRACTOR/SUPPLIER is required to notify ITER-India that it has completed a specific task or a specific deliverable and is proceeding to the next task or to the next action on the specific deliverable. A NP is meant to enable ITER-India to follow the progress of the contract and possibly to witness a critical manufacturing step at the CONTRACTOR/SUPPLIER & its supplier's premises. The Notification shall be sent by the CONTRACTOR/SUPPLIER to ITER-India at least 10 working days prior to the scheduled manufacturing step. A NP shall not affect the production flow of the Supplier that shall continue the work even without a reply from ITER-India.
A Hold Point (HP) is a milestone where the Supplier is required to notify the ITER-India, that it has completed a specific task or a specific deliverable and must stop the associated processes until a HP Clearance is issued. The HP Clearance shall be issued on the basis of clearly identified Quality Control and data and acceptance test results to be provided to the ITER-India at the time of the request. ITER-India shall have a maximum of 10 working days to review the Suppliers data to confirm or reject it. In case of clearance, the Supplier shall resume its activity. In case of rejection, the Supplier shall develop a recovery plan that shall be submitted and reviewed by the ITER-India within 10 working days of submission. In case of ITER-India objection, the ITER-India shall detail its reasons in writing and CONTRACTOR/SUPPLIER shall have 10 working days to answer the ITER-India objection and, whenever suitable, develop a revised recovery plan.
Any contact with the suppliers of the CONTRACTOR/SUPPLIER under the CONTRACT by the ITER-India shall be managed and coordinated by the CONTRACTOR/SUPPLIER

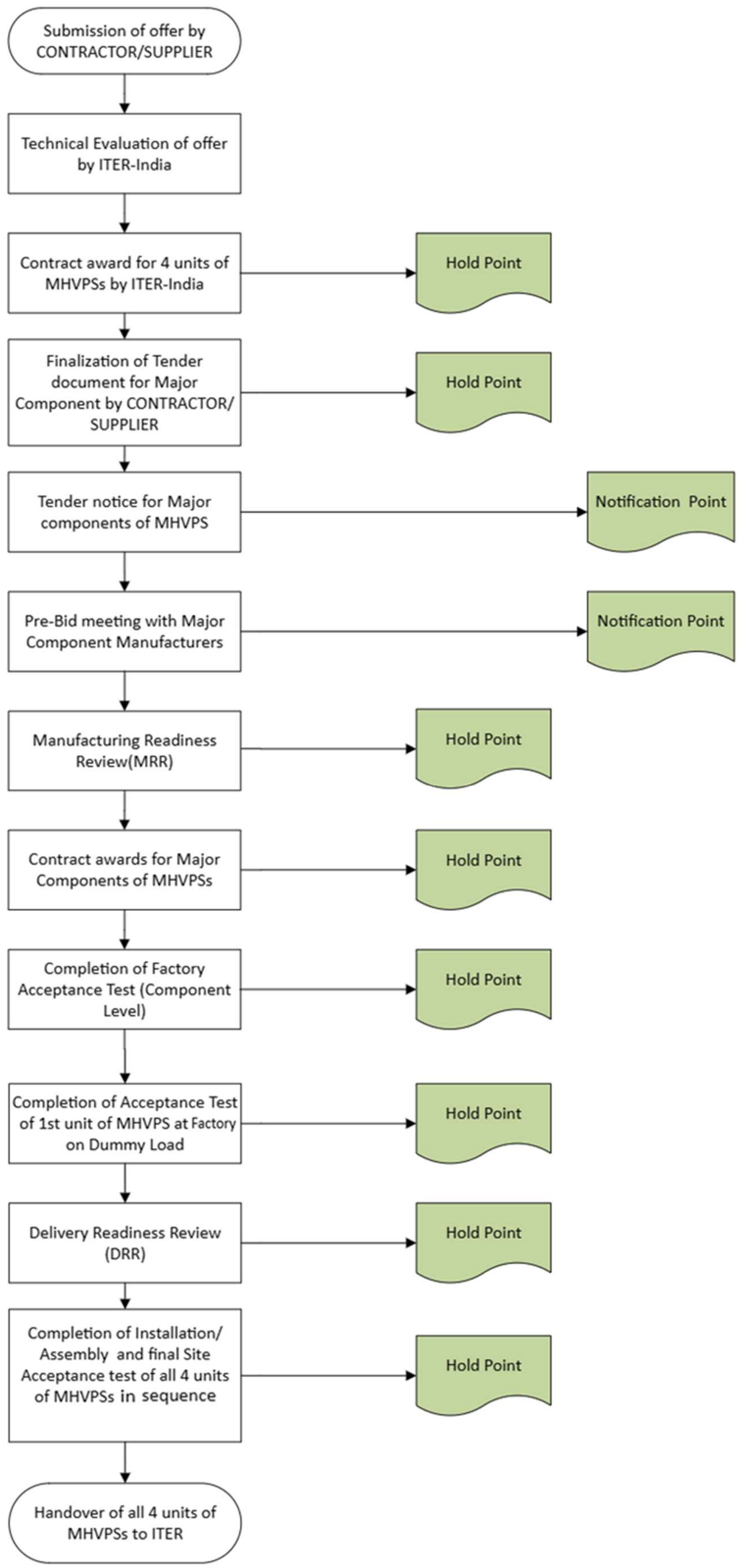

Figure 1 : Major activities/milestones & corresponding monitoring points

5.1 Periodic Reports and Meetings

5.1.1 Reporting

5.1.1.1 The CONTRACTOR/SUPPLIER shall ensure that its suppliers submit periodic reports to the CONTRACTOR/SUPPLIER and agree on periodic review meetings with the CONTRACTOR/SUPPLIER in order to monitor contract execution. The CONTRACTOR/SUPPLIER shall also ensure that its suppliers maintain data and documents and make them available upon CONTRACTOR/SUPPLIER's request to verify that the CONTRACT requirements have been implemented and satisfied. Such reports, data and documents shall be transmitted to ITER-India, for the approval/acceptance of milestones by the ITER-India.

5.1.1.2 The CONTRACTOR/SUPPLIER shall provide to the ITER-India a monthly progress report on all works under the CONTRACT by the 2nd calendar day of each month.

5.1.1.3 The CONTRACTOR/SUPPLIER shall hold at the disposal of the ITER-India and make available to it such information and documentation as the ITER-India deems necessary to determine the progress, quality and status of the work. Final documentation for ITER-India's records shall be in English. Quality control documents at the supplier level (such as procedure specifications) need to be translated into English unless specifically requested by the ITER-India

5.1.1.4 The CONTRACTOR/SUPPLIER shall report immediately to the ITER-India of any occurrence which could delay or jeopardize the proper execution of activities related to the CONTRACT.

5.1.2 Progress meetings

5.1.2.1 Progress meetings shall be conducted as required by the ITER-India or the CONTRACTOR/SUPPLIER upon mutual agreement. The frequency of such meetings shall vary throughout the progress of the CONTRACT, typically from once per month during the initial phases to once per two months at the end, assuming no qualification or production problems arises. The meetings shall be held by video conference, teleconference or physically on the ITER-India or the CONTRACTOR/SUPPLIER premises or on the supplier's premises.

5.1.2.2 Meeting minutes shall be prepared by the CONTRACTOR/SUPPLIER and submitted to the ITER-India not later than 7 (seven) calendar days after the meeting.

5.1.2.3 The ITER-India shall forward to the CONTRACTOR/SUPPLIER any comments within 7 (seven) calendar days of the receipt of the minutes. If no comments are made within this time frame, the minutes are deemed to be accepted.

5.2 Reviews and Inspections

5.2.1 Reviews

5.2.1.1 Reviews shall be carried out according to Figure 1 and as per Section 8 of *'HVPS Tender Part-A(II-1) Scope of Supply & Work, Technical Specifications for MHVPS'*.

5.2.1.2 In case of concerns regarding the quality of production, the ITER-India shall have the right to request the CONTRACTOR/SUPPLIER to carry out on-the-spot checks in addition to the checks foreseen in the technical specifications. In such a case, the ITER-India has to provide a description of its concerns and the rationale behind such request. Upon receipt of such request, the CONTRACTOR/SUPPLIER shall evaluate the potential impact of such additional spot checks on the production costs and schedule. Based on all these considerations, the Parties shall agree on a course of action to resolve such issues. The actual date(s) of the on-the-spot checks shall be determined by agreement between the Parties.

5.2.2 Right of Access

The CONTRACTOR shall ensure that its suppliers inform the CONTRACTOR of all locations where contracts are implemented. The CONTRACTOR/SUPPLIER shall provide the ITER-India with such information as soon as available. It shall further ensure that contracts include the rights of on-the-spot access to specified locations subject to the following provisions in this section.

5.2.3 Right of access of the CONTRACTOR/SUPPLIER

5.2.3.1 The CONTRACTOR/SUPPLIER shall ensure that its representatives are granted access to the premises of the suppliers and sub-suppliers in order to witness on-site tests and critical fabrication operations, and to participate in periodic review meetings.

5.2.3.2 The CONTRACTOR/SUPPLIER shall also ensure that its representatives are granted access to the premises of the suppliers at all reasonable times in order to carry out on-the-spot checks in addition to the tests foreseen in the technical specifications.

5.2.4 Right of access of the ITER-India or its representatives

5.2.4.1 The CONTRACTOR/SUPPLIER shall grant access rights to the ITER-India or its representatives and regulatory body representatives to its facilities and records and those of its supplier(s) for the purposes defined in the Quality Plan & Manufacturing and Inspection Plan (MIP).

5.2.4.2 When visits for purposes other than indicated in section 5.2.4.1 are envisaged, the request of ITER-India must be submitted at least 15 (fifteen) calendar days in advance, unless otherwise agreed by the Parties. The CONTRACTOR/SUPPLIER shall make its best efforts to ensure that appropriate facilities are available for use by such representatives.

5.2.4.3 In case of marked up interventions in the Manufacturing and Inspection Plan, it is the CONTRACTOR/SUPPLIER's responsibility to ensure that adequate notice is given to the ITER-India to facilitate such interventions and make travel arrangements.

5.2.4.4 The ITER-India shall agree with the CONTRACTOR/SUPPLIER in advance of the appointed ITER-India representatives who shall participate in activities described in the preceding sections. The appointed ITER-India representatives may be accompanied by CONTRACTOR/SUPPLIER representatives on their visits to the CONTRACTOR/SUPPLIER's and/or its suppliers' premises unless otherwise agreed by the Parties.

5.2.5 Right of access of the CONTRACTOR/SUPPLIER to the Delivery Destination

5.2.5.1 The ITER-India shall ensure that the IO grants appropriate right of access to its facilities to the representatives of the CONTRACTOR/SUPPLIER and its suppliers in order to supervise/perform the installation and/or the acceptance testing of the Items at the facilities of the Delivery Destination, where necessary.

5.2.5.2 The ITER-India shall ensure that the IO provides the CONTRACTOR/SUPPLIER with the necessary information and assistance in the performance of the installation and/or the acceptance testing of the Items at the facilities of the Delivery Destination

6 Quality Assurance

6.1. Quality Requirements shall be in accordance with ISO 9001 requirements. The CONTRACTOR/SUPPLIER shall also ensure the quality of all components and services meet the requirements of *Part A(II-1) – Annexure B: Technical Specifications for EC MHVPS'*.

6.2. Should any question whatsoever arise with respect to the requirements defined in the *'Quality Requirements for IO Performers (ITER_D_22MFG4)'*, the CONTRACTOR/SUPPLIER shall ask the ITER-India for clarification prior to proceeding with the work.

6.3. The CONTRACTOR/SUPPLIER Quality Plan subject to approval by the ITER-India shall be applied to all the work under the CONTRACT. For this purpose, the CONTRACTOR/SUPPLIER shall ensure that the suppliers carrying out contracts placed under the CONTRACT shall follow the QA requirements under the relevant QA classifications.

6.4. A list of the documentation associated with the Quality Requirements is given in Table 1 below. Moreover, on completion of the tender process, a description of the supplier's quality system shall be submitted to the ITER-India for information.

Table 1: Quality Requirements

ITER-India Quality Requirements
Prior to commencement of work on the CONTRACT: ▪ Obtain ITER-India's approval of CONTRACTOR/SUPPLIER's dedicated Quality Plan
Prior to commencement of Sub-contract work : ▪ Obtain ITER-India's approval of Sub-supplier's dedicated Quality Plan for Major Sub components viz. SPS modules & Multi-secondary Transformer.
Prior to start of manufacturing: ▪ Obtain ITER-India's acceptance and mark up of CONTRACTOR/SUPPLIER and its Sub-Supplier's "Manufacturing Inspection Plan"
During manufacture: ▪ Update Quality Plans as necessary and seek ITER-India's re-acceptance ▪ Notify ITER-India's representatives of any intervention points as marked up on the "MIPs" ▪ Sign the relevant operations and interventions in the "MIPs" as work progresses.
During contract implementation: ▪ Issue "Deviation Request" and "Non-Conformance Reports" as necessary
Prior to delivery: Complete the "Contractor Release Note" as per *'Quality Requirements for IO Performers (ITER_D_22MFG4)'*

6.5. Quality Plans shall follow *'Quality Requirements for IO Performers (ITER_D_22MFG4)'*.

6.6. Manufacturing and Inspection Plans (MIPs) shall comply to *'Quality Requirements for IO Performers (ITER_D_22MFG4)'*.

6.7. Suppliers not performing critical quality activities may be exempted from the requirement to produce Quality Plans and MIPs at the discretion of the ITER-India Quality Assurance Responsible Officer and in discussion with the CONTRACTOR/SUPPLIER Quality Assurance Responsible Officer. This decision shall be dependent on the level of detail about Suppliers work in the CONTRACTOR/SUPPLIER Quality Plan. In such cases, the work can be included in the CONTRACTOR/SUPPLIER's MIP and managed in accordance with the CONTRACTOR/SUPPLIER's management system.

6.8. CONTRACTOR/SUPPLIER shall ensure that its suppliers do not start work on any contract without a Quality Plan in place that has been accepted by the ITER-India.

6.9. CONTRACTOR/SUPPLIER shall ensure that its suppliers do not start manufacturing without an MIP in place that has been accepted by ITER-India.

6.10. CONTRACTOR/SUPPLIER shall implement, in compliance with Quality Plan, the monitoring activities including quality audits and any inspections to verify the compliance with the requirements.

6.11. ITER-India shall designate appropriate certified auditors to conduct quality audits to verify compliance with CONTRACTOR/SUPPLIER's and its suppliers Quality Assurance Program. The audit teams may be composed of ITER-India personnel and/or specialist contracted personnel.

6.12. ITER-India shall designate appropriate inspectors to perform inspections of the CONTRACTOR/SUPPLIER's suppliers to verify compliance with quality related activities. These inspections shall be performed in accordance with the MIPs. The inspectors may be ITER-India personnel or specialised inspectors contracted for that purpose.

7 CE Markings

7.1. CE Markings shall be implemented in accordance with European directives requirements, if applicable.

7.2. The list of European directives concerning CE marking is available on the following web site http://www.conformance.co.uk/directives/index.php Other useful information can be found in the "Guide of implementation of directives based on the New Approach and the Global Approach": http://ec.europa.eu/enterprise/policies/single-market-goods/files/blue-guide/guidepublic_en.pdf.

8 Change Management

All requirements of the CONTRACT and subsequent changes proposed by either the ITER-India or the CONTRACTOR/SUPPLIER during the course of execution of the CONTRACT are subject to the Deviation Request process that shall be described in Quality Plan.

Deviation and Non-Conformances shall be processed according to *'Procedure for the management of Deviation Request, ITER_D_2LZJHB'* & *'Procedure for Management of Nonconformities, ITER_D_22F53X' respectively.*

9 Information and Documentation Requirements

9.1 General Documentation Requirements

9.1.1 CONTRACTOR/SUPPLIER shall prepare the following documents in the English language unless otherwise provided in the CONTRACT:

- Intellectual Property provisions,
- each definitive technical specification for a contract under this Tender,
- day-to-day correspondence and administration between the Parties,
- all documents that are necessary to determine the progress and status of work and validate the capabilities of involved suppliers,
- all QA and safety related documentation,
- all other documentation necessary to verify the sound management of the procurement under the CONTRACT.
- Risk Plan shall set out a register of the risks which may impinge on the successful execution of the works.

9.1.2 CONTRACTOR/SUPPLIER shall issue, manage and control its documents and records in accordance with its QA Programme. Tools and software to be utilized according to Design Collaboration Implementation Form (DCIF) for EC HVPS (5.2.P4.IN.01_DCIF_for_EC_HVPS_PA_AKBX65).

9.1.3 CONTRACTOR/SUPPLIER shall ensure that all documesnts and records are uniquely identified and traceable by CONTRACT references, including subsequent revisions, and are made accessible to ITER-India authorized individuals.

9.2 Design Documentation Requirements

9.2.1 CONTRACTOR/SUPPLIER shall exchange CAD data relevant for the design and associated site interfaces in the CATIA version indicated by the Design Office of the ITER-India. CAD data associated only with production may be exchanged in other formats if compatible with the ITER-India software and agreed by the ITER-India. The CONTRACTOR/SUPPLIER shall ensure then that CAD data from suppliers is accurately converted to such version of CATIA.

9.2.2 All 3D models and 2D drawings are subject to the Procedure for the Management of CAD Work & CAD Data.

9.3 Quality Records

Quality Control and Acceptance Test records shall be maintained according to the procedures of Quality Plan. Availability to ITER-India of the required data is a pre-requisite for granting Authorizations to proceed and Hold Point clearances.

10 Environment, Safety and Health

10.1 CONTRACTOR/SUPPLIER and its suppliers shall observe all applicable environment, safety and health provisions for work on the PURCHASER's SITE, as well as specific requirements set out in this tender document.

10.2 Any activity by CONTRACTOR/SUPPLIER personnel or its Suppliers at the PURCHASER's SITE - ITER Organization, France shall be subject to the *"Internal Regulations",(Ref: ITER_D_27WDZW)*. Any additional applicable provisions regarding environment, safety and health shall be communicated by the ITER-India to CONTRACTOR/SUPPLIER at least 30 calendar days in advance of the activities to be performed at the PURCHASER's SITE - ITER Organization, France.

Part A(II-1), Annexure-B: Technical Specifications for EC MHVPS

GeM Bid No.	GEM/2025/B/6267679
Title	Tender Part A(II-1), Annexure-B: Technical Specifications for EC MHVPS

ITER-India, Institute for Plasma Research
Block A, Sangath Skyz, Bhat-Motera Road, Koteshwar,
Ahmedabad 380005, Gujarat, India

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Acronyms & Abbreviations

AC	: Alternating Current
CODAC	: Control & Data Acquisition
CIS	: Central Interlock System
CSS	: Central Safety System
CW	: Continuous Wave
DC	: Direct Current
EC	: Electron Cyclotron
EC H&CD	: Electron Cyclotron Heating & Current Drive
EC HVPS	: EC High Voltage Power Supply
ECRH	: Electron Cyclotron Resonance Heating
FDP	: Final Design Phase
HV	: High Voltage
HVAC	: Heating, Ventilation and Air Conditioning
HVPS	: High Voltage Power Supply
ITER	: International Thermonuclear Reactor
I&C	: Instrumentation and Control
INTF	: ITER-India Test Facility
IEC	: International Electrotechnical Commission
IO	: ITER Organization
JADA	: Japan Domestic Agency
MHVPS	: Main High Voltage Power Supply
MW	: Mega Watt
PEN	: Power Pulsed Electrical Network
P&ID	: Piping & Instrumentation Diagram
PFD	: Process Flow Diagram
PS	: Power Supply
PSS-OS	: Plant Safety System – Occupational Safety
PSM	: Pulse Step Modulation
QA	: Quality Assurance
RF	: Radio Frequency
SPS	: Switch Power Supply module
SPDL	: Short Pulse Dummy Load
SL	: SIL Level

1 System Overview & Performance Specifications

1.1 System Overview

The ITER project foresees 20 MW of EC power injected into the plasma, in continuous operation (CW) at 170 GHz, using RF Sources (known as "Gyrotrons") each with an output power of 1MW.

The EC system draws the required power from the ITER pulsed power electrical network (PPEN) and provides a regulated set of applied high voltages to the RF sources via a set of high voltage power supplies. The Power Supply set consists of a MHVPS, a Body and Anode PS, which provide the voltages and currents as required by the RF sources.

Two types of gyrotrons are available from different suppliers' viz. DTG (Diode type Gyrotron) & TTG (Triode Type Gyrotron). The main difference between the two is presence of Anode PS in TTG which governs beam current (MHVPS load) and Gyrotron Output power. EC High Voltage Power Supply connection scheme, operating Sequences, modulation requirements and load parameters are detailed in the Appendix-1 for MHVPS actual load behaviour with gyrotron.

Typical configurations of the main components associated with the PS set for two TTGs are shown in Figure 1 (note some minor components are neglected).

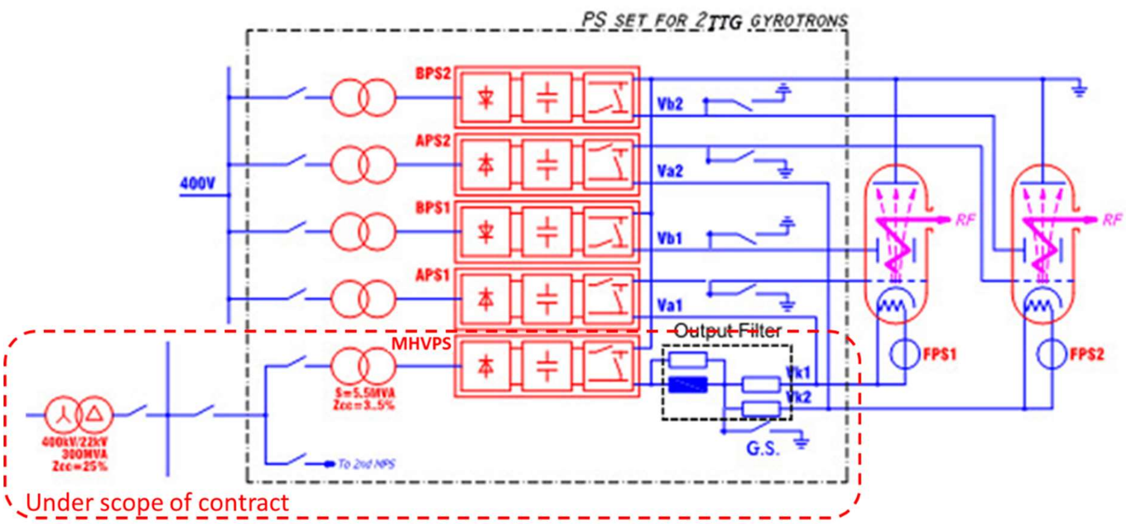

Figure 1 : Typical configuration of the main components for the TTG EC MHVPS.

This tender document covers the scope of ***Main High Voltage Power Supply (MHVPS)*** to be coupled with Triode Type Gyrotrons (TTG).

1.2 MHVPS Parameter Definition

The MHVPS voltage is required to be as close as possible to the desired reference voltage, which ensures that the applied voltages to the cathode of gyrotrons prevent a change of oscillating mode or high variations in output power.

The variation between the reference and applied voltages arises from several factors, which are illustrated in Figure 2, includes:

- Accuracy Bandwidth: range in which the average achieved voltage deviates from the set voltage
- Resolution: value of the smallest step in which the voltage can be controlled
- Terms "overshoot" and "undershoot" are defined with respect to ground. The Cathode Voltage being negative with respect to ground, a cathode voltage overshoot means an increment of its absolute value.

- Ripple: Level of instantaneous voltage variation arising mainly from the module switching and line voltage.
- Repeatability: variation in average achieved voltage from shot-to-shot keeping the same reference voltage.

The maximum limits of these parameters are listed in Table 1**Error! Reference source not found.**.

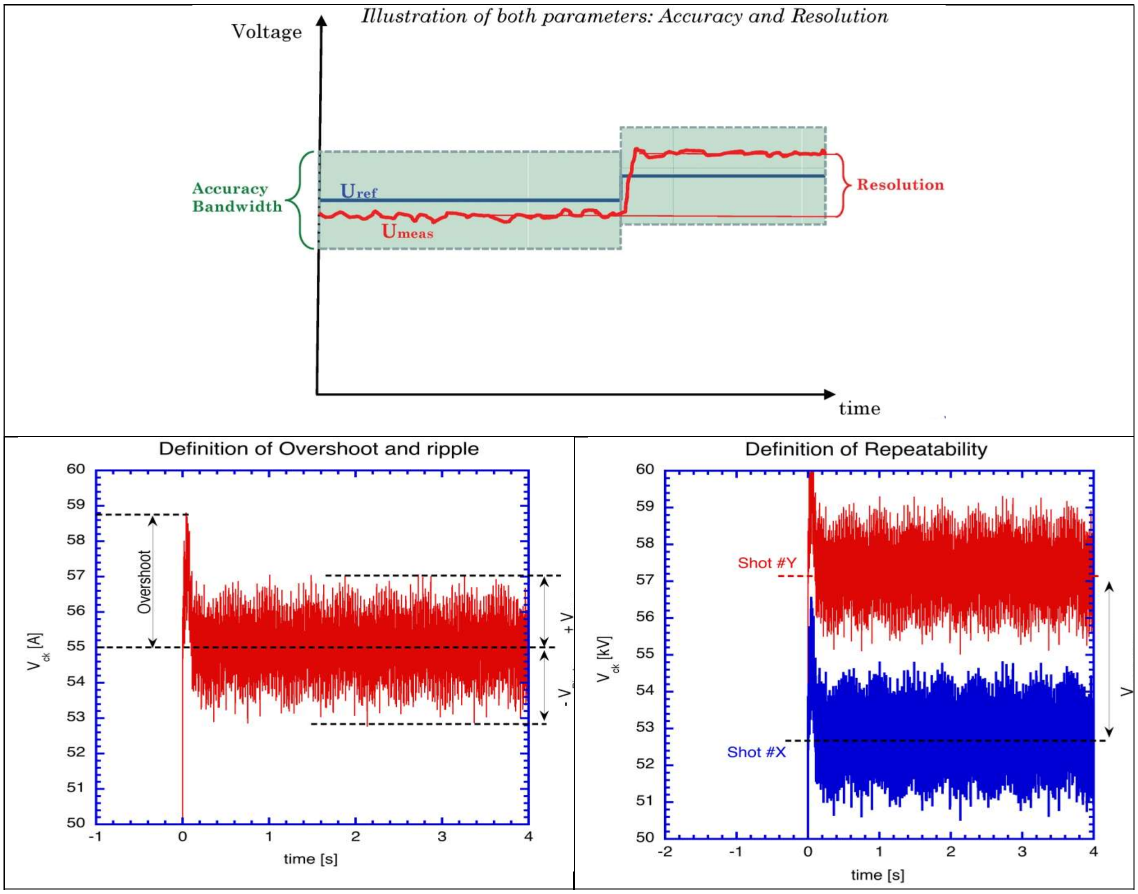

Figure 2 : Definition of MHVPS parameters

1.3 MHVPS functional parameters and operating mode

The positive terminal of the MHVPS shall be connected to the grounded collector, the negative terminal to the cathode. Thus, the MHVPS positive output voltage V_{ck} corresponds to $-V_k$ in **Error! Reference source not found.** of Appendix-1:.

The nominal value of the MHVPS voltage V_{ck} shall be 55 kV with regulation between 35 kV to 55 kV. The nominal DC current is 110 A, equivalent to 2 gyrotrons generating a RF power of 1 MW.

The total efficiency of the MHVPS, defined as the ratio between the power supply output DC power and the input AC active power at the nominal conditions, shall be > 97% in steady state operation.

The voltage ramp-up time is defined as the time elapsed between the 10 % and the 90 % of the V_{ck} final "ON' value. Similarly, the ramp-down time is computed between the 90 % and the 10 % of the starting 'ON' value.

*The "step" parameters in **Error! Reference source not found.** take into account that a TTG may have a RF power step-up/down by the anode potential: in this case, the overshoot effect, induced by the load step shall be limited to <2% of rated voltage while undershoot is not critical.*

In case of a severe fault, as an arc in the gyrotron or in the transmission line, the PS shall be able to switch-off the output voltage to comply with the total charge delivered to the arc, shutdown time and transient duration specified in Table 1.

After the severe fault event, the MHVPS shall re-establish the output voltage according to the pause time and rise time for the pulse restart. This pause time and rise time shall be adjustable within the range defined in **Error! Reference source not found.** and its value controlled by the EC Plant Controller via the MHVPS controller.

The harmonic content rejected in the PPEN by the MHVPS rectified currents should comply with the IEC guidelines. The Supplier shall adopt all the actions necessary to minimize the harmonic distortion (e.g. phase shift of the transformers' 3-phase voltages, management of the modules switch-on/off).

The limitation prescribed for the power transformers inrush current (limited to 10 times the transformers rated current) entails the need of soft-start units, which are in that case under supplier procurement scope.
Both the terminals of the MHVPS consist of insulators sized for the nominal voltage (55 kV). The positive terminal may not be directly grounded, but its voltage to ground is limited in the range ±5 kV by surge arresters.

The MHVPSs shall have over-current and over-voltage protections with adjustable thresholds. Their tripping can produce the output voltage shutdown.

The MHVPS shall be able to provide a set of measurements concerning its internal status and parameters. The characteristics of such measurements (in terms of accuracy, resolution, times, etc.) shall be adequate to verify all the specifications reported in Table 1 : MHVPS Specifications**Error! Reference source not found.**.

The Technical specifications for the MHVPS are summarized in Table 1 : MHVPS Specifications**Error! Reference source not found.**. along with a parameter description and typical reference value(s).

Table 1 : MHVPS Specifications

	Parameter	Value	Comment
1	V_{ck} waveform and modulation type	DC	The positive output is referred to the grounded collector
		ON/OFF	Output voltage modulated between "ON" value ≤ 55 kV and "OFF"
2	V_{ck} nominal	55 kV	The range 0 – 35 kV is achievable by coarse steps, the range 35 – 55 kV can be regulated with the resolution in Item #7
	V_{ck} range	0 – 55 kV	
	V_{ck} fine regulated range	35 – 55 kV	
3	Ramp-up/down time	≥0.1 ms	Regulated ramp-up/down time (10 – 90 %) configured by an internal reference generator
	Settling time	< 50 µs	
	Max overshoot/undershoot[1]	≤ ±1 % (±550 V)	
4	Step settling time	< 50 µs	Load step transient: more important in TTGs
	Step overshoot/undershoot	≤ ±2 % (±1100 V)	

[1] Undershoot shall be limited to <2% of rated voltage during Anode voltage ramp-down, however limits on overshoot during load step be removed.

	Parameter	Value	Comment
5	V_{ck} accuracy	≤ ±0.5 % (± 275 V)	Difference between the measured output and the reference voltages
6	V_{ck} repeatability	≤ ±0.5 % (±275 V)	Average deviation of the DC output voltage between pulses configured with identical parameters
7	V_{ck} resolution	≤ 0.5 % (275 V)	Smallest variation of V_{ck} resulting from a variation of the reference voltage
8	V_{ck} ripple	≤ 1 % (≤550 V_{pp})	This limit can be higher if the V_{beam} ripple can be compensated by the BPS (the ripple has low frequency)
9	V_{ck} modulation range	0 – 55 kV	ON-OFF modulation
10	V_{ck} modulation frequency	0 – 1 kHz[2]	
11	Max V_{ck} modulation duty cycle	½	'ON' voltage duration divided by the modulation period
12	Modulation maximum ramp-up/down time (10 – 90 %)	< 40 µs	Time characteristics of the V_{ck} ON/OFF modulation
	Modulation settling time	< 20 µs	
13	Nominal cathode current (reference)	2 × 50 A	
	Alternative higher nominal cathode current	2 x 55 A	To cope for future gyrotron power increase Implementation depends on the possibility to accommodate the associated cost increase
14	Total charge delivered to an arc in case of fault	≤ 100 mAs	Calculated to be equivalent to < 10 J for an assumed arc voltage of 100 V
15	Shutdown time	≤ 10 µs	Time between the detection of an arc (often over-current) and the instant when V_{ck}<10% of the nominal voltage
	Transient duration	≤ 20 µs	Time between arc detection and the instant when V_{ck} remains inside the accuracy range
16	Minimum pause time for a restart after a fault outside the PS system	200 ms	In case of a severe fault, the output voltage must be switched-off and re-established within these times

[2] Note that ITER INDIA is encouraged to increase the modulation frequency range with the MHVPS up to 5kHz so as to adopt the full power modulation strategy. If achieved, it is understood that the cooling interfaces will be adapted accordingly.

sr. no 9 and 10 specify the modulation range and frequency. The MHVPS under this procurement arrangement will be interface with Triode type Gyrotron (JADA scope). The modulation will be controlled by the APS and its associated HV switch, the MHVPS shall be subject to indirect modulation by the APS due to load.

	Parameter	Value	Comment
	Rise time after a fault event outside the PS system	0.1 – 1 ms	
17	Total MHVPS efficiency	> 95 %	Steady state operation at the regulated V_{ck} range (35 – 55 kV) and related current generating at least 3.5MW of output power
		> 96 %	Steady state operation at the gyrotron operating V_{ck} range (45kV-50kV) and related current generating at least 4MW of output power
		> 97 %	Steady state operation at nominal values
18	MHVPS power factor	> 0.9	
19	Load to the PPEN	22 kV ± 10 %	
20	Maximum pulse length	3600 s	
21	Maximum Duty Cycle	¼	

1.4 MHVPS Short Pulse Dummy load functional specification

This Procurement includes one DL for MHVPS (short pulse). The main requirements for these loads are listed in Table 2. Note that a MHVPS full power dummy load with longer pulse length will be available at Purchaser's Site to test the MHVPS.

Table 2 : SPDL specification

DL Parameter	Short Pulse MHVPS DL (scope of tender)
Load type	Resistive (not inductive)
Resistance	610Ω
Equivalent capacitance (including 10 m cable)	Cable capacitance
Tolerance (at 25 °C)	±10 %
Nominal voltage	–55 kV DC
Nominal current	100 A
Maximum pulse length at nominal conditions (5.5 MW	250 ms
Maximum duty cycle (for 5.5 MW pulse)	5.5 MW every 200 s
Cooling system	Air/Demineralized water

The withstanding and maximum voltages are to be based on Table-1 of IEC 61936-1 (2nd and 3rd column, respectively).

Adjustable spark gaps shall be installed in parallel to the MHVPS dummy load to test the MHVPS protection system.

The "Short" pulse dummy load, described in Table 2, which is within the scope of this procurement, provides rapid testing of the MHVPS once these are installed in their final positions. This load will be easily moveable and positioned close to the MHVPS to minimize effect of long cables.

All dummy loads will be equipped with the necessary cooling system (preferably air cooled, with fans if necessary) to comply with the loading conditions defined above. The appropriate detectors and meters are provided with each load to monitor their status and ensure proper operating conditions. These meters and detectors will be connected to the PS control system.

2 System Description

The reference scheme selected for the EC MHVPS is based on the Pulse Step Modulation (PSM) topology, consisting of many pulsating dc low-voltage modules placed in series and supplied by power transformers (Cast resin dry type) with several secondary windings. This solution provides high dc output voltages with fast dynamic responses.
In a PSM based HVPS, high frequency switching ripple of single SPS module voltage i.e., 708V peak-peak before filter inductors is observed.

Filter inductors are selected based on maximum allowable output voltage ripple of 550V peak-peak (±0.5%) and to protect the SPS modules' IGBT during short circuit.

The configuration of the PSM based PS is considered with 96 numbers of SPS modules which allows.

- Input voltage of SPS module close to the standard voltage class for COTS component selection
- Manufacturing feasibility of multi-secondary transformer
- Output ripple within acceptable range
- Feasibility of filter inductor at the output in terms of size & space.

For example, selection of SPS input voltage with in 690V allows use of standard capacitor bank in SPS module. Based on standard industrial practice, 1700 V IGBT can be utilized.

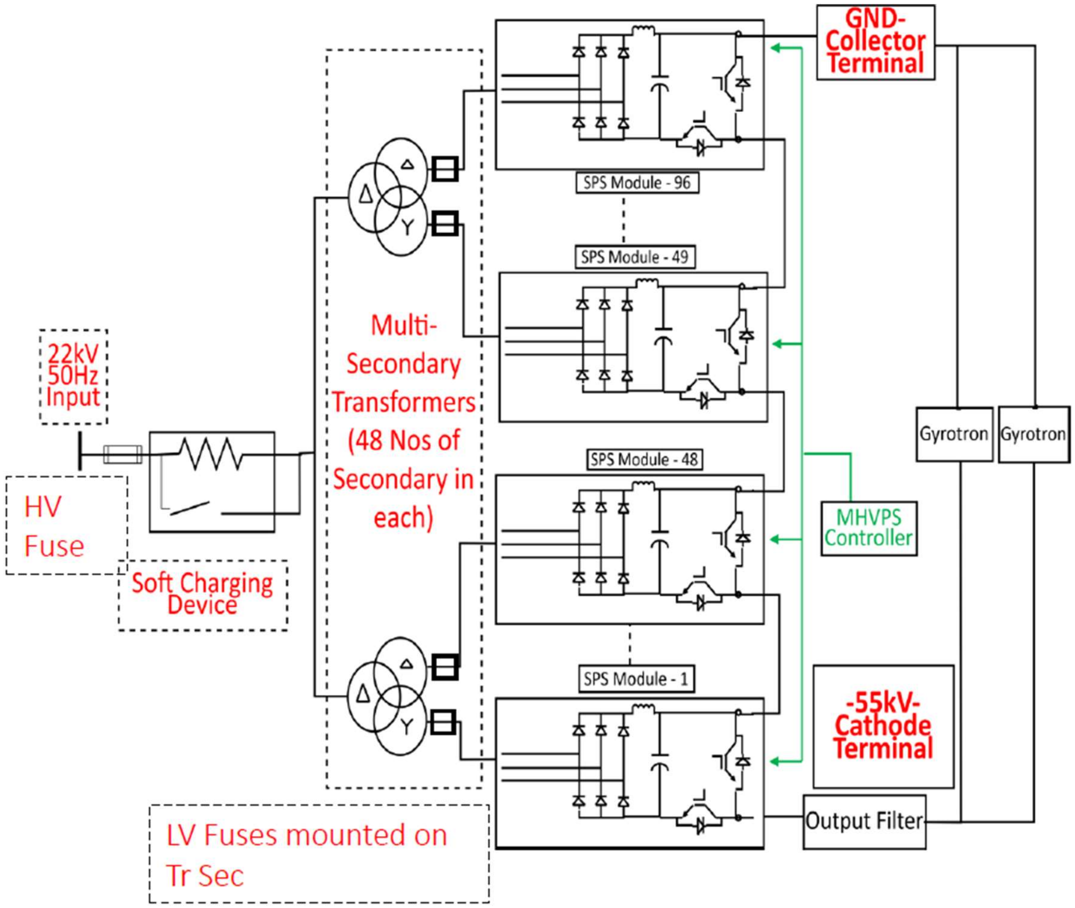

Figure 3 : EC-MHVPS reference scheme

3 Interface

3.1 General

The MHVPS system will have electrical interfaces with the following systems:

1. The Pulsed Power Electrical Network (PPEN) system (22 kV AC);
2. The Steady State Electrical Network (SSEN) system (400 V AC);
3. The EC gyrotrons;
4. The Grounding Network;
5. The plant I&C system (the interface could consist of optical fiber terminals);

Note that each PS set will include at least one Local Control Cubicle (LCC), which will exchange signals with the ECH&CD Plant System I&C either directly or through other control unit(s) of the MHVPS system.

Additional interfaces between the MHVPS system and site/services include:

1. Interface with the ITER cooling system;
2. Interface with the ITER Liquid and Gas distribution system (compressed air and nitrogen);
3. The building and the respective facilities;

3.2 Interface with the 22kV distribution system

The PPEN electrical parameters are listed in Table 3, which are to be assumed for the design of the MHVPS System.

Table 3: Main specifications of the AC MV network (PPEN).

Parameter	Value
Nominal voltage	22 kV
Highest system voltage	24 kV
Voltage operating range	22 kV ± 10 %
Nominal frequency	50 Hz
Frequency range	50 Hz ± 1 %
Distribution system	3Ph+E

The PPEN is equipped with 3 step-down transformers, each having the following characteristics: 400/66–22 kV, 300/250–150 MVA, Z12 = 11%, Z13 = 25% and Z23 = 14% (with tolerance of 10% @ 66 kV and 7.5% @ 22 kV). The PPEN supplies the 22 kV to the MHVPS system through six three-phase single-core cables. The cables are routed building 32, through the tunnel work under the assembly hall to the southwest region of the RF Building. The copper conductor section is 240 mm^2.

The power transformers in-rush currents shall be limited to 10 times the transformers rated current. If this value is to be exceeded by the transformer, a limiting system (soft-start) should be installed. In such a case, these components would be included in the scope of this procurement.

The boundary between the PPEN and the MHVPS system will be the end of the cables inside the RF building. All the cabling downwards (toward the gyrotrons) from this interface point is included in the scope of the MHVPS procurement. The MHVPS Procurement also includes the cable terminals and their connections, which will be connected to the MV AC cells circuit breaker or motorized disconnecting switch (the choice will be based on the analysis of the electrical network protection), that could be included in the soft-start unit.

The last design calculations of PPEN at 22kV confirm that MHVPS component connected to PPEN should be designed to withstand a maximum short circuit current of 33.65 kA. As a reference, all PPEN components are sized to withstand a 40kA short circuit current during 1 second. If required, PPEN circuit breakers, can be tripped to protect the MHVPS system. The supplier shall identify the need of such protections prior to the design.

In order to minimize the current harmonics rejected on the PPEN network, the MHVPS shall adopt a 12-pulses (or greater) rectifier topology. For information, Table 4 lists the current harmonics values of an ideal 12-pulses rectifier whose current wave has a rectangular shape.

Table 4 : current harmonics for an ideal 12-pulses rectifier

Harmonic order	Harmonic current limit
Lower (except the fundamental one) and intermediate	0
11	9.09 %
13	7.69 %
17	5.88 %
19	5.26 %

23	4.35 %
25	4 %
35	2.86 %
37	2.7 %

3.3 Interface with the LV distribution system

The main function of the Steady-State Electric Network (SSEN) is to transform AC power received from the French 400 kV transmission grid and distribute it to the ITER plant components (SSEN clients) that require steady state electric power.
The SSEN provides electrical power to PBS clients according to the following classification:

- Class I-Safety: Uninterruptible DC for components
- Class II-Safety: Uninterruptible AC for components
- Class III-Safety: Emergency AC power (temporarily interruptible) for components
- Class IV: AC grid power (indefinitely interruptible).

The low voltage (400/230 V) (here Class II & Class IV) is supplied by the Steady State Electrical Network (SSEN). The main parameters of the SSEN supplying the heating systems are listed in Table 5.

Table 5 : Main specifications of the Class IV LV network (SSPEN).

Parameter	Value
Nominal voltage	400/230 V
Voltage operating range	400 V ± 10 %
Nominal frequency	50 Hz
Frequency range	50 Hz ± 1 %
ITER Voltage Class	IV and II
3-phase distribution system	3Ph+N+PE
1-phase distribution system	1Ph+N+PE
Total harmonic distortion	< 5 %

The interface between the SSEN and the MHVPS system are the terminal boards of the LV panels placed near the west side of the RF building. The connections to the EC MHVPS equipment are included in the Procurement.

The MHVPS system control equipment will be supplied by uninterruptible AC power network (here Class-II) as described in table below.

Table 6: Main specifications of the Class II LV network (SSPEN).

Parameter	Value
Nominal voltage	230 V
Voltage operating range	230 V ± 10 %
Nominal frequency	50 Hz
Frequency range	50 Hz ± 1 %
ITER Voltage Class	II
Distribution system	1Ph+N+PE

EC class II distribution board in RF building	1.0 kW
Total harmonic distortion	< 5 %

The number of SSEN connections will depend on the system design. The present interface assumes one connection of class II & class IV type for each MHVPS.

3.4 Interface with the grounding grid

Grounding refers to the connection point/bus to the site/building earth grid. Grounding scheme must conform to the reference document under title '*ITER Electrical Design Handbook*'. SUPPLIER will connect the ground terminal of each MHVPS to the closest terminal of the ground network of the building (included in the building plants). The cable and its connector leading from each PS ground terminal is the interfaces between the PS internal grounding system and the IO grounding network. Likewise, the interface is between cables leadings from the cubicle earth terminals to the site/building earth grid. The type of termination shall be agreed with the ITER INDIA during the design phase.

The ground network inside each MHVPS will be provided, which prevents closed current loops.

3.5 Interfaces with CODAC

The architecture of the ITER I&C system is schematized in Figure 4 : Architecture of the ITER I&C System. The main elements of this system are:

- Control, Data Access and Communication system (CODAC);
- Central Interlock System (CIS);
- Central Safety System (CSS) via PSS-OS;
- Plant System I&C.

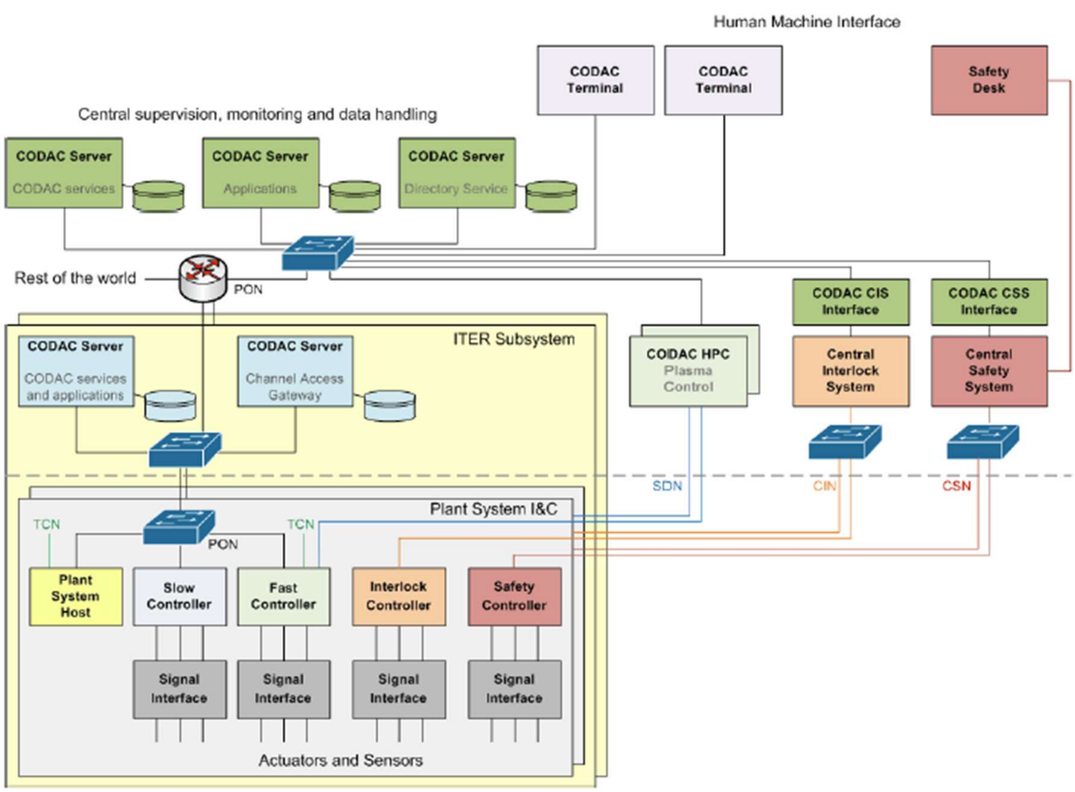

Figure 4 : Architecture of the ITER I&C System

The interface with CODAC is typically with the three systems:

A. CODAC I&C (instrumentation and Control)
B. CSS (Central Safety System) via PSS-OS
C. CIS (Central Interlocking System)

The interface between the MHVPS local controller and the CODAC systems will be the connection at the LCU (Local Control Unit) with the CODAC Network, which will be used to transmit information between the PS LCU and the EC Main Controller and the other EC sub-system LCUs.

The following sub-sections describe in more detail the interfaces with each of the CODAC systems.

3.5.1 Interfaces with CODAC I&C

The ITER I&C system architecture with the CODAC I&C is illustrated in Figure 4. Note that the ECH&CD system is considered as a single plant and the MHVPSs as sub- system within this plant. As a consequence, one controller of the ECH&CD system will be interfaced with the CODAC by the PON.

The control of the MHVPS system will be realized by PLCs and/or Fast Controllers (e.g. Industrial PCs). They shall be connected to the components of the MHVPSs by cables and/or optical fibers and shall exchange signals with the controllers that are higher in the hierarchy.

CONTRACTOR/SUPPLIER will be responsible for the MHVPS control system design and on the basis of the requirements specified in the technical specifications (Section 4.1). The Procurement shall include the hardware and software interfaces with the plant (ECH&CD) controller.

3.5.2 Interface with CSS (via PSS-OS)

EC MHVPS have an interface with CSS though PSS-OS. MHVPS controller shall have a hardwired interface with PSS. On reception from PSS, HVPS shall be configured to safe state. It shall also accept request from PSS to reset local safety functions. Refer Section 4.1.2.7 for further details.

CONTRACTOR/SUPPLIER shall design the MHVPS control system structure based on the requirements and standards specified in the technical specifications. The system's safety functions shall be seamlessly integrated into the appropriate control framework. The procurement process shall encompass dedicated hardware and software interfaces for integration with the PSS-OS.

3.5.3 Interface with CIS

The CONTRACTOR/SUPPLIER shall design the structure of MHVPS control system on the basis of the requirements and the standards indicated in the technical specifications. The interlock functions of the MHVPS system shall be integrated in the proper control system. The Procurement shall include dedicated hardware and software interfaces with the interlock plant (ECH&CD) controller.

The MHVPS control system complying to the Interlock requirements shall be detailed out during final design phase.

Kindly refer Section 4.1.2.6. for further details.

3.6 Interfaces with the Cooling Water System

The Supplier must minimize the heat losses by an optimized system design and component selection. The heat shall be dissipated partially in the building air and partially in the water-cooling systems, with preference to minimize the thermal load to the building air.

The CWS parameters and the chemical characteristics are given in below table.

Table 7 : Parameters of the ITER cooling water systems

Cooling water parameter	CCWS-2A

pH @25°C	6.5 – 7.5
Water Conductivity @25°C, max	1 µS/cm
Dissolved O_2 concentration, max	50 µg/kg
Total organic content, max	100 ppb
Particle maximum dimensions	10 µm
Chloride, max	10 ppb
Iron, max	10 ppb
Silica, max	200 ppb
Water inlet temperature, max	31°C
Water inlet temperature, min	> dewpoint and ≥ 10°C.
Water outlet temperature, max	75°C
Water inlet pressure, max	0.8 MPa
Pressure drop (max @ nom flow)	0.55 MPa
Total flow rate available for the MHVPS system (l/s), max	5 l/s
Cooling plant materials	**Stainless steel, copper, elastomeric, thermoplastic**

The total flow rate available is for the operation of the MHVPS system in steady-state and baseline modulation regime at the gyrotron operating range (45kV-50kV and related current generating 4MW of output power per MHVPS unit). Additional flow rate will be available for the individual acceptance tests of the MHVPS units at nominal power (nominal PS values).

3.6.1 MHVPS cooling system requirements

The MHVPS cooling plant shall be designed on the basis of the nominal PS values, maximum pulse length and of the duty cycle (see Section 1.3) The cooling design should minimize the coolant flow required, while ensuring sufficient margin for safe operation. Critical components that risk over heating shall have integrated temperature monitoring and an interlock system, which prevents damage to the components or PS.

The use of aluminum components (e.g. heat sinks) in contact with the cooling water is forbidden.

ITER INDIA encourages CONTRACTOR/SUPPLIER to use demineralized water (rather than air cooled) for heat evacuation from the MHVPS modules. The module cooling system design shall minimize the heat load to the building air. The water circulation in the modules shall be controlled by flow switches with appropriate interlocks.

The temperature measures and the flow states coming from the sensors shall be collected and managed by the MHVPS Local Controller that shall send the processed information to the EC Plant Interlock and Control System and to the PS local interlock system.

Isolation valves shall be installed at the interface points with the building plant and anywhere needed to facilitate the maintenance procedures. Proper automatic air bleed valves, filters and drain valves shall be included as required for maintenance of individual PSs.

The interface between the Site water cooling plant and the MHVPSs will be a set of 6 to 12 feed/return pipes with valves. The flanges of these feed/return pipes define the boundary between the building plant and the MHVPS procurement.

The final parameters (flow, pressure drop, mechanical interfaces, etc.) of the cooling plant of the MHVPS modules will be defined during the design phase. Note that any modification must maintain compliance of the maximum cooling parameters as defined above.

3.6.2 Other PS cooling system requirements

ITER will provide air ventilation for the RF Building by ducts and openings.

The parameters of the HVAC system are summarized in below table.

Table 8: Indoor ambient conditions controlled by the HVAC system

Condition	Value
Indoor temperature range	10 to 35 °C
Indoor temperature range tolerance	±2 °C
Room relative humidity	15 to 85 %
Minimum fresh air requirement	30 m^3/hr/person
Room pressure relative to outside environment	Positive
Minimum filtration efficiency: filter class (EN 779)	G4/F7
Building HVAC design basis value on L1 (1,2)	624 kW
Building HVAC design basis value on L1 (1)	544 kW

1: Estimated peak heat dissipation from all the PS components installed on that level during plasma pulse. The scope under this Tender represents 1/3rd of the total MHVPS components.

2: Heat dissipation from transformer is assumed to be averaged as per maximum operation duty cycle (1/4)

The HVAC system is designed to guarantee the maximum indoor temperature and indoor humidity indicated in the above table. These values are assumed as an average over the room volume. The CONTRACTOR/SUPPLIER may assume that the transformers are disconnected from the grid if the HVAC design basis power value is insufficient for specific operating conditions.

CONTRACTOR/SUPPLIER will provide a list of heat loads and flow requirements to each cooling circuit and to the building HVAC system during the FDP. The loading will be described for the different operating scenarios envisioned for the MHVPS.

3.7 Interfaces with the Liquid and Gas Distribution System

The ITER compressed air plant includes a distribution system up to the HV zones of each MHVPS. The compressed air system ends in an isolation valve. From this isolation valve, the tube or pipe work channel distribute the compressed air to the various pneumatic actuators. The interface between the MHVPSs and the compressed air distribution system is the connection between the tube/pipe work and the compressed air isolation valve. Any additional filter, pressure regulator, flow measuring device, gauge needed for a proper functioning of the EC MHVPS system is included in this procurement.

3.8 Interfaces with the building

EC MHVPS are installed in RF building 15. This is a 3-level building, divided on the north-south axis into "bays". The two south end bays of the 2 first levels are allocated to the EC MHVPS. The Main High Voltage Power Supply (MHVPS) units are located on Level-1 while the Level-2 being allocated ECC Cubicle.

The total space allocation for 4 nos. of MHVPS is 10.4m x 17.4m.

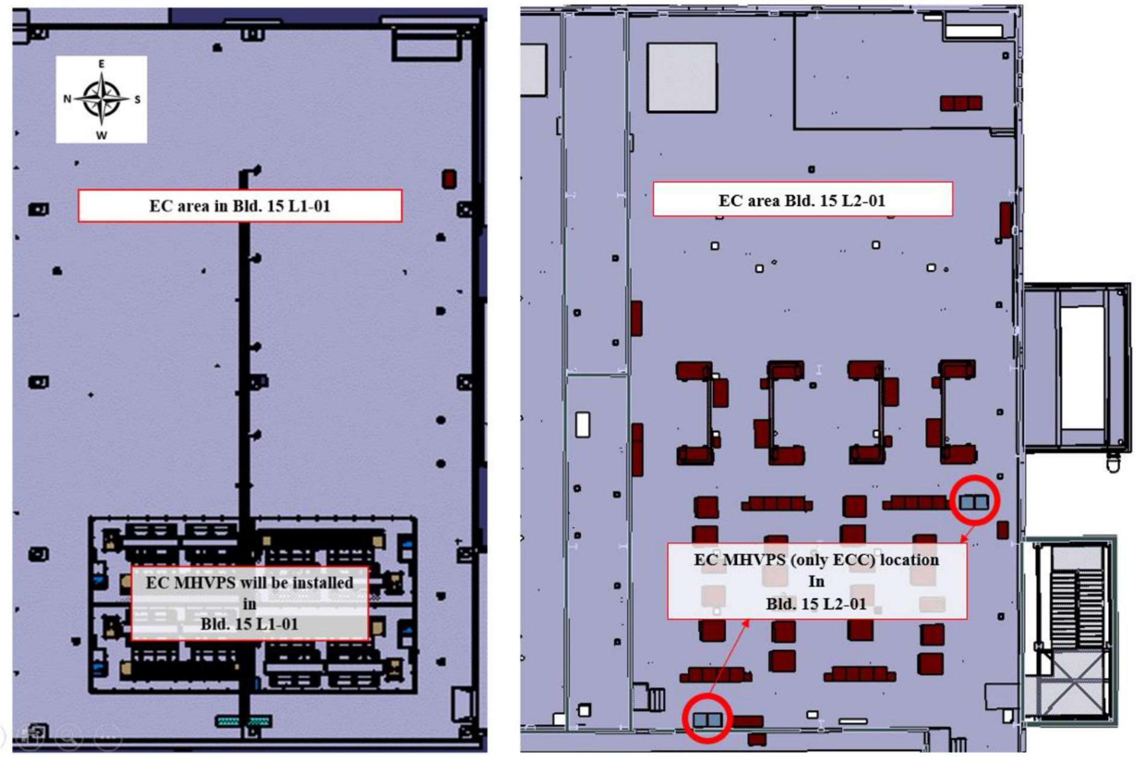

Figure 5 : Space reservation for EC MHVPS

All the components are installed indoors, and occupy the first two of three levels of the RF building. The reference drawings define the lay down areas for all the PS equipment. No extra area will be allocated for the PS equipment. Assembly of the PS equipment is assumed to be performed in the same allocated space.

The transport and lifting tools for installing the PS equipment is a task included in the Procurement. The building crane (Safe Working Load of 5 tons) is provided and can be used lifting equipment. The crane operation is managed by the IO.

The maximum load to the floors and interfaces shall be in accordance with *Section 9.2 of Tender Part A(II-1), Annexure C: Quality & Site Specification*. These values shall be confirmed during the final design phase.

4 Technical requirements

4.1 Instrumentation and Control system

The EC control system follows an integrated approach, in which the complete control system will be structured including the main and local control units from each sub-system procurement. The integrated approach will ensure compatibility between the local control units, the main controller and CODAC.

4.1.1 EC MHVPS System local control

EC MHVPS system shall be equipped with its hardware and software to

- Acquire data from sensors (of control, interlock and safety type);
- Process data and make decisions on EC MHVPS system local actions;
- Transfer data to/from the plant (ECH&CD) controller;
- Control and coordinate local actuators;
- Record the sequences of the MHVPS state changes to document faults and anomalies;
- Interface with HMI.

The EC MHVPS local control system shall adopt a modular design and can be controlled in local or remote mode, in particular during commissioning, testing and maintenance phases. The local controllers are to be configurable for synchronous operation and parallel interlocks.

EC MHVPS local control system shall include a Human Machine Interface (HMI). The HMI shall allow operation of individual MHVPS with the relative dummy loads. The HMI provides the capability to implement and check all the functions of the EC MHVPS system, included the realization of reference signals.

Fiber Optic cables is the preferred method of transmitting signals between the equipment internal to EC MHVPS system as well as between the EC MHVPS local controller and the EC PSH. The signal transmission speed inside the EC MHVPS system must be consistent with the equipment response and with their protections in case of faults.

The EC MHVPS Local control system shall include adequate easy-access test points in order to simplify and expedite the maintenance and trouble-shooting activities.

During the FDP, SUPPLIER and the ITER INDIA shall agree on the final design of the EC MHVPS control system, including structure, features, signal lists, test points, etc.

4.1.2 Architecture of the Plant Control System

Figure 6 depicts the Plant Control System architecture. It only shows one set of power supplies together with its interfaces to CODAC, CIS, and CSS (via PSS-OS).

Each PS set, composed by 1 MHVPS shall be designed as an independent subsystem, which will feed two gyrotrons.

It is noted that the EC plant controller, which is presently not defined, is not shown in the diagram of Figure 6 and is not part of this procurement. EC Plant controller shall act as interface layer between MHVPS units and CODAC/CIS/CSS.

It is expected that, in order to perform the control and protection functions of the power supplies, there will be a number of PLCs and power converter fast controllers (which have to be defined by the supplier).

It is expected that slow control functions, as the temperature control, will be implemented within PLCs, possibly within those that provide the interface to PSH.

The Suppliers scope of work is to provide the individual controller with necessary functional ability to operate the 4 nos. of MHVPS units and communicate with the EC Plant Controller (remote or local). Figure 6 only depicts the architecture and not the procurement scope.

The Plant System Controller is a Fast Controller. Its function is to act as interface between CODAC and the analogue I/O of each PS set. In order to allow independent operation of each set, there shall be one Fast Controller for each set. It will interface to CODAC via PON. It will contain a number of ADC and DACs and shall be able to acquire and generate signals compatibly with each PS analogue input/output specification.

The Plant Protection System is the interface between the MHVPS controller and CIS. This interface will have to deal with both slow and fast protection signals. This system will not perform any other function a part from interfacing to CIS.

All the regulatory occupational safety functions shall be implemented within the MHVPS. Additionally, each MHVPS shall interface to the PSS-OS, by means of a set of remote input/outputs.

Each MHVPS set shall inform PSS-OS about any local safety function that has been triggered. Each

HVPS set shall accept PSS-OS requests to reset local safety functions.

A mini-CODAC will be used during commissioning and test phases. Note that PSH, EC Plant Controller, CODAC, mini-CODAC, CIS and CSS-OS (or PSS-OS) will be supplied by ITER India/IO and are not included in this procurement.

The interface between each PS set and the "interface layer" is described in the following sub-sections.

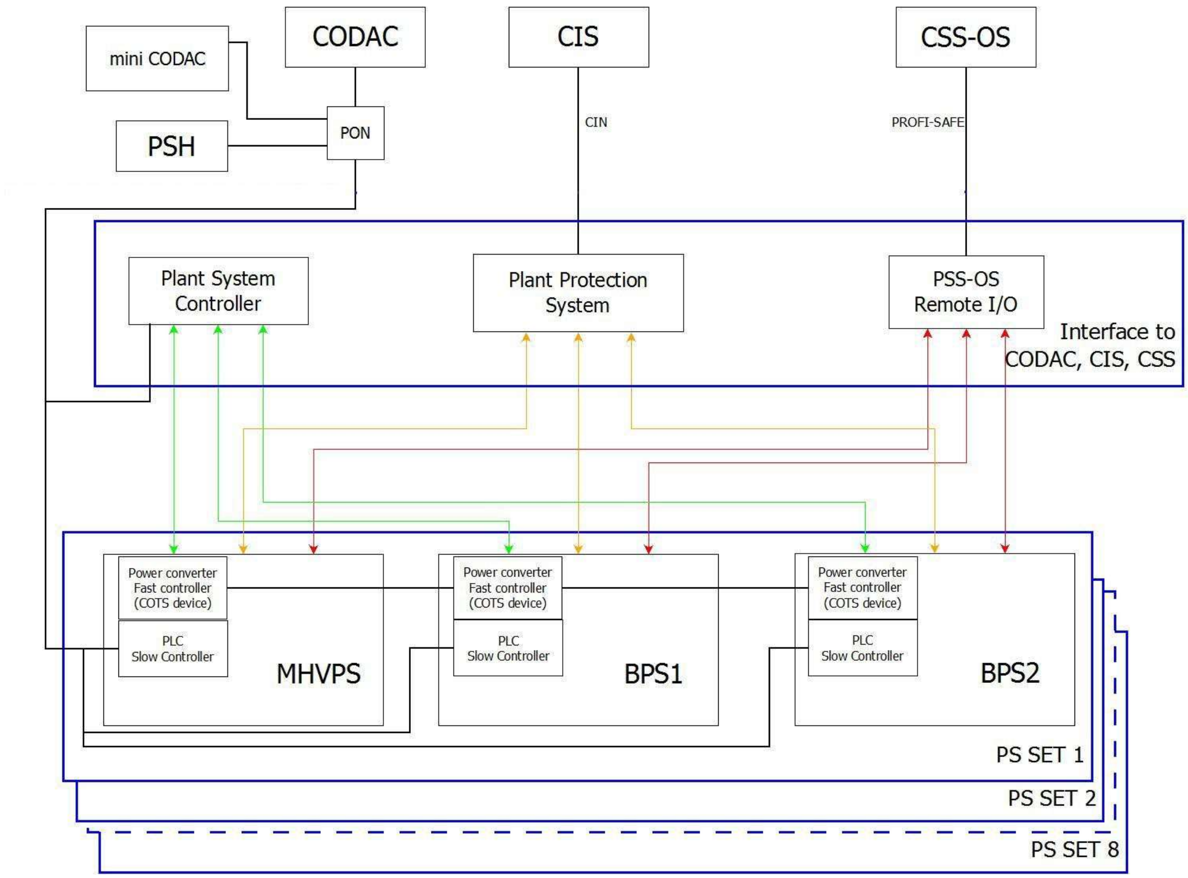

Figure 6 : Plant Control System architecture

4.1.2.1 Interface between Power Supply Units and Gyrotron Controller

The HVPS can be controlled either locally (for test purpose) or remotely, from CODAC or from gyrotron controller. In remote operation, the local slow controller will receive its commands over the Plant Operation Network (PON) from the CODAC or over the Profinet link from the Gyrotron Controller.

Gyrotron controller have two major interfaces with MHVPS:

- Protocol Interface (Profinet) for any periodic communication between Gyrotron and HVPS slow controller
- Hardwired Optical Links: digital, Analog

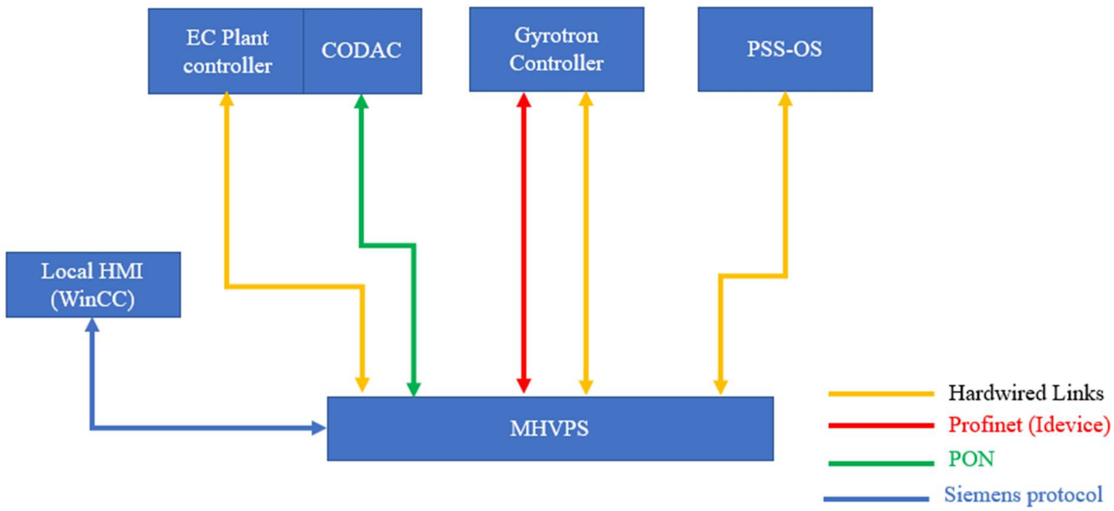

Figure 7: Interface between the MHVPS controller and the gyrotron controller

4.1.2.2 Interface between Power Supply Units (here, MHVPS Controller) and Plant System Controller (here EC Plant Controller)

The EC Plant Controller shall be able to interface with the MHVPS and CODAC in order to:

- Generate voltage references for the MHVPS. Send the voltage references to the MHVPS and read the signals back for diagnostic purposes.
- Read the output voltage and current from the MHVPS and send the measurements to CODAC

The interface shall implement the following functions:

4.1.2.2.1 Input Voltage Reference

Function: Provide reference voltage to regulate power supply output.
Interface:

- Analogue signal +/- 10V where maximum voltage corresponds to 8V and 0V equal to 0V output
- Signal referred to local control ground.
- 3dB Bandwidth: 50kHz or higher

4.1.2.2.2 Input Voltage Reference read back (output)

Function: Provide the read back of the Input Voltage Reference for diagnostic purposes.
Interface:

- Analogue signal +/- 10V where maximum voltage corresponds to 8V and 0V equal to 0V output
- Signal referred to local control ground.
- 3dB Bandwidth: 50kHz or higher

4.1.2.2.3 Output Voltage

Function: Provide the output voltage measurement.
Interface:

- Analogue signal +/- 10V where maximum voltage corresponds to 8V and 0V equal to 0V output
- Signal referred to local control ground.
  - 3dB Bandwidth: 300kHz or higher
- Typical precision: +/- 0.3% (intended as the overall precision of the system composed

by the transducer and the transmission system, on the overall range of variation of the system temperature)

4.1.2.2.4 Output Current
Function: Provide the output current measurement.
Interface:

- Analogue signal +/- 10V where maximum current corresponds to 8V and 0A equal to 0V output.
- Signal referred to local control ground.
- 3dB Bandwidth: 100kHz or higher
- Typical precision +/- 1%

4.1.2.3 Internal signals related to faults (output)
Function: In case of a fault detected by the local control units.
Interface:

- The interface to be used to transfer information will be defined by SUPPLIER and agreed with ITER INDIA once the detailed design of the MHVPS is known.
- For instance, it could be a network interface via Ethernet providing data acquired by the controller in the MHVPS during the fault events or a set of analogue signals to be acquired by the fast controller triggered by an event signal from the MHVPS.

4.1.2.4 Internal signals related to PS availability (output)
Function: The Plant System Controller shall be able to monitor the availability status of the MHVPS. Depending on the design, the MHVPS will comprise a certain number of modules to achieve a high output voltage; information on the internal faults of such modules shall be sent upon request to the Plant Controller, even if they do not affect the normal operation.

Interface:

- The interface to be used to transfer information will be defined by SUPPLIER and agreed with ITER INDIA once the detailed design of the MHVPS is known.
- For instance, it could be a network interface via Ethernet providing data acquired by the controller in the PS during the fault events or a set of analogue/digital signals to be acquired by the fast controller triggered by an event signal from the MHVPS.

4.1.2.5 Interface between Power Supply Units and PSH Operating state (output)
Function: A state machine shall be implemented, which considers all the possible operating state of each power supply. The list of states has to be defined and mutually agreed in order to be compatible with the ITER operating states.

For commissioning and test purposes, at least the following operating conditions shall be considered:

- Normal operation where the 4 MHVPS works independently

Interface:

- Digital signals specifying all the envisaged states shall be sent to the PSH via the PLC slow controller.

4.1.2.6 Interface between Power Supply Units and Plant Protection System (CIS)
The Plant Protection System shall be able to interface with the PS units and CIS in order to:

- Read and time stamp the information related to PS faults, and send them to CIS,
- Send commands to PS units to switch on the envisaged mitigation actions.

The Plant Protection System shall be divided in two main components, to cope with both fast and slow faults, as well as with the related mitigation actions.

The interface shall implement the following functions:

4.1.2.6.1 Output protection signals

Function: all the information related to internal protection activations shall be sent to the Plant Protection System. Initiating cause shall be provided as an output signal. Plant Protection System will time-stamp the events using CODAC timing information. Data necessary to analyses the event will be acquired by means of the already specified interface to the "plant controller".

Interface:

- At least 4 configurable digital/optical outputs shall be available. The final number has to be defined in agreement with SUPPLIER and ITER-India.
- At least one channel shall be dedicated to provide information about arc detection with a delay of 3us max.
- The function of the remaining channels is presently uncommitted. It will be defined whenever necessary but before the preliminary design review.

4.1.2.6.2 Input protection commands for mitigation actions

Function: some fast mitigation actions, as ramp down of the output voltage, shall be envisaged as input from the PIS.

Interface:

- At least 4 configurable optical inputs shall be available. The final number has to be defined in agreement with SUPPLIER and ITER-India.
- At least one channel shall be dedicated to request a fast PS shut down, with a delay not greater than 3us.
- The function of the remaining channels is presently uncommitted. It will be defined whenever necessary but before the preliminary design review.

Some slow actions, in case of no severe faults, shall be envisaged to ramp down the output voltage without any timing constrains.

4.1.2.7 Interface between Power Supply Units and PSS-OS

The Plant Safety System shall provide I&C Safety functions for the protection of people and the environment against all conventional hazards (toxicological, physical, electrical, cryogenic or other), which it may produce in normal and abnormal circumstances.

The implementation shall be compliant with applicable French regulations.

The supplier shall perform an HAZOP study in order to identify all the possible safety issues.

Each function shall be described with at least the following fields:

- Safety function name: define a name or unique identifier.
- Safety function description: a textual summary description of the function.
- Sensors: indicate what type and number of measurements are required for the function.
- Safety logic: describe the logic required for the function.
- Actuators: indicate what type and number of actuators are required for the function.
- Risk to protect: indicating which risk is being covered with this function.
- Risk description: a summary description of the risk being covered with this function.
- Risk class: report the safety class assigned by the ITER Safety analysis.

The Plant Safety functions shall communicate all hazards, warnings and alarms to the PSS-OS.

Monitoring data about the status of the safety functions and about its triggering shall be sent to the PSS-OS. The interface shall support the ability to reset each function in order to re-authorize the use of the actuators, once the Occupational risk has been eliminated.

Interfaces shall rely on few standardized functional concepts:

- Local Occupational Safety function actuation status: actuated/not actuated
- Reset command to the Local Occupational Safety function

Details of this interface shall be proposed by the supplier to be discussed and agreed with ITER INDIA.

The interface shall implement the following functions:

4.1.2.7.1 Internal signals related to faults (output)

Function: all the faults related to Occupational Safety shall be sent to PSS

Interface:

- 1 digital interface for every safety state to be transferred.

4.1.2.7.2 Reset signals of internal faults (input)

Function: the reset of the fault signals related to Occupational Safety shall be sent by the PSS to the PS internal controller.

Interface:

- 1 digital interface for every safety state to be transferred.

4.1.2.8 Dummy load

Each PS can be connected to a dummy load for commissioning and test purposes.

When the PS is connected to the dummy load, the signals coming from the CIS shall be disabled in order to allow the PS test to be performed during the ITER operation.

4.2 I&C and electrical equipment Cubicles

All cubicles shall be compliant with the document *'Plant Control Design Handbook, (ITER_D_27LH2V)* and *'Electrical Design Handbook'*. The cubicles must be connected to the ground grid of the Site; all their metallic parts (frame, doors, panels etc.) will be linked to the ground bolt. The grounding circuits should be designed for a single short-circuit withstand and consistent with the IEC 60204-11 and IEC 62271-200.

A 230 V AC mains plug are to be available inside each cabinet and shall be protected by a 16 A and 30 mA differential circuit breaker.

A holder for documents shall be fitted outside one of the cabinet doors.

The wiring channels shall be halogen-free and flame retardant (see section 4.6) fitted with a cover and secured by screws.

The signals terminal blocks and the command/control boards are to be separated by a protection shield from the hazardous parts.

The MHVPSs internal circuits shall be protected by proper main circuit breakers. Additional circuit breakers are to be implemented to separate and effectively protect different subsets of equipment according to their location or functionality. Each AC/DC circuit breaker shall cut off all the phases and the neutral or the polarities ($\pm V_{DC}$ / 0V).

The cubicles shall be fitted with low-consumption lamps for internal lighting, switched on by the opening of the doors.

Adequate test points, with easy access, shall be included in the equipment to enable maintenance and trouble-shooting to be carried out as quickly as possible.

CONTRACTOR/SUPPLIER shall provide all the documents certifying the conformity of the equipment to the IEC standards and the shielding code (EM) according to IEC 61000-5-7 of the electronic card's enclosures.

All cubicles must be properly cooled/heated based on the Site Conditions (ref. section 3.6) to ensure that all internal components can properly operate and that no damage occurs to them.

All the cables shall be clearly identified with a label of an approved type and this label shall be clearly visible within the cubicle/panel.

The thickness of the steel of the cabinets will be at least 1.5 mm. the plates will be passivated and painted by epoxy polyester powder coating; the fences shall be hot-galvanized and the minimum wire diameter shall be 2.5 mm.

4.3 Enclosures and fences

To avoid access to hazardous parts, all the parts of the EC MHVPSs will be housed in a metallic enclosure (fences) or cabinets, in compliance with the IEC Standard 60529. The fence's mesh protection degree must be at least IP 2XBH, while the cabinets must be at least IP 52DH. All access doors are to include locks and complaint with the safety procedures described in Section 4.5.

The fences and the mechanical cabinets must be connected to the ground grid of the Site; all their metallic parts (frame, doors, panels etc.) will be linked to the ground bolt. The grounding circuits should be designed for a single short-circuit withstand and consistent with the IEC 60204-11 and IEC 62271-200.

All the ground connections shall be easily spotted.

CONTRACTOR/SUPPLIER will connect the ground terminals of EC MHVPS system to the closest terminals of the grounding network of the building by low impedance connections (e.g. copper bars). Adequate test points, with easy access, shall be included in the equipment to enable maintenance and trouble- shooting to be carried out as quickly as possible.

4.4 Power Connections

CONTRACTOR/SUPPLIER shall select and place the electric connections according to the Technical Specifications, to the features of their equipment and to all the applicable IEC standards (in particular, IEC Standards 60287, 60502 and 60840). All power, measurement, control and auxiliary cables shall be made of copper.

The power connections from the MHVPSs to the gyrotrons shall be realized, as a rule, by coaxial (or triaxial) cables of due section and insulation. The cables from the EC MHVPS to the RF source, located on RF building L3, are in the scope of this procurement. Pair of HV connectors are provided by the RF source supplier (JA-DA), but the installation of the connectors on the HV cables is part of this procurement. A ground return from the RF sources to the MHVPS will be provided with the MHVPS set. The ground return will provide a low inductive path for both low and high frequencies.

Cable insulation shall be Low Smoke, Zero Halogen, Fire Retardant (LSOHFR), in compliance with the IEC Standards 60332-1, 60332-2, 60332-3. Cables shall be de-rated for parallel connections and installations as prescribed by the latest issue of the applicable IEC standards. As per reference document, *'Electrical Design Handbook'*, XLPE insulation is preferred, PVC insulation is not allowed.

All cables shall have appropriate mechanical support to minimize constrains on the connectors and respect manufacture requirements on bending radius.

Power cables shall be separate from measurement, control and auxiliary cables. SUPPLIER shall maintain sufficient distances between the various types of cable trays to allow access and according to equipment safety margins.

CONTRACTOR/SUPPLIER shall demonstrate (at the FDP) that the proposed cabling and wiring systems comply with IEC standards related to electromagnetic interference and electromagnetic compatibility according to *'Electrical Design Handbook'*.

All the cables shall be clearly identified with a label of an approved type and this label shall be clearly visible within the cubicle/panel.

The internal power connections and terminations shall be mechanically strong and thermally adequate, according to reference document, *'Electrical Design Handbook'*.

Routing of the cable tray in the RF building is shown on drawings in Appexndix-2 of the present document.

4.5 Grounding Connections and Switches

CONTRACTOR/SUPPLIER shall provide all internal grounding connections of the MHVPS components with copper conductors having sections adequate to carry the fault current without voltage rises dangerous for the human safety. All the power ground connections for high-voltage equipment shall be designed according to the IEC standards. All the ground conductors shall be easily accessible.

The MHVPS components are to be accessible only under top safety conditions: therefore, each MHVPS shall be equipped with a grounding switch connected to the high-voltage output terminals of the unit. The opening of the high-voltage enclosure doors (or of any other high-voltage entrance) shall be allowed only after the switch has been closed (grounded). Similarly, the opening of the switch shall be possible only after the enclosure doors have been closed.

The switches or equivalent devices (e.g.: switch ground hook) are to discharge the HV cables and ground them prior to human access within the HV enclosures to avoid all the dangerous states for the PS and RF Source operators.

A remote controllable off load switch is to be included with the PS set, to allow connection/isolation of one RF Source, while the other remains connected to the same MHVPS. Connecting or disconnecting is made when no HV is applied to either RF Source. The cables to the two RF sources coming from the same MHVPS must be individually insulated and grounded. The status of these as the others safety devices shall be properly monitored and controllable from the MHVPS local control system. These signals and controls are also to be included in the safety control functions of the Plant system I&C.

The operations on the grounding switches shall be constrained to an interlock key system (out of the scope of this procurement) connected with the HV-LV sources upstream and downstream the EC MHVPSs. The interlock characteristics shall depend also on the upstream EC MHVPS equipment (e.g. soft-start) and power network (see Section 3.2). The ITER INDIA will provide to CONTRACTOR/SUPPLIER the details on the interfaces of the interlock key system with the power supply system during the tendering process.

Limit switches shall signal to the MHVPS control system the status of the grounding switches (a opened contact in a limit switch means that the grounding switch is closed to ground). Each enclosure will be equipped with red and green lights that indicate the status of the grounding switches.

The grounding switch operation shall be motorized or at pneumatic control.

All the components and systems shall be designed, manufactured and tested according to the IEC standards.

4.6 Signal Transmission and Insulation

The transmission of the signals between components placed inside high voltage areas and components/equipment placed in low voltage (accessible) areas shall be as much as possible via optical fibers, which also assure a high insulation of the signals.

Alternative methods for signal transmission for galvanic insulation between high voltage and low voltage parts may be proposed and presented FDP.

A fail-safe logic shall be adopted for all the alarm/fault signals both for their elaboration and for their transmission.

All cabling shall be selected, sized and laid according to applicable IEC standards.

Cable and optical fiber insulation shall be LSOHFR, according to the Standards IEC 60754 and IEC 60332.

All cables and optical fibers shall have appropriate mechanical support to minimize strains on the connectors and to respect manufacture requirements on bending radius.

All cables shall be marked with an approved label (consistent with cabling diagrams and ITER naming convention), which is clearly visible and identifies connection points. When possible cables between common connection points will be grouped.

Analogue signals shall be routed separately (using different cables) from digital signals. Twisted pair cables shall be used to reduce interferences to control, protection and monitoring signals.

SUPPLIER is responsible to demonstrate at the FDR that the proposed cabling and wiring systems comply with the applicable electromagnetic compatibility standards.

The design of the fibre optic transmission system shall allow at least a 10% spare fibre optic cable capacity.

4.7 Design and Construction

The design and construction of the equipment shall conform to the best current engineering practice. The essence of design shall be simplicity and reliability in order to give long continuous service with minimum maintenance requirements.

"Off-the-shelf" components shall be used to the most possible extent. The design report shall include a chapter with the justification for the use of specially designed components, if any.

The use of ignitrons (containing mercury) is not accepted PURCHASER's SITE.

Modularity shall be used to the maximum possible extent to minimize the time required for maintenance and repair.

All components and cables shall be securely braced against mechanical forces during transport and against electromagnetic forces occurring during normal operations and fault conditions.

4.8 Layout and installation requirements

The ITER ECRH and ICRH systems will be located in the Building 15. The Building 15 has been designed to house an EC system capable of delivering 20MW heating power to the ITER plasma, which requires the installation of 24 RF sources and 12 associated HVPS sets.

Before the start of the installation phase, ITER-INDIA will make available all the areas where the MHVPS system will be installed. ITER-INDIA will make available to SUPPLIER the services described in *Tender Part A(II-1), Annexure-C: Quality & Site Specification, Section 9.3*.

The RF building has an internal metal/concrete structure (as described in reference drawing Appendix-2) with three levels (L1, L2 and L3). A corridor running East-West separates the IC (North) and EC (South) at each level. The building main door is located on the east side of the ground level corridor (see **Appendix-2: Layout of EC MHVPS in the RF building.** of the present document).

Equipment will enter the main door and then pass through the corridor to a set of doors to the EC zone of B-15. Just inside the EC zone, there is a removable hatch that is used to lift equipment to either the L2 or L3 from L1 using the overhead crane. The hatch from L1 to L2 is square (4 m of side), while the hatch from L2 to L3 is rectangular (4.75 by 10 m), The overhead crane is rated for 5 tons SWL.

CONTRACTOR/SUPPLIER is to use drawings presented in **Appendix-2: Layout of EC MHVPS in the RF building.** to develop a detailed layout of the MHVPS system; the sketches of the components and their positioning, included in the drawings, are given only for indication. CONTRACTOR/SUPPLIER shall provide in-depth description of the layout drawings including the areas for equipment transport, maintenance and operation during FDP. Also, CONTRACTOR/SUPPLIER is responsible to develop in the FDP the detailed layout drawings, according to the IEC standards and particularly the IEC 61936 and NF C 13-000. The layout will be compatible with installation/maintenance access and compliant with human safety requirements.

The ground floor area (see **Appendix-2: Layout of EC MHVPS in the RF building.**) is split into a part assigned to the MHVPS and one to the AC equipment (e.g. MV and LV boards, soft-start units, possible AC filters, etc.); the latter is located towards the west side near the Assembly Hall, the other area will contain the twelve MHVPS with their auxiliary components and the related Dummy Load.

The present layout places two MHVPSs inside one HV enclosure, which provides a modular design with independent access (for maintenance and operation activities) between MHVPS sets. SUPPLIER is to respect this approach in developing the final layouts. Note that the HV enclosures should also include the PS auxiliary equipment (grounding switches, high- voltage probes, dc filters, power resistors, filament heating PSs, etc.).

CONTRACTOR/SUPPLIER can also propose its own layout inline to the requirements as mentioned above. In addition, the Supplier, in the layout study, will try to minimize the length of the cable connections to the RF Source.

A dedicated shelter, located on the RF building south side, is allocated to the Long Pulse Dummy load (not in present scope).

The electric cables shall be distributed in raceways comprising cable trays, steel conduits and PE duct banks. In the RF building cable tray is preferred over other types of raceways.

In general, four independent raceways are established as a function of the voltage and service, grouped as follows:

- Medium voltage power cables level;
- Low voltage power cables level;
- Control level;
- Instrumentation level.

The reference drawings [refer Appendix-2] show the raceways of the cables and optical fibers, they are composed by a main way, starting from the cables entrance area located in the west side of the building (toward the edifice south wall), developing along the west – east direction and its branches in the directions of the MHVPS components (not included in the drawings). Main ways and branches of the cable's trays (or ducts) shall be included in the MHVPS Procurement. Also, all the internal connections of the MHVPS system shall be carried out by SUPPLIER.

ITER INDIA will provide any additional layout drawings of the relevant ITER areas and/or buildings upon request of SUPPLIER. Possible revisions of the layout drawings shall be finalizing during the FDP and will be in agreement with ITER-India.

The final design shall be compliant with:

- The MHVPSs shall be installed into the areas indicated in the drawings (Appendix-2);
- The MHVPSs size shall be consistent with the available dedicated areas and shutters as showed in the reference drawings;
- The maximum load to the floors shall be in accordance with *Section 9.2 of Tender Part A(II-1), Annexure C: Quality & Site Specification*. These values shall be confirmed during the FDP. The basement geometry of the devices shall be agreed with the ITER-INDIA during the FDP.

4.9 Use of Oil and Combustible Materials

Material that release hazardous fumes in case of fire, shall not be used without prior approval by the IO. Combustible materials shall be kept to a minimum.

PVC shall be avoided. PCB and PCT (polychlorinated 2-phenyl and 3-phenyl) type materials shall not be used in any component.

The CONTRACTOR/SUPPLIER should avoid the use of indoor installation of oil filled equipment.

4.10 Audible noise

All equipment shall operate without undue vibrations and with the lowest possible audible noise (also required during stationary conditions) to avoid any harmful effect to the equipment. All equipment prone to vibrations or loud audible noises are to be properly isolated (from adjacent structure) and/or insulated (from noise). In particular, the daily average exposure noise level of one PS unit must not exceed 74 dB(A). Alternatively, the CONTRACTOR/SUPPLIER must demonstrate that the daily average exposure noise level of an equivalent 12 MHVPS in the RF building configuration does not exceed 80dB(A) according to the French Decree 2006-892 (19 July 2006).

5 Testing and Acceptance requirements

Each MHPS is subject to Factory and On-site acceptance tests. For each of these tests, the type test (first of a series) will be a complete test, while the remainder of the series will be subject to a reduced set (referred to as Routine tests). Note that ITER INDIA may request part or all of Type test instead of the Routine tests for the series MHVPS subject to deviation process.

The following sections describe each of these tests as well as the MHVPS general requirements.

5.1 General requirements

The whole of the provided equipment shall be subjected to inspections and tests (in compliance with the IEC and NF C standards) to prove its compliance with the technical specifications both during the manufacture at the Supplier's facilities and during the Installation & Testing at PURCHASER's SITE.

The following sections provide a preliminary description of the tests and conditions for the MHVPS sets, which shall be completed by the tests specified in the relevant IEC and NF standards. CONTRACTOR/SUPPLIER shall develop a complete testing plan (including modifications and additional tests, which shall be agreed with the ITER INDIA during the FDP). Both the factory type and routine tests procedures (see Section 5.2) will be delivered before the FDP. These test procedures will be subject to review and revision based on the Inputs from ITER-India. In addition, CONTRACTOR/ SUPPLIER shall submit a Site Commissioning Program during FDP.

CONTRACTOR/SUPPLIER will notify ITER INDIA at least four weeks in advance of all Factory tests. The ITER INDIA reserves the right to participate in all the type and routine factory tests.

CONTRACTOR/SUPPLIER shall prepare and submit to the ITER-INDIA the Factory Test Report within 45 calendar days of the successful completion of the Type and Routine tests. The report shall include all records, certificates, test conditions and performance curves concerning the testing procedures. These test records, certificates and performance curves shall be supplied for all tests, whether or not the tests have been witnessed by ITER-INDIA.

The factory tests must be fully competed and accepted by the ITER-INDIA prior to any equipment is packed and dispatched from the site of the factory tests, unless otherwise agreed with ITER-INDIA in advance.

Site acceptance tests (see Section 5.4) shall be performed on each item and aim at verifying its performances and the equipment insulation.

CONTRACTOR/SUPPLIER shall provide all the test equipment, auxiliaries (power grid connections, cooling systems, protections, etc.), monitoring, control, and measurements systems as required to successfully perform the factory and site tests, unless otherwise agreed with ITER-India in advance.

Any item of equipment or component that fails to comply with the specification requirements in any respect or at any stage of manufacture or testing, shall be rejected by the ITER-India either in whole or in part as the ITER-INDIA considers necessary. CONTRACTOR/SUPPLIER shall provide either a replacement or revised product, at SUPPLIER's own charge, to fulfill the failed requirements. The relevant tests shall then be repeated to demonstrate compliance of the MHVPS. ITER-India reserves the right to repeat the entire set of tests depending on the scope of the failed component or assembly.

Initiation of an item warranty period is dependent upon the date of delivery of the Item and the successful completion/subsequent ITER-INDIA approval of the on-site Final Acceptance test of each Item.

5.2 Factory tests

The Factory Tests aim at demonstrating the compliance of the individual components and assembled set of the MHVPS set to the technical specifications. All tests shall include all electrical, mechanical and hydraulic tests in accordance with the relevant IEC Standards, the tests listed in the technical specifications and any additional test agreed between the ITER INDIA and the CONTRACTOR/ SUPPLIER during the FDP to ensure that the supplied equipment meets the specification requirements. In particular, the ITER INDIA and the SUPPLIER shall agree the tests for the equipment not covered by any IEC standard and not specifically mentioned in this specification.
Both the Type and Routine Factory tests shall be carried out at SUPPLIER's site (or the site of a Sub-Supplier). If this is not possible, SUPPLIER and ITER INDIA shall agree on an alternative suitable site for Factory Tests.

The Type and Routine Factory Tests are to be performed simulating the operating conditions at ITER as much as possible. The MHVPS shall be connected to the Dummy loads with the same cable type and length (typically 10 m) that will connect the MHVPS to the RF Sources.

Whenever it is not specified, the pulses have a length of 250 ms and a cycle time of 200 s.

The Type and Routine Factory tests are described in the following sub-sections grouped according to the MHVPS type.

5.2.1 Factory Acceptance Test (FAT/Extended FAT) for the MHVPS

The MHVPS factory tests are based on the relevant technical specifications (see Section 1.3).
The tests are divided into the Type (first MHVPS) and Routine (all subsequent MHVPS) Factory acceptance tests. These are described in the following two subsections.

5.2.1.1 MHVPS Factory Type Tests

The Factory Type test for the MHVPS include:

- **Output voltage tests**
  The MHVPS at factory will be tested at nominal voltage and nominal current for pulse duration 250ms.
  The output voltage shall be tested with 16 pulses on the dummy load.
  The test reference and output voltages shall be recorded and analysed to verify the following performances of the MHVPS:

  - Accuracy (Item #5 in Table 1);
  - Repeatability (Item #6 in Table 1);
  - Resolution (Item #7 in Table 1);
  - Ripple (Item #8 in Table 1);
  - Ramp-up/down, settling time and overshoot/undershoot (Item #3 in Table 1).

The on/off modulation performances (Items #9, #10 and #11 in Table 1) shall be verified by 10 pulses (0 to 55 kV) at a frequency of 50, 100, 200, 500 and 1000 Hz (2 pulses for each frequency).

- **Long pulse tests**

The measurements described in the previous Output voltage test shall be repeated for long pulse tests, directed to verify the equipment behaviour during pulses of the ITER maximum time length and operation pattern at nominal voltage or current. The pulses are so defined:

  - Pulses time length: 3600 s.
  - Pulses duty cycle: _>1/4.

Long pulse at the maximum current

  - Current: nominal value (100A).

Power: To be agreed between ITER-India and CONTRACTOR/SUPPLIER during the FDP.

Long pulse at the maximum voltage

  - Power: To be agreed between ITER-India and SUPPLIER during the FDP. Voltage: nominal value (55kV).

The temperature rise test shall be also performed according to IEC 60146-1, Chapter 7.4.2 and IEC 61378-1 for individual components. In particular, testing of the modules in an equivalent environmental condition representing the assembled system shall be performed. The CONTRACTOR/SUPPLIER shall arrange the loads and all the fittings necessary for the test's execution.

- **Wire burn tests**

The measurement of the charge delivered in case of arc (Item #13 in Table 1) will be implemented by a calibrated wire at 10J that short-circuits the MHVPS at the nominal voltage. The calibrated wire will be located after the cabling (of an equivalent length) to the gyrotron.

- **Shutdown and restart tests**

A relevant fault signal simulated at the PS terminals shall start its shutdown and the subsequent restart of the output voltage to the final value of 55 kV. The times necessary for this sequence shall be recorded and compared with the specifications of Items #14 and #15 in Table 1.

- **Efficiency and power factor tests**

The efficiency and the power factor (Items #15 and #16 Table 1) of the MHVPS shall be estimated for at least 2 pulses at the nominal voltage and 1 on/off modulation at 1 kHz.

- **Inrush current tests**

The measurements of the MHVPS inrush AC current shall be recorded for 10switching and compared with the values fixed in the design.

- **Current harmonics tests**

The spectrum of the current at the MHVPS AC side must be acquired. The magnitude of the harmonics up the 37th order shall be estimated and compared with the values of Table 4.

- **Dry-type transformer tests**

The power transformer of the MHVPS first unit shall be tested according to IEC 60076-11 and IEC 61378. It shall be submitted to the following type tests:

  - Temperature-rise test;
  - Measurement of the peak in-rush currents for each phase (10 separate measurements);
  - Short-circuit test.
  - Insulation test between primary and secondary as per IEC standard

The routine tests described in Section 5.2.2 will involve also the first unit transformer(s).

5.2.2 MHVPS routine tests

The Routine Factory tests are based on the critical tests of the Type Factory Tests. These are listed below, note that the ITER-INDIA reserves the right to perform a complete Type test for any series MHVPS pending the success of the Routine tests and the first Type test.

- Voltage to ground withstand test (auxiliary and control circuits)
  The voltage withstand test for the auxiliary and control circuits shall be performed according to IEC Standard 60146-1-1. The requirements of the test are satisfied if no discharge occurs on the test object.

- Voltage to ground withstand test (main circuits)
  The test shall be performed according to the IEC Standard 60146-1-1. The requirements of the test are satisfied if no discharge occurs on the test object. The MHVPS output terminals shall be tested at least at 1.7 times the nominal voltage (Vck) for one minute.

- Design and visual check
  All the MHVPSs shall be tested according to IEC Standard 62271.

- Dry-type transformer tests
  All the tests for the power transformers shall be performed in accordance with IEC Standard 60076-11 and 61378 and can be summarized as in the following list:
  - Measurement of winding resistance, voltage ratio, vector group, short-circuit impedance, load/no load losses, stray capacitances;
  - Separate source AC withstand voltage tests;
  - Induced AC withstand voltage tests.

5.2.3 Auxiliaries equipment and components tests

5.2.3.1 Grounding switch tests

All the grounding switches shall be tested according to the IEC Standard 62271-102 where applicable. The following tests shall be included as a minimum:

- **Voltage to ground withstand test (main circuit)**
  The grounding switches in opened position shall be subject to short-duration power frequency test (20 kV RMS, 50 Hz for 1 minute). The requirements of the test are satisfied if no discharge occurs on the test object.
- **Voltage to ground withstand test (auxiliary and control circuits)**
  The voltage withstand test for auxiliary shall be performed according to IEC 60146-1-1. The requirements of the test are satisfied if no discharge occurs on the test object.
- **Mechanical operating test**
  Ten closing-opening operations shall be performed.
- **Design and visual check**
  The design and visual check shall be performed according to IEC 62271.

5.2.3.2 Local control and protection system tests

The following routine tests shall be carried out, as a minimum, on the local control and protection assembly:

- **Insulation to ground test**
  Each circuit intended for connection to AC mains supplies or DC supplies shall withstand 2 kV RMS at 50 Hz applied for 1 minute. The preceding tests shall be followed by the measurement of insulation resistance at 500 V DC. The requirements of the test are satisfied if no discharge occurs on the test object.
- **Functional test**

All equipment shall be fully tested to check that it complies with the functional requirements of the technical specifications and performs the operations for which it was designed. The safe and correct operation of all the protective circuits and the overall protection coordination shall be checked.

5.2.3.3 AC-side tests

The following routine tests, as a minimum, shall be carried out on the AC assembly:

- **Insulation to ground test**
  Each circuit intended for connection to AC mains supplies shall be tested in accordance with the IEC 60071-1.
- **Functional test**
  All equipment shall be fully tested to check that it complies with the functional requirements of the technical specifications and performs the operations for which it was designed. The safe and correct operation of all protective circuits and the overall protection coordination shall be checked.

5.2.3.4 Transducer tests

It is generally assumed that transducers are certified by the Manufacturer. If not, each transducer shall be subjected to tests performed by the SUPPLIER and to be agreed between the SUPPLIER and ITER-India, in order to demonstrate the compliance of the transducer with the required performance specifications.

5.2.3.5 Water cooling system tests

Test pressures should be based on piping design pressure in accordance with the piping design code (ASME B31.3 for ITER) and, if applicable, the European Pressure Equipment Directive.

5.2.3.6 EMC/Immunity tests

The tests shall verify the compliance of the whole equipment supplied under the Contract with the applicable immunity requirements of IEC Standard 61000-6-2 (level 3) and IEC Standard 61800-3 (second environment cat. 4).
The EMC compliance shall take in consideration:

- The emission;
- The immunity;
- The DC fields perturbation and the effects;
- The EMC requirements in term of grounding, earthing, screening, and so on.

The whole equipment including the internal wiring shall be designed and tested, in accordance with the IEC Standard 61000-4, considering the electromagnetic environment and perturbations.

5.2.3.7 Cable tests and test reports

Electrical and optical fibre cables shall be tested in accordance with the applicable IEC standards, in particular with IEC 60502, IEC 60480 and IEC 60332. The SUPPLIER shall provide the test certificates.

5.3 Assembly/Integration demonstration of Unit-1

The demonstration of Unit-1 at ITER-India lab, Gandhinagar shall include:

- Equipment unloading, handling, unpacking and movement to site
- Demonstration for equipment storage & preservation
- Equipment marking, drilling/penetration
- Holding arrangement of components
- Standalone Testing of EC MHVPS components
- Installation of EC MHVPS components

- Layout as per layout plans and clearances
- End to End Interface connections and checks
- Voltage to Ground Withstand Test
- MHVPS operation, equipment maintenance and troubleshooting

5.4 Site Acceptance Tests at PURCHASER's Site

Section 8 of Tender Part-A(II-1) includes the site installation plan and the site commissioning program among the documents that the CONTRACTOR/SUPPLIER shall deliver during the job development. The SUPPLIER shall formulate these documents also on the basis of the ITER-India information and they should be agreed with him.

The Site Acceptance Tests are based on the Factory Type and Routine tests. In general, the ITER-India envisions a more simplified set of tests on-site mainly aimed at demonstrating the performance of the MHVPS as was achieved at the Factory. However, ITER-India may request to perform all or a subset of the Factory Type Tests for the Site Acceptance Tests of all MHVPS subject to change control.

In addition, the Site test program will include specific tests associated with the installation and commissioning of the PS that could not be performed at the Factory. In particular those tests associated with the different installation/commissioning activities in the same building (included the consequent safety rules), full power tests and the general layout of the installation areas. As the MHVPS dummy load is be installed in a designated area (see drawing in **Appendix-2: Layout of EC MHVPS in the RF building.**), it will not possible to move it near the locations of the MHVPSs during the tests. The PS behavior is strongly affected by the cabling distance between the MHVPS and the dummy load. Therefore, the acceptance criteria of the DC tests shall be adapted to the final length of the cable.

MHVPS will be first placed in the final position prior to the start of any tests. The tests will include the testing of the cabling to either the RF Sources or the fixed dummy load.

All site tests will be conducted using the GUI of EC MHVPS, while external simulators will be utilized to demonstrate remote hardwired links.

After the positioning of the MHVPSs components at PURCHASER's SITE, it shall be verified according to the site acceptance tests described in the following sub-sections.

5.4.1 Voltage insulation tests

The voltage withstand test for the main circuits (voltage higher than 400 V) shall be performed according to the IEC Standard 60146-1-1. The requirements of the test are satisfied if no discharge occurs on the test object. The MHVPS output terminals shall be tested at least at 1.7 times the nominal voltage (V_{ck}) for one minute.

The voltage withstand test for the auxiliary and control circuits shall be performed according to the IEC Standard 60146-1-1. The requirements of the test are satisfied if no discharge occurs on the test object.

5.4.2 Functional tests

All equipment shall be fully tested to check its correct working. The safe and correct operation of all the protective circuits and of the overall protection coordination shall be checked. The test procedures are to be based on the Factory Type Tests. The specific tests are to be agreed between CONTRACTOR/SUPPLIER and the ITER INDIA prior to the FDP.

Moreover, functional tests to verify the correct connection to the auxiliaries (power supply, compressed air, etc.) shall be performed.

5.4.3 Full power tests

The tests described in the Sections 5.2.1 shall be repeated at full voltage and current on the dummy loads.

Table 9: Reference parameters for the MHVPS output voltage tests

	Voltage [kV]	Current [A]	Ramp-up/down time
1	40	70	100 µs
2	40	100	100 µs
3	40	70	500 µs
4	40	100	1000 µs
5	45	70	100 µs
6	45	100	100 µs
7	45	70	500 µs
8	45	100	1000 µs
9	50	70	100 µs
10	50	100	100 µs
11	50	70	500 µs
12	50	100	1000 µs
13	55	70	100 µs
14	55	100	100 µs
15	55	70	500 µs
16	55	100	1000 µs

6 Codes & Standards

The design, manufacture and testing of all the supplied equipment shall in accordance with the most updated issue of the relevant IEC Standards and Recommendations.

Components associated with the EC PS (here MHVPS) procurement shall comply with the European directives concerning CE marking, if applicable
(see: http://www.conformance.co.uk/directives/index.php)

A detailed list will be prepared during design stage *(as per reference document, 'Electrical Design Handbook').* Latest amendments will be adapted for all standards

Appendix-1:

EC Power Supply connection scheme, operating Sequences, modulation requirements and load parameters

❖ EC Power Supply Connection Scheme

The envisioned schematic diagram of the Triode Type Gyrotron (TTG) is illustrated in Figure 8**Error! Reference source not found.**. Particular attention is given to the related electrodes. The anode electrode is present in the TTGs and can be used to modulate and control the RF power.

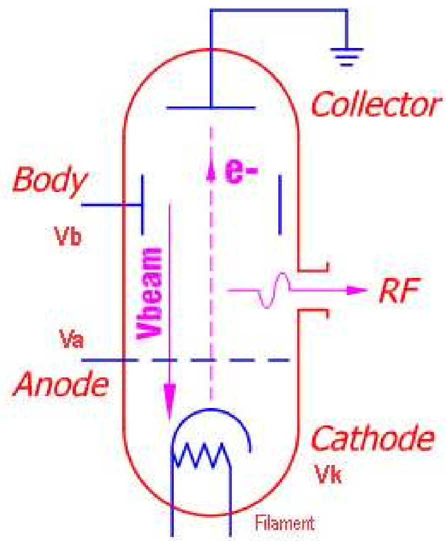

Figure 8 : Scheme of TTG

The main characteristics and functions of the potentials applied to the gyrotron electrodes are described in **Error! Reference source not found.** Table 10 based on the configuration shown in Figure 8.

The MHVPS is connected to the gyrotron cathode and supplies a majority of the electrical power required to generate the electron beam and microwave power. The positive terminal of the MHVPS is connected to the collector, the collector is grounded as a rule.

Table 10 : Description of the potentials applied to the gyrotron electrodes

Symbol	Potential Description	Polarity	Main functions
V_c	Collector potential	Grounded	
V_k	Potential applied to the cathode by the MHVPS	Negative to ground	Supply of the required electrical power to the beam
V_b	Potential applied to the body by the BPS	Positive to ground	Accelerates the electrons prior to the cavity and increases the gyrotron efficiency
V_{beam}	Acceleration/beam voltage $V_{beam} = V_{kb} = V_k - V_b$	Negative	Controls the RF power in TTGs

V_a	Potential applied to the anode by the APS	Positive to cathode	Can controls the RF power in TTGs, in particular, shut off the generated RF power independently of V_{beam}

The gyrotron acceleration voltage, named also beam voltage, corresponds to the potential difference $V_{kb}=V_k-V_b$. The output RF power is governed by control of the beam voltage. This can be used to regulate the amplitude of the RF power directed to the plasma.

In addition to the potentials described above, the TTGs have an additional potential applied to the anode of the gyrotron. This potential is able to cut off the microwave power, independently of the potential applied to the cathode. This can be used to regulate and modulate the RF power directed to the plasma.

Normally, the modulation in TTG is achieved by modulating APS (referred to cathode) only. The strategy in modulating the applied voltages has a significant impact on the gyrotron operation and applied thermal loading. MHVPS may require to provide full power (ON/OFF) modulation in the entire modulation frequency range (from 0 to 5kHz).

❖ Modulation Scenario with TTGs

The RF modulation *(load modulation for MHVPS)* with TTGs is achieved by switching on/off the APS only. Along with the RF power, MHVPS observes load modulation from full load to no load and vice versa at 50us/10us rate governed through APS rise/fall time. Overshoot occurs when beam current modulate from full load to no load in synchronization with APS voltage as shown in Figure 9.

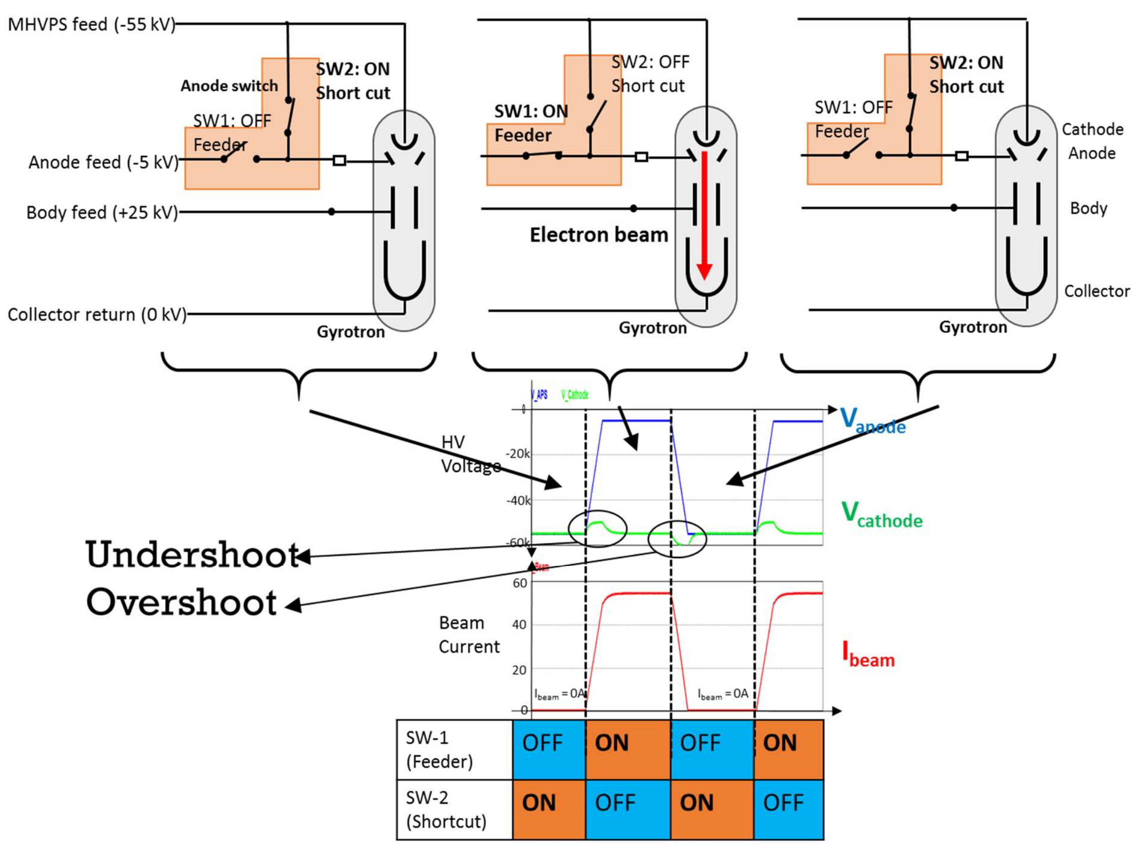

Figure 9 : Reference Modulation scheme of a JA Triode Type Gyrotron

❖ Gyrotrons load parameters

Table 11 shows the typical values of the stray capacitances between the gyrotron electrodes.

Table 11 : Stray capacitances between gyrotron electrodes

	Capacitance	Value	Comment
1	Body to collector, C_{bc}	< 2500 pF	Including 10 m of coaxial cable (estimated at 100 pF/m)
2	*Cathode to collector, C_{kc}*	*< 2000 pF*	*Including 10 m of coaxial cable (estimated at 100 pF/m)*
3	Cathode to body, C_{kb}	< 200 pF	
4	Anode to collector (TTG)	< 700 pF	
5	Anode to body (TTG)	< 450 pF	
6	Anode to cathode (TTG)	< 1600 pF	Including 10 m of coaxial cable (estimated at 100 pF/m)

The PS designs (in particular MHVPS) are strongly impacted by the beam voltage (V_{kb}) and current I_b characteristic. The dependencies $I_b = f(V_{kb})$ and $P_{RF} = f(V_{ak})$ (see Figure 10) at the reference working conditions of the gyrotrons

In a TTG, the APS is also used to control the beam current and the RF power. Figure 11 illustrates the dependency between the beam current on the anode-to-cathode voltage. Also in this case, the actual curve could be revised based on the most recent progress in Gyrotron development.

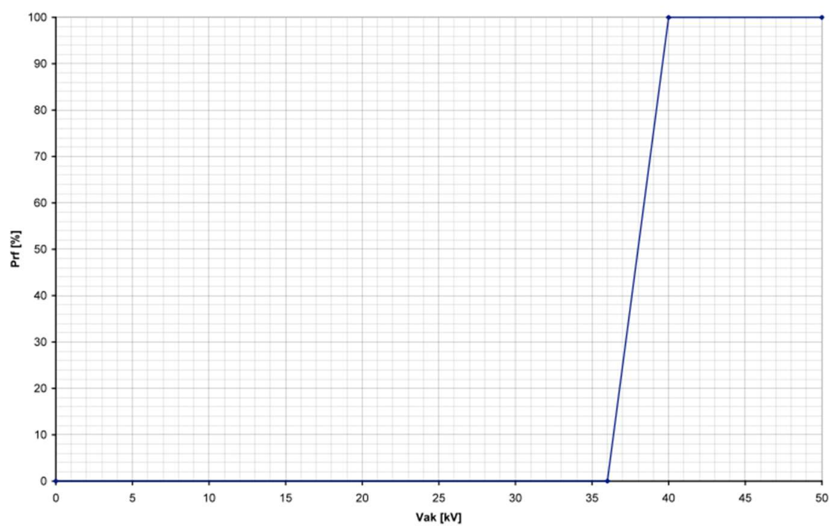

Figure 10 : Example of gyrotron (TTG) characteristic PRF = f(Vak).

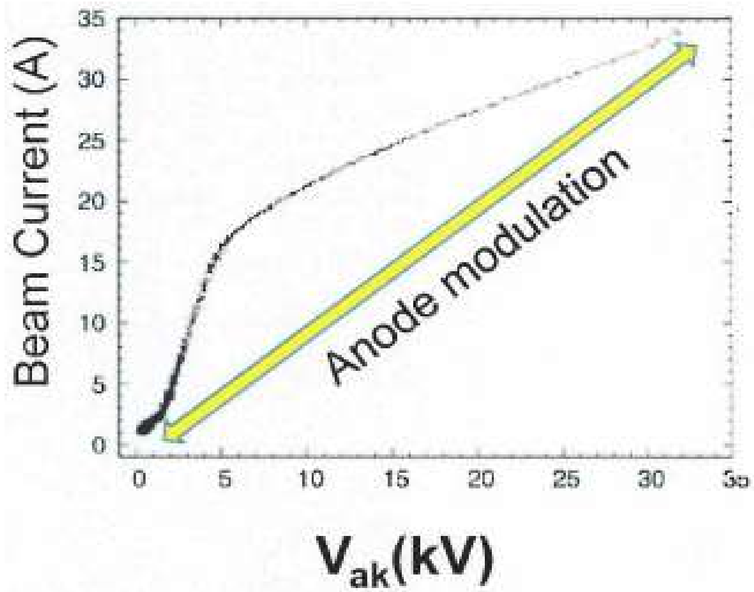

Figure 11 : Experimental Ib = f(Vak) characteristic for a TTG. The beam current is controlled by a modulation of the anode voltage.

Appendix-2: Layout of EC MHVPS in the RF building.

In red: tentative space allocation for EC PS components
In blue: tentative rooting for CCWS system
In orange: tentative rooting of cable tray system
In purple: tentative rooting of compressed air system

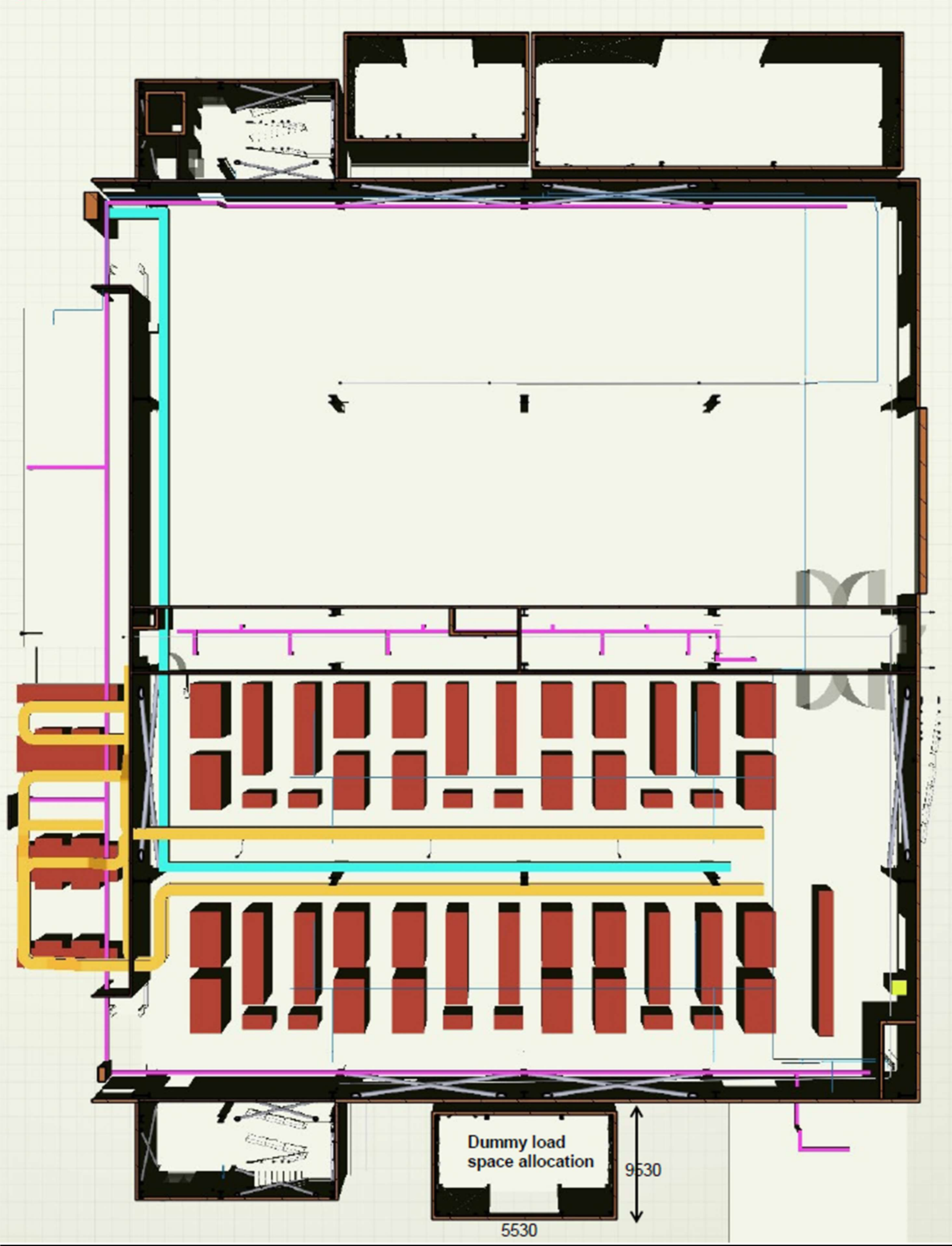

Figure 12: Building 15 Layout EC MHVPS ground level (L1) showing main interfaces

Figure 13: Building 15 Layout EC PS ground level (L1) showing main dimensions

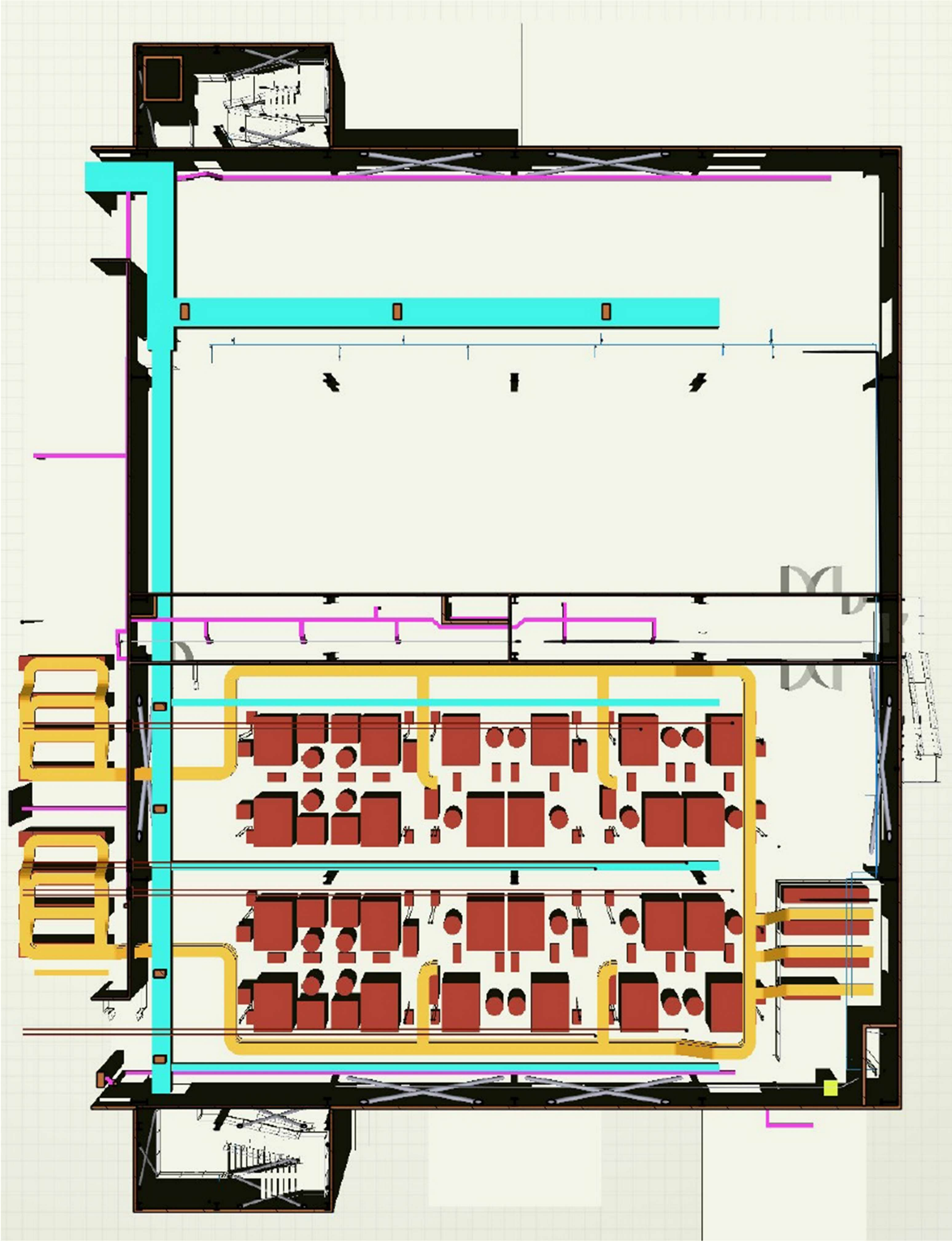

Figure 14: Building 15 Layout EC PS level L2 showing main interfaces

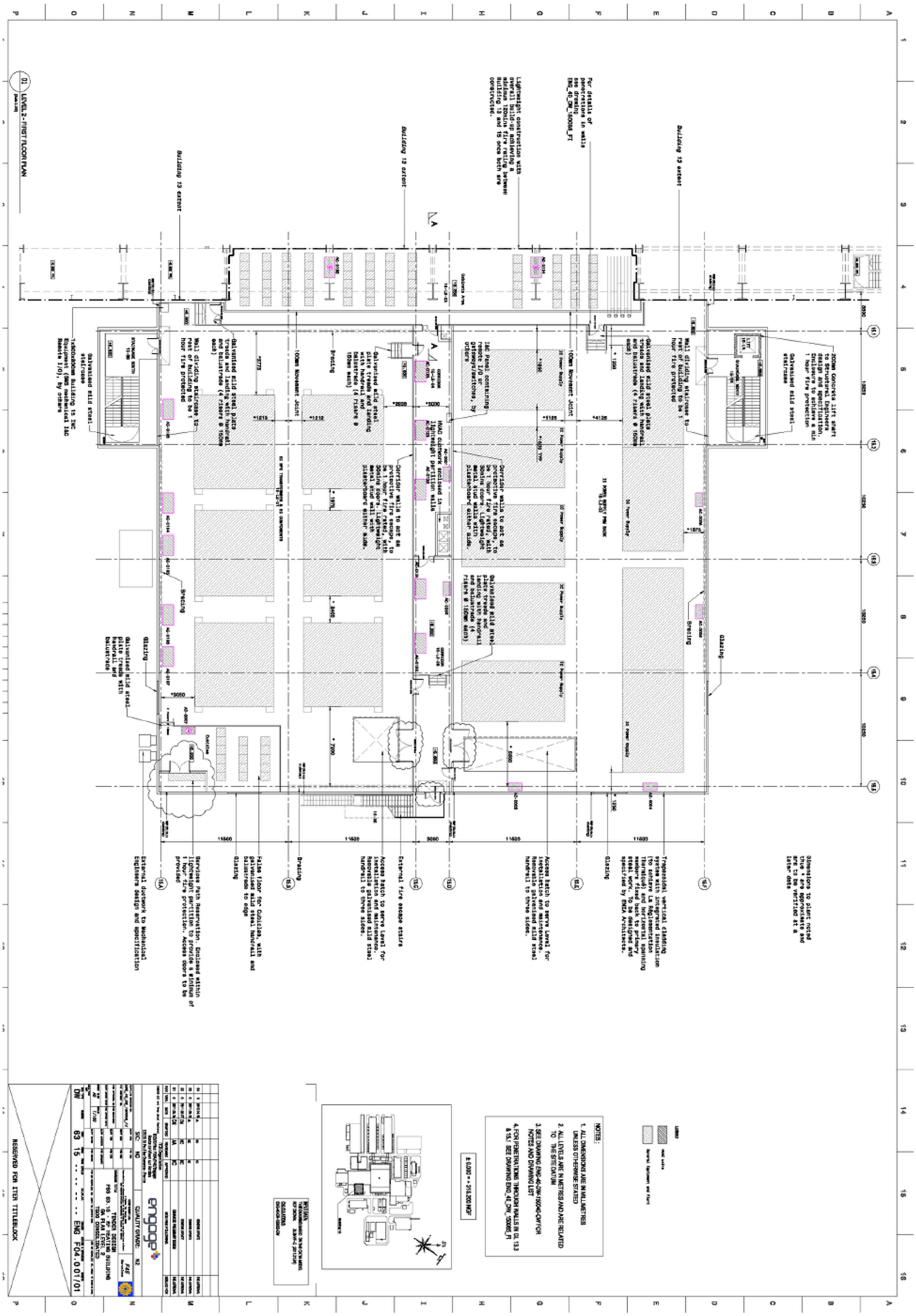

Figure 15: Building 15 Layout EC PS level 2 (L2) showing main dimensions

Part A(II-1), Annexure C: Quality & Site Specifications for EC MHVPS

GeM Bid No.	**GEM/2025/B/6267679**
Title	**Tender Part A(II-1), Annexure C: Quality & Site Specifications for EC MHVPSs**

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Acronyms & Abbreviations

CE	: Conformité Européenne
EC	: Electron Cyclotron
EC MHVPS	: EC Main High Voltage Power Supply
EDH	: Electrical Design Handbook
ESP	: Equipment's Sous Pression meaning "Pressure Equipment's"
H&CD	: Heating and Current Drive
HV	: High Voltage
HVAC	: Heating, Ventilation and Air Conditioning
HVPS	: High Voltage Power Supply
IEC	: International Electrotechnical Commission
LV	: Low Voltage
M&TE	: Measuring and Test Equipment
MHVPS	: Main High Voltage Power Supply
NA	: Not Applicable
NSC	: Non-Seismic Category
PS	: Power Supply
QA	: Quality Assurance
QC	: Quality Class
RF	: Radio Frequency
SL	: Seismic Level
SPS	: Switched Power Supply
SIC	: Safety Important Component

1 Introduction

This document describes the Quality & site specifications for detail design, manufacturing, testing, supply and integration of the EC MHVPSs.
The objective of the "QUALITY PLAN" is to ensure that the product quality requirements and customer requirements are accurately determined and satisfactorily complied.

The purpose of this document is to implement the methodology to be adopted and ensure that the quality policy adopted for design, procurement, outsourcing, subcontracting, in house development/manufacturing, factory inspection and testing, shipping release, integrated testing at ITER-India site at Gandhinagar to meet ITER-India quality requirements.

2 Quality Classification for EC MHVPSs components

MHVPS is assigned the following Quality Class (Table 1).

Table 1 : Quality class for MHVPS Components

Component Name	Quality	ESP	Safety	Seismic
22kV Step-down Multi-secondary Transformer-1	QC2	NA	Non-SIC	NSC
22kV Step-down Multi-secondary Transformer-2	QC2	NA	Non-SIC	NSC
High Voltage Rack (Including SPS Modules)	QC3	NA	Non-SIC	NSC
Hydraulic Cooling Circuit	QC3	See	Non-SIC	NSC
Output Filter	QC3	NA	Non-SIC	NSC
Output Disconnectors and Earthing Switches	QC3	NA	Non-SIC	NSC
SPS Controller	QC3	NA	Non-SIC	NSC
MHVPS Slow Controller	QC3	NA	Non-SIC	NSC
Short Pulse Dummy Load (200ms/250s)	QC4	NA	Non-SIC	NSC

EC-MHVPS System is assigned Quality Class according to the '*ITER Quality Classification Determination document (IDM Ref: ITER_D_24VQES)*.

3 Safety requirements at site

The EC MHVPS is classified as non-SIC (Safety Importance Component)

The primary hazards associated with the MHVPS are those associated with high power electrical power conversion systems to ensure personnel safety, all aspects of the EC MHVPS design and installation shall conform to applicable French codes and standards, and in particular to the IEC 60479, IEC 61140, IEC 62271-1.

CONTRACTOR/SUPPLIER shall ensure that the all MHVPSs equipment enclosures wherever applicable are earthed. Exceptions may be considered by ITER-India for devices designed to operate at a floating potential with respect to ground.

Each enclosure shall be provided with suitable bonding leads to connect together all the part osf the enclosures (e.g. doors) and all items inside the enclosure requiring earthing.

The fences must be connected to the ground grid of the Site; all their metallic parts (frame, doors, panels etc.) will be linked to the ground bolt. The grounding circuits should be designed for a single short-circuit withstand and consistent with the IEC 60204-11 and IEC 62271-200.

CONTRACTOR/SUPPLIER shall ensure that all earthing connections between items of the supply, equipment enclosures and local earth connection points are provided. ITER-India will make available the local earth connection points for the HVPSs equipment, CONTRACTOR/SUPPLIER shall ensure that the earthing connections shall be designed and performed for a single short-circuit withstand and consistent with the IEC 60204-11 and IEC 62271-200. All the ground connections shall be easily spotted.

The MHVPS components are to be accessible only under top safety conditions: therefore, each MHVPS shall be equipped with a grounding switch connected to the high-voltage output terminals of the unit. The opening of the high-voltage Fence door shall be allowed only after the switch has been closed (grounded). Similarly, the opening of the switch shall be possible only after the Fence doors have been closed.

The switches or equivalent devices (e.g.: switch ground hook) are to discharge the HV cables and ground them prior to human access within the HV enclosures to avoid all the dangerous states for the M H V PS.

A remote controllable off load switch is to be included with the MHVPS set, to allow connection/isolation of one gyrotron, while the other remains connected to the same MHVPS. Connecting or disconnecting is made when no HV is applied to either Gyrotron. The cables to the two Gyrotrons coming from the same MHVPS must be individually insulated and grounded. The status of these as the others safety devices shall be properly monitored and controllable from the EC MHVPS local control system. These signals and controls are also to be included in the safety control functions of the Plant system I&C (the latter task is not included in the PS procurement).

The operations on the grounding switches shall be constrained to an interlock key system (out of the scope of this contract) connected with the HV-LV sources upstream and downstream the MHVPSs. The interlock characteristics shall depend also on the upstream MHVPS equipment (e.g. soft-start) and power network.

Limit switches shall signal to the EC MHVPS control system the status of the grounding switches (a opened contact in a limit switch means that the grounding switch is closed to ground). Each enclosure will be equipped with red and green lights that indicate the status of the grounding switches. The grounding switch operation shall be motorized or at pneumatic control.

CONTRACTOR/SUPPLIER shall ensure that emergency push-buttons are provided, at least one in the HVPSs Local Control area and one in the HVPSs power conversion area. The emergency pushbuttons shall comprise as a minimum the following actions:

- Tripping of the 24 kV MHVPS input Circuit Breaker
- Notification to EC H&CD Plant Controller

4 Hazard Analysis

The EC MHVPS is classified as non-SIC (Safety Importance Component) The primary hazards associated with the EC PS are those associated with high power electrical power conversion systems to ensure personnel safety, all aspects of the EC PS design and installation shall conform to applicable French codes and standards, and in particular to the IEC 60479, IEC 61140, IEC 62271-1 listed in the reference document, *'Electrical Design Handbook (EDH)'*. Cast-resin transformers (F1 fire behaviour class) are required to limit fire risk and maintenance requirements.

5 Audible Noise

All equipment shall operate without undue vibrations and with the lowest possible audible noise (also required during stationary conditions) to avoid any harmful effect to the equipment. All equipment prone to vibrations or loud audible noises are to be properly isolated (from adjacent structure) and/or insulated (from noise). In particular, the daily average exposure noise level of one PS unit must not exceed 74 dB(A). Alternatively, the

CONTRACTOR/SUPPLIER must demonstrate that the daily average exposure noise level of an equivalent 4 PS in the RF building configuration does not exceed 80dB(A) according to the French Decree 2006-892 (19 July 2006).

6 RAMI requirements

RAMI requirements are specified in the ITER Project requirements document for the main functions necessary for the ITER machine operation and for the additional main functions necessary for the physics program. The MHVPS sub-system shall contribute to the inherent availability objectives for the ECH&CD system.

CONTRACTOR/SUPPLIER shall provide information, and preferably evidence, on the reliability of equipment offered and of the compliance of the actions appropriate to the required quality level.
CONTRACTOR/SUPPLIER shall indicate the times necessary for the substitution of the main components in case of faults and the suggested spares necessary to re-establish the system operation in the minimum time.

The design and construction of the equipment shall conform to the best current engineering practice. The essence of design shall be simplicity and reliability in order to give long continuous service with minimum maintenance requirements.

"Off-the-shelf" components shall be used to the most possible extent. The design report shall include a chapter with the justification for the use of specially designed components, if any.

The use of ignitrons (containing mercury) is not accepted.

Modularity shall be used to the maximum possible extent to minimize the time required for maintenance and repair.

All components and cables shall be securely braced against mechanical forces during transport and against electromagnetic forces occurring during normal operations and fault conditions.

7 Investment Protection

EC main high voltage power supply feeds 6MW power to RF source; the power supply comprises of major components like multi-secondary transformers, SPS modules, controller etc. While fulfilling functional performance, power supply design is supposed to provide investment protection of all related equipment against possible damaging events.

Investment Protection analysis should include analysis with identification of such risk functions along with recommended/ included mitigating measures and derives ITER Interlock Integrity Level. according to MQP policy for *"ITER Investment protection (ITER_D_3VUMVWv4.1)"*.

8 Requirements for Cleaning, Packaging, Transport and Storage

CONTRACTOR/SUPPLIER to provide "Specifications for Handling and Transportation" of all the procured components. These Specifications shall include, at least, the dimension and weight of each transported package and the detailed instructions for properly handling and transporting each package.
CONTRACTOR/SUPPLIER shall include in each package any stress sensor and provision to make possible an effective and easy monitoring of the package conditions and to ensure that the package itself and anything included is substantially sound.
The packaging must provide adequate mechanical and environmental resistance to road and/or ship transport. The packaging must provide adequate attachments for loading and unloading by crane or equivalent lifting/moving tools and for its stable fixation on trucks and ships.

The sub-components forming the MHVPS system and their parts shall be packaged and loaded for overland transport respecting the size and weight limits indicated in the European Directive 96/53/CEE dated 25 July 1996. It is assumed that standard limits will be respected.

In order to ensure a clear identification of the components transported in the package, the CONTRACTOR/SUPPLIER shall identify all the components by a metallic or plastic plate attached to the component, where the identification code (ID) is written. The ID will be deduced from the reference document *"ITER Numbering System, (ITER_D_28QDBS)"*.

The packaging of the components, ready for shipment, shall be inspected at the manufacturer premises to verify the respect of the requirements for transport. The inspection shall consist of a visual verification of the packaging and of a review of the formal and technical documentation for transport. The inspection and documentation verification shall be performed with the presence of representatives of the ITER-India. An official note of the inspection shall be prepared and approved by the representatives.
The handling must be performed adopting procedures that minimize the risk of damages to the components. The storage must prevent any possibility of contact with any contaminant agent.

ITER-India shall under take road and ship transports using the most appropriate carriers.

CONTRACTOR/SUPPLIER shall provide all the documentation requested by the local authorities to deliver the components to PURCHASER's SITE.
At the arrival in the ITER site, the packaging containing the components ready for unloading shall be checked. This check shall consist in:

- Visual verification of the packaging;
- Checking of shock recorders and/or acceleration sensors prepared to monitor shocks and vibrations during transport;
- Checking of all the requested administrative documentation;

An official note of the check shall be prepared and approved by representatives of the Supplier/ITER-India.
Specific preservation plan be produced by CONTRACTOR/SUPPLIER if needed for specific components. Preservation duration may last up to 2 years after the equipment is received at PURCHASER's SITE.

9 Site conditions

9.1 Ambient conditions

The Ambient conditions for the RF Building are summarized in the Table 2.

Table 2: Indoor ambient conditions controlled by the HVAC system

Conditions	Value
Indoor temperature range	10 to 35 °C
Indoor temperature range tolerance	±2 °C
Room relative humidity	15 to 85 %
Minimum fresh air requirement	30 m^3/hr/person
Room pressure relative to outside environment	Positive
Minimum filtration efficiency: filter class (EN 779)	G4/F7

9.2 Seismic Conditions

The MHVPS is classified NSC (Non-Seismic Category) according to ITER Seismic Nuclear Safety Approach (no seismic requirements for safety) and shall be subject to a seismic analysis. The MHVPS shall be designed to restart and operate after an SL-1 event without special maintenance or test.
Floor response spectra for the system are to be considereds as per the *HVPS Load Specification (ITER_D_65Q4B3)*.

9.3 Facilities in the RF Building

The RF Building structure shall provide the following systems and services (in general, may not be accessible to CONTRACTOR/SUPPLIER) to ensure the necessary conditions and a suitable environment both for the staff and the equipment:

- Lighting and service power;
- Fire detection, alarm and suppression;
- Drainage systems;
- Earthing system and lightning protection;
- Heating, Ventilation and Air Conditioning system, including associated hot and chilled water distribution systems;
- Overhead cranes;
- Potable water and drainage for personnel requirements where necessary;
- Access control system;
- Communication network system;
- Compressed air (dry) system;
- Temporary power supplies during installation for tooling etc.;
- Local support;
- Office space;
- Support for workshop;
- Telephone lines/internet access etc.;