IDM UID
898A2R
VERSION CREATED ON / VERSION / STATUS
10 Jan 2023 / 2.0 / Approved
EXTERNAL REFERENCE / VERSION

System Load Specifications

Load Specification for the IC H&CD HVPS

Load Specification for the IC H&CD High Voltage Power Supply

Approval Process			
	Name	*Action*	*Affiliation*
Author	**Gassmann T.**	**10 Jan 2023:signed**	**IO/DG/ENGN/EDD/HCD/ICNS**
Co-Authors			
Reviewers	**Lamberlin L.** **Liu H.** **Mukherjee A.** **Nafradi G.** **Perrin J.- L.** **Roccella R.** **Ruiz P.** **Vertongen P.**	**08 Feb 2023:recommended** **10 Jan 2023:recommended** **31 Jan 2023:recommended** **10 Jan 2023:recommended** **11 Jan 2023:recommended** **25 Jan 2023:recommended** **23 Jan 2023:recommended** **15 Jan 2023:recommended**	**IO/DG/CNST/CMO/BCW** **IO/DG/SQD/NS** **IO/DG/ENGN/EDD/HCD/ICNS** **IO/DG/SQD/NS** **IO/DG/ENGN/CIO/PFI/DIS** **IO/DG/ENGN/CIO/IEA** **IO/DG/ENGN/CIO/IEA** **IO/DG/SQD/QMD**
Approver	**Boilson D.**	**08 Feb 2023:approved**	**IO/DG/ENGN/EDD/HCD**
Document Security: Internal Use *RO: Beaumont Bertrand EXT*			
Read Access	**LG: heatings, LG: ICH EXT, GG: IO DDGs (and Senior Advisors), AD: ITER, AD: External Collaborators, AD: IO_Director-General, AD: External Management Advisory Board, AD: IDM_Controller, AD: Auditors, AD: ITER Management Assessor, project administrator, RO**		

Change Log			
Load Specification for the IC H&CD HVPS (898A2R)			
Version	***Latest Status***	***Issue Date***	***Description of Change***
v1.0	Revision Required	05 Oct 2022	
v2.0	Approved	10 Jan 2023	Scope limited to transformers which are the only QC2 components

Table of Contents

1 Purpose

The purpose of this document is to specify the individual loads and load combinations which shall be considered for Ion the Cyclotron High Voltage Power Supply (IC HVPS) system transformers, used for the Integrity Justification. The sole purpose is to:

- Describe the loads affecting the IC HVPS transformers and their load path through the mechanical connections for the verification of the structural integrity;
- Define the interface loads with Building 15 and with other services;
- Satisfies requirement defined in SRDs [10], [11];
- Satisfies requirements defined in the PA Annex B (or Technical Specifications) [2], [3].

This load specification follows the requirements detailed in [1].

2 Scope

The scope of this document is the MV multi-secondary transformers of Ion Cyclotron High Voltage Power Supplies (IC HVPS) for Ion Cyclotron Radio Frequency Sources (IC RF Source). IC HVPS system comprises 9 nos. of 22kV incoming switchgears procured by F4E, 8 HVPS units supplied by IN DA, 10 HVPS units to be supplied under IO direct procurement (IO/21/CT/4300002606 contract) and dummy load system for Site Acceptance test. IC HVPS shall be installed inside the RF building (Building 15).

Each of the 8+10 IC HVPS units include 2 transformers, under the scope of this load specification. Each transformer is considered as a single self-standing component. Hence structural integrity shall be demonstrated for each transformer.

The scope of this Load Specification covers:

- The list of all the single loads and the load combinations to be considered to verify the structural integrity of the IC HVPS system transformers, and the load category of all load combinations;
- The specification of all load values related to individual loads that must be considered to verify the structural integrity of the IC HVPS transformers;
- The number of load cycles to be considered for each load;
- The identification of all states of the IC HVPS system transformers.

Notes:

- There will be up to 2 different designs of IC HVPS transformers and differences for the loads will be highlighted in this document.
- The loads were derived from the set of Project LS [4] and only the applicable single and combination loads are propagated.
- Specifying the states is not necessary because no design driving loads occur in these states.
- The IC HVPS system transformers shall be designed to withstand all the loads and load combinations described in this document.
- Transformers are the only IC HVPS components which are QC2 classified, the rest being QC3 classified. Hence, as per [1] [SLS004-R], transformers are the only IC HVPS components subject to this load specification
- There no PIC in the IC HVPS.

3 Scope of reviewers

Table 3-1 Scope of the reviewers

Reviewer	Scope
Aparajita Mukherjee	PBS51 section leader shall review that: • The general applicability of the information included in the load specification is correct; • The scope is correctly defined in terms of geometry; • The Load Specification covers the required damage limits for all the applicable loading categories, the related design criteria and the functional requirements for all the parts of the IC HVPS.
Lamberlin Lionel	PBS 63.15 RO shall review that: • The consistency of this Load Specification with the referenced interfaces with PBS 63.15, and the correctness of the related conclusion.
Liu Haibo	PBS51 SRO shall review that: • The Safety requirements are met, accordingly to the safety class of the IC HVPS.
Patrick Vertongen	PBS51 QA shall ensure that: • The QA requirements are met, accordingly to the quality class of the IC HVPS.
Pedro Ruiz	IEA reviewer shall review that: • The requirements described in [1] are implemented in the Load Specification.
Jean-Lou Perrin	B15 DIS area manager shall review that: • The list of interfaces and any additional aspects related to the IC HVPS Integration.
Gabor Nafradi	Radiation Safety Group member shall review that : • The Safety requirements are met regarding the radiation environment.
Riccardo Roccella	EM Loads

4 References

[1]. Guideline for ITER System Load Specifications, ITER_D_33TTPJ v3.2
[2]. IC HVPS IO/21/CT/4300002606 contract technical specifications, ITER_D_C9ZKTD v1.8
[3]. IC HVPS PA 51.P4.IN.01 Annex B, ITER_D_2FRJMT v4.7
[4]. ITER Load Specifications (LS), ITER_D_222QGL v6.2
[5]. ITER Coordinate Systems, ITER_D_2A9PXZ v3.7
[6]. ITER Abbreviations, ITER_D_2MU6W5 v1.17
[7]. EDH Part 3: Codes & Standards ITER_D_2E8DLM v 1.3
[8]. ITER Coordinate Systems, ITER_D_2A9PXZ v3.7
[9]. Final Design Review Dossier - INDA HVPS FDR, ITER_D_38Z6HB
[10]. SRD-51 (ICH&CD) from DOORS, ITER_D_28B33K v6.0
[11]. SRD-51-HV (was 42-IC) (Ion Cyclotron Heating and Current Drive Power Supplies), ITER_D_2MHS2W v3.2
[12]. Seismic Relative Displacements between the Building Floors, ITER_D_KWXL6B v1.0
[13]. Application of the FRS Simplified Methodology to Building 15 - PBS 63.15 RF Heating Building, ITER_D_QPBST4 v1.2
[14]. EU-DA Report – PA 6.2.P2.EU.02 - Methodology to be Used to Generate the Seismic Floor Response Spectra for Ancillary Buildings at ITER, ITER_D_PN36V6 v3.1
[15]. Instructions for Seismic Analyses, ITER_D_VT29D6 v2.0
[16]. NF EN 1998-1:2005 (Dec 2007), Eurocode 8 - Design of structures for earthquake resistance, ITER_D_983V2K v2.0
[17]. Application of the FRS Simplified Methodology for the equipements close to the ground - F4E_D_3DGRH6, ITER_D_QZYDL3 v1.0
[18]. Allowable values and limits in service level C and D for ITER mechanical components ITER_D_3G3SYJ

5 System Classifications

The detailed quality classifications for the IC HVPS components are listed in [2] and [3]. The ITER classifications for the IC HVPS transformers are listed in Table 5-1.

Table 5-1 General classifications for the IC HVPS

Quality	Safety	Seismic	Vacuum	Tritium	Remote Handling	ESPN	ESP
QC2	Non SIC	NSC	NA	NA	NA	NA	NA

6 Codes and standards

The codes and standards applicable to this IC HVPS Transformers are listed in following references:

- EDH Part 3: Codes & Standards [7] for all electrical equipment;

The applicable code for IC HVPS Transformers are, as per following.

- IEC 60076-11 : Dry Type Transformers
- IEC 61378-1 : Converter Transformer

7 Definitions

7.1 Units

The units used in this analysis are the standard SI base and derived units listed in the Table 7-1. Standard prefixes are also used. Temperature is given in degrees Celsius. To avoid misinterpretations, it must be prevented that units are specified globally and that load values are given without unit. Therefore, all values given in the load specification shall be given with their units and no global unit specification shall be made.

Table 7-1 Units

Quantity	Unit Name	Unit Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Temperature	Celsius	°C
Acceleration	-	$m \cdot s^{-2}$
Force	Newton	N
Moment	-	N·m
Pressure	Pascal	Pa ($N \cdot m^{-2}$)

7.2 Coordinate systems

The global coordinate system considered for the engineering analysis shall be the TGCS (Tokamak Global Coordinate System) [5]. Unless stated otherwise, all loads are specified in this coordinate system. The axes / directions of the TGCS are named: radial, toroidal, and vertical; also the directions “poloidal” and “toroidal” are used for load directions, as reported in Figure 7-1 below.

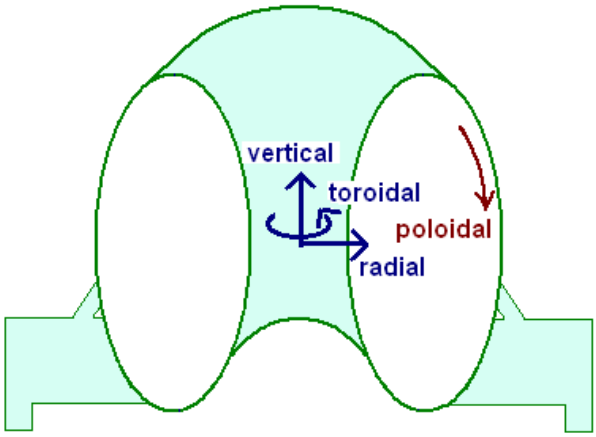

Figure 7-1 Definitions of the plasma CS (red) and the cylindrical CS (blue)

7.3 Abbreviations

The ITER Active Web Abbreviations Dictionary and the official list of abbreviations can be found in [6]. See below a list of abbreviations used on this document:

CCWS	Component Cooling Water System
DA	Domestic Agency
DW	Dead Weight
IC	Ion Cyclotron
ESPN	Equipement Sous Pression Nucléaire
EU DA	European Domestic Agency (F4E)
IC HVPS	Ion Cyclotron High Voltage Power Supply
H&CD	Heating & Current Drive
FDR	Final Design Review
ITER	International Thermonuclear Experimental Reactor
I&C	Instrumentation & Control
IN-DA	Indian Domestic Agency
PA	Procurement Arrangement
PR	Project Requirements
QA	Quality Assurance
IC RF	Ion Cyclotron Radio Frequency
SIC	Safety Importance Class
TBC	To be confirmed
TBD	To be defined

8 Types of Loads

The loads acting on IC HVPS Transformers can be classified within 5 categories:

- **Inertial Loads:** these are caused by accelerations of masses induced by gravity, seismic events and displacements of supporting structures imposed by plasma disruptions.
- **Pressure Loads**: forces distributed over surfaces due to coolant fluid or atmosphere acting on evacuated volumes or external pressure conditions caused by accidental events.

- **Assembly or installation Loads** due to pretension and live loads.
- **Manufacturing Loads**: residual tensions produced by brazing or welding procedures.
- **Specific Loads** (e.g. corrosion, wearing, vibration).

9 Main Loads

The following table provides a list of the main loads applicable to the IC HVPS Transformers. Design information for these loads can be found in the relevant sections provided.

Table 9-1 Characteristic loads from IC HVPS

Load Event	Section	Characteristic loads
Self-weight (DW)	13.1.1	Load due to the component self-weights
SL-1, EC8, SL-2	13.1.2	Seismic events

10 Path of the Main Loads

The nominal paths of loads are shown in Figure 10-1, which presents the main interfaces involved in carrying these loads to ground.

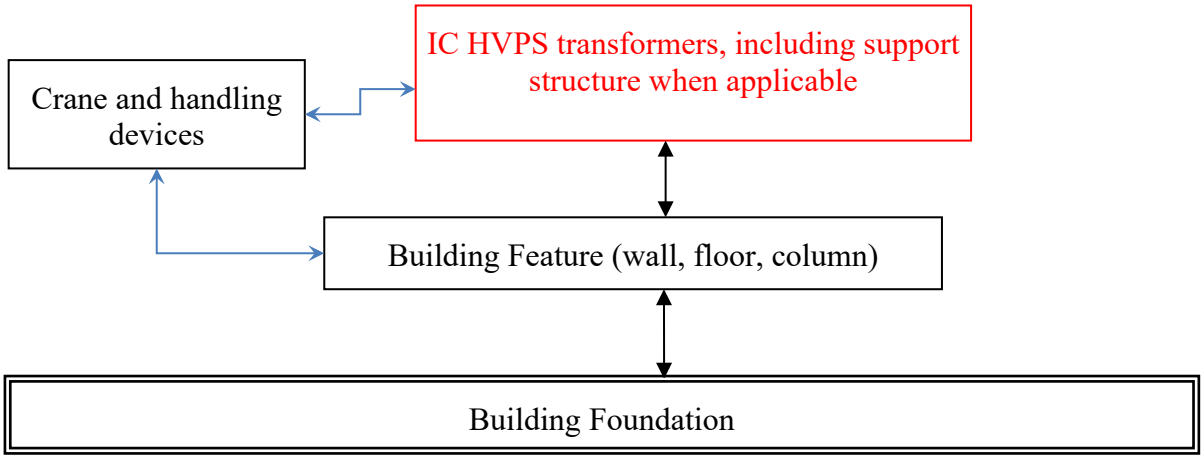

Figure 10-1 ITER structural load path diagram

11 System Description

11.1 Design status

The IC HVPS transformers:

- Prototype to support RF Source R&D Phase been manufactured by IN DA (non IO delivery). The prototype HVPS, including multi-secondary transformers, was used in an integrated test campaign on the R&D RF Source and the performances were validated. The prototype HVPS and R&D RF Source do not qualify for IO delivery.
- Final Design review for IN-DA IC HVPS was conducted. However, closure is yet pending [9].
- IO/21/CT/4300002606 contract has been signed and Kick of Meeting took place. Currently in final design phase.

Since its conceptual design review, a series of PCRs/Notes/Memo have been proposed and implemented to the IC HVPS design. The main ones are:

- PCR-M0048 Baseline alignment to updated IC HVPS technical specification (ITER_D_ETMEQT)
- Note on Driver Stage Voltage Requirement. (ITER_D_ATW5VF)
- IC HVPS driver and end stage voltage (ITER_D_YG3EJF)
- PCR 118 - Inconsistencies in ICRF Procurement (ITER_D_28H8WG)
- PCR 303 - Modification of IC HVPS procurement allocation (ITER_D_ETL2US)
- PCR-625 - Procurement and installation of Trays in auxiliary plant buildings (ITER_D_PF8EXC)
- PCR-001091 - Regrouping of PBS51 and PBS52 switchgear procurement (ITER_D_XP55HP)

The following reference shows the CM model of the HVPS in B15. The transformer are visible in B15-L1-02 while the HVPS cabinets are at B15-L2-02. (no available model with only the transformer for now)

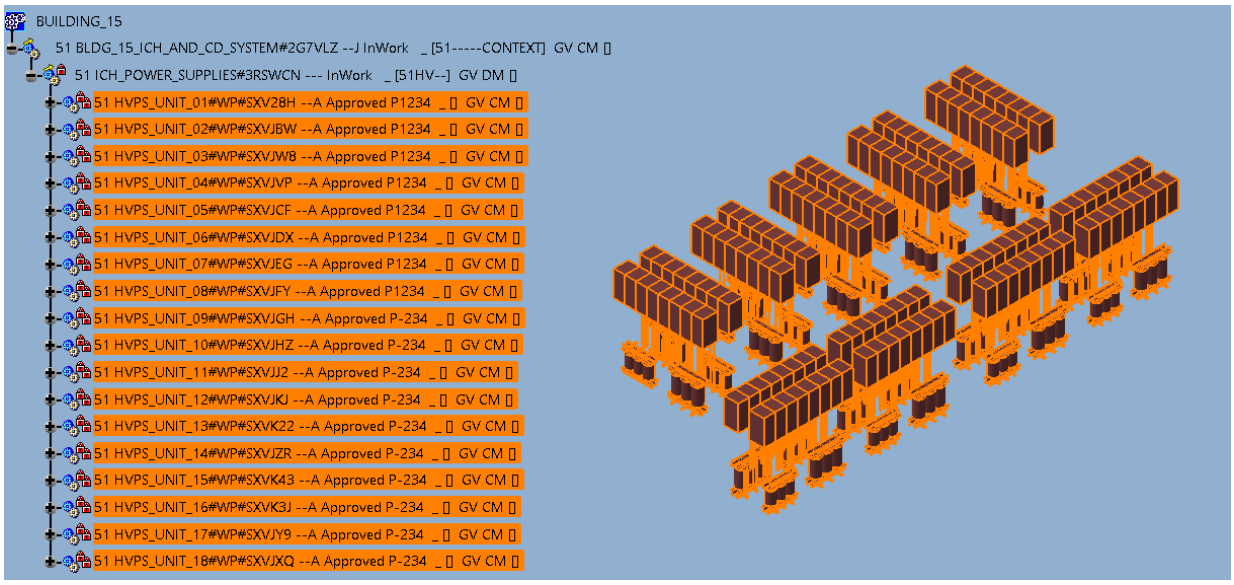

Figure 11-1: Configuration model of the 51 HVPS in B15 (transformer at lower level)

11.2 System Design Description

The Ion Cyclotron Heating and Current Drive system (IC H&CD, or in short, IC) shall provide radio-frequency (RF) heating and current drive to the ITER plasmas. A total of 20 MW of RF power is available for injection into the plasma.
The IC H&CD system is composed of the antenna port plugs, the matching systems, the transmission lines, the RF power sources, the high voltage power supply, plus auxiliary sub-systems and services such as decoupling units, control systems and test facilities. Main components layout is described in the Figure 11-2:

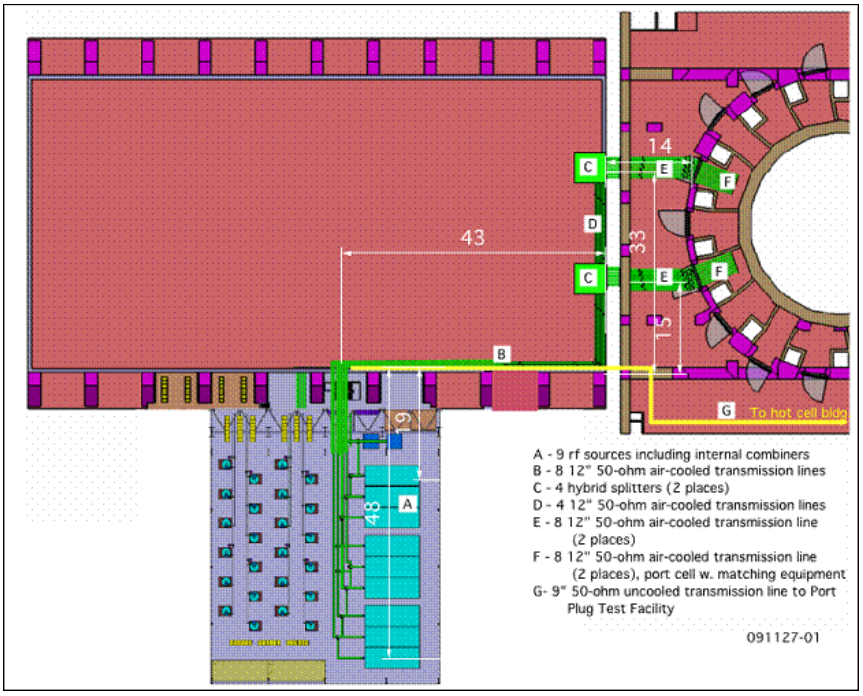

Figure 11-2: ICH&CD system layout

The IC HVPS scheme follows the concept of Pulse Step Modulation. Here Dual output HVPS is developed to cater the requirement of IC RF Sources. The IC HVPS Transformers are as shown in Figure 11-3 (Left side: All Transformers, Right Side: Pair of Transformer for 2 HVPS), which shall be installed at L1 of Building 15. #2 Nos. of Stepdown Transformers are to be used for each IC HVPS.

The power conversion modules and other accessories are housed inside HV Cabinet as shown in Figure 11-4. HV Cabinet consist the Switched Power Supply Module, Inductors, Voltage and Current Measurement devices, DC side Disconnector/earth switch and cooling network. The HV Cabinet is designed and manufactured in compliance to IEC standards [7].

IC HVPS units shall be installed inside Building 15 where Transformers are at L1 while HV Cabinet and controller at L2. Figure 11-3 represents the Layout of 8 IC HVPS units, to be supplied by IN DA. The Equipment Controllers shall be installed at L2, in dedicated area for controller as shown in green in Figure 11-4.

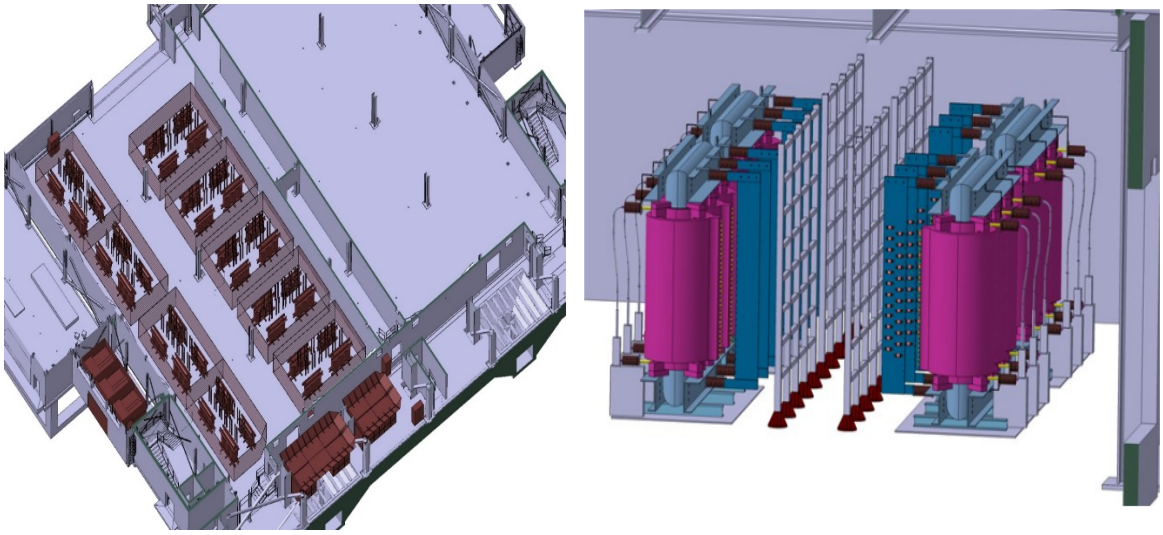

Figure 11-3: ICH&CD HVPS system layout at B15-L1

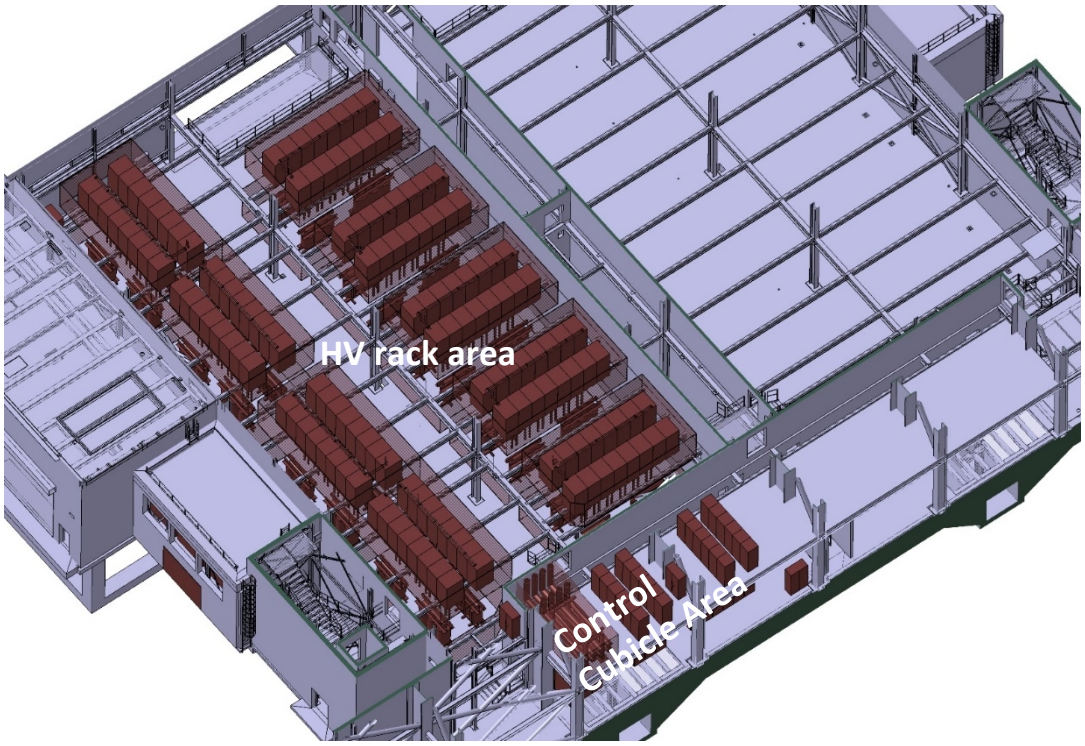

Figure 11-4: ICH&CD HVPS system layout at B15-L2

Resistive dummy load bank are to be used for validation of all 18 IC HVPS units. Load Bank units shall be installed outside the B-15, in dedicated area as shown in 11-5.

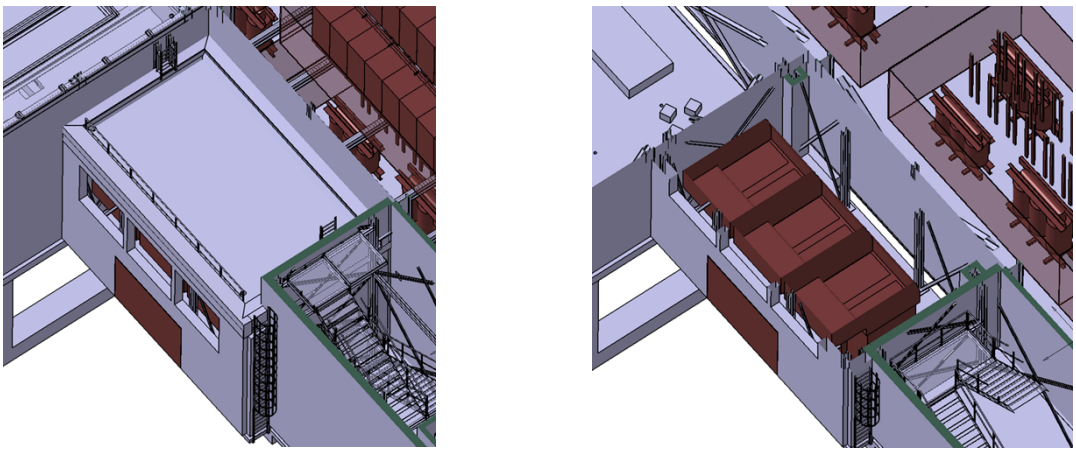

Figure 11-5: IC HVPS dummy load shelter (15-AN-04)

The heat generated inside the IC HVPS units shall be recovered by demineralized water, provided by CCWS-2A.

Inside Building 15 at L1, 22kV Switchgear shall be installed, which are the interface points with ITER PPEN system as shown in Figure 11-6. Each Switchgear unit consists of 3 units viz. 1 incoming feeder and 2 Outgoing feeders for 2 units of IC HVPS.

- Sets are in the scope of EU DA under EC HVPS PA 5.2.P4.EU.01. Breaker type has been selected by the manufacturer (Ampegon) after analysis of the protection scheme.

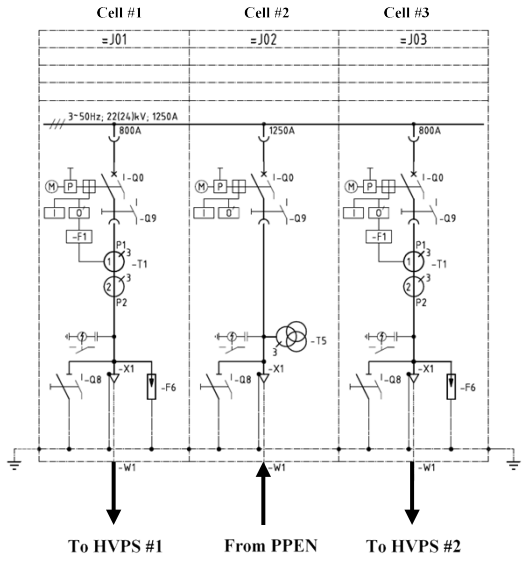

Figure 11-6: Feeder line of IC HVPS system layout at B15-L1-04 from EU-DA

11.2.1System, Components and Parts

The main components of the IC HVPS are listed in Table 11-1. However present Load Specifications covers only Power Transformers. Remaining components are listed here for information to realize its integration with system.

Table 11-1 Main IC HVPS components

IC HVPS components	INDA IC HVPS	IO IC HVPS	F4E
22 kV switchgear	-	-	x
HV cables	x	x	-
Power transformers	**x**	**x**	**-**
LV cables	x	x	-
HV cabinet	x	x	-
LV-AC cubicle	x	x	-
Control cubicle	x	x	-
Dummy load	x	x	-
HV DC cable	x	x	-

The transformer is considered as a single self-standing component/part. It is considered an Off the Shelf component. The materials involved in the component will depend on the manufacturer's choice. Hence it is the responsibility of the manufacturer to provide an analysis with the correct material assumptions.

11.2.2 Fabrication, assembly in factory, testing and transportation

The IC HVPS transformers have to be delivered to the ITER site after being properly manufactured / assembled and inspected.
Loads during manufacturing are expected to be negligible in front of the seismic loads. Transformer can be found with the shipping documentation.

11.2.3 Installation and Commissioning

The IC HVPS transformers are transported from the storage building to B15 L1 using either lifting trucks and cranes, forklift or heavy duty roller gear. The installation is done by aligning, fixation and anchoring the IC HVPS transformers to the concrete.

The transformer supplier shall define the transport configuration(s) and verify its integrity based on his assumptions.

IC HVPS transformers commissioning shall be done with contractor hired by supplier, in compatibility with IO site working rules.

11.2.4 Function / Normal Operation

The IC RF source generates 24 MW of RF power with 8 RF sources plus one spare in CW conditions. PBS51 system shall be able to generate RF pulses of up to 3600s with a duty cycle of 25% .The RF sources shall be operable over the 36 to 60 MHz range [10].

The RF sources operate in any of the five modes of operation of the IC H&CD system:

- Plasma heating and current drive
- Wall conditioning
- Antenna conditioning
- Antenna RF tests on Port Plug Test Facility
- RF source test on high power load

The operation modes above all correspond to the same operation load for the transformer. There are no loads specific to one ICH mode.

2 Units of IC HVPS, each one including 2 transformers, are to be used to feed 1 RF Source. 8 IC HVPS unit from IN DA are to be used for 4 IC RF Sources while 10 IO IC HVPS to be used to

feed 5 IC RF Sources. IC HVPS provide controlled voltage to IC RF sources to support operation in above mentioned cases.

11.2.5 Interfaces

The IC HVPS transformers interface with other ITER systems and IC H&CD sub-systems are listed in the PBS 51 SRD [10]. The Interface Control Documents (ICDs) and the associated Interface Sheets (ISs) are stored in IDM (ITER_D_2E4R6H).
Several of these interfaces naturally involve:

- A structural connection, e.g. support that will transfer forces and/or moments.

The interfaces with the transformer that involve a mechanical and/or a thermal load are listed in Table 11-2.

Interface	Interface loads	ICD/IS
PBS 63 - RF Building	• Building Loads	(ITER_D_2EPRZE v1.4) (ITER_D_2V3WQZ v2.8)

Table 11-2: List of IC HVPS transformers interfaces which impact mechanical or thermal loads

12 States of system and components

The following list describes all the different states of the IC HVPS transformers in view of load specifications. The load combinations are partly based on this list. Incidental and accidental loads are not described here.

1. Manufacturing
2. Factory Acceptance Test
3. Transportation and Delivery
4. On site Installation
5. Site Acceptance Testing
6. Commissioning
7. Plasma operation
8. Stand by between plasma pulses
9. Shut down for maintenance and upgrades

As explained above, there is no specific load associated with manufacturing. There is also no specific modes associated with the maintenance and upgrade.

At the present design level no other states and components of the system have been identified.

12.1 Transport/assembly

The IC HVPS transformers will have to be transported to ITER site. During the manufacturing, transport and assembly, the IC HVPS transformers will be moved using various tools (crane, assembly tooling etc.). This state will end when the IC HVPS transformers are installed into ITER buildings on site.

Transformer installation will consist of alignment, fixation and anchoring of the Transformer at L1 of Building 15.

The dead weight is applicable during transportation, delivery and installation.

12.2 Testing

Transformers shall be subject to FAT and SAT as per [7]. In particular, these transformer being dry-type transformers. IEC 60076-11 shall be followed.

Mechanical loads and thermal load are associated to the FAT and SAT.

12.3 Operation

The only loads applying to IC HVPS transformers during operation are the Mechanical load (Dead weight, attaching structure, etc.) and thermal load.

Operation encompasses the plasma operation & commissioning.

As explained above, the ICH modes of operation correspond to this mode.

13 Single Load cases

The single load cases are all described here as well as in [1]. The loads are classed in four categories, defined in section 4 of [1] and based on the expectation of their occurrence:

Category I: Operational Loading Conditions

Category II: Likely Loading Conditions

Category III: Unlikely Loading Conditions

Category IV: Extremely Unlikely Loading Conditions

In order to limit the extent of this document only the loads that are essential for the IC HVPS transformers are specified.

13.1 Mechanical loads

13.1.1 Dead Weight

The maximum transformers weight is defined in the following table:

Table 13-1 Components and associated maximum masses for the IC HVPS Procurement

Component	Location	Mass [kg]
2.4MVA Multi- secondary Transformer	15-L1-02	12000
1.2 MVA Multi- secondary Transformer	15-L1-02	7000

These maximum weights correspond to what is described in the building interface (see section 11.2.5). The further details of same are available at FDR dossier [9].

The transformer are delivered and transported fully assembled. The dead weight is applicable in both transport and installed configurations.

13.1.2 Seismic Loads

An earthquake consists of an oscillatory movement of the earth's surface. The ground acceleration can be both in the horizontal and in the vertical direction and typically has a spectral content which leads to some level of support reaction load amplification. A seismic event is, in many cases, the most demanding loading condition, in particular for the support and interface structures (e.g. supports) which must be sized for high strength, and often also for high stiffness. Seismic load excitation corresponds to the specific selected site for the ITER construction. For buildings and equipment that are classified in seismic class NSC, two levels of ground motion is considered:

- SL-1 corresponds to an event with a probability of the order of 10^{-2} per year and represents an investment protection earthquake level (following the Nuclear Pressure Equipment regulation it corresponds to a foreseeable event). The facility has to be designed to restart and operate after an SL-1 event without special maintenance or test;
- Eurocode 8 - Conception et dimensionnement des structures pour leur résistance aux séismes (EC8).

The SL-2 event must also be assessed, but the IC HVPS Transformers are not required to resist this load. The requirement from the SRD [11] is that the IC PS shall not jeopardize the RF building structural stability in case of SL-2 event.

Seismic events - The IC HVPS transformers shall withstand the loads caused by a seismic event according to the acceptable damage limits of components, to their Safety Class and to the category of the event.

SL-1 Seismic events - The seismic analysis shall consider SL-1 as a category II event (as a single load event), inclusive of any applicable amplification factor.

EC8 Seismic events - The seismic analysis shall consider EC8 as a category IV event (as a single load event).

System and components conditions in seismic analysis – The seismic analysis shall assume the IC HVPS components in their worst foreseeable conditions, even if related to different operating conditions.

The seismic load specification for B15 is described in [13] and additional information is available in [14]. The load path during a seismic event is the same as the load path for gravity. [17] is applicable to equipment situated at less than 3 m from the ground or on the ground and not fixed on the first ceiling.
Relative displacement between structural supports of the transformer is not considered.
As no detailed dynamic analysis will be performed and the number of cycles per event is directly calculated, 10 equivalent maximum stress cycles shall be considered for each seismic event whenever a fatigue or a cyclic load analysis is required (Note 2 in Appendix B of [4]).

The damping factor to be considered, as per [4] Table 7-6, is 2% for SL-1 and 3% for SMHV and SL-2.

The seismic load is not applicable during installation.

13.2 Interfaces Loads

The IC HVPS system has interfaces with other ITER systems and IC H&CD sub-systems, listed in the SRD-51 [10]. The Interface Control Documents (ICDs) and the associated Interface Sheets (ISs) are stored in IDM (ITER_D_2E4R6H).

These interface naturally involve a structural connection, e.g. support that will transfer forces and/or moments.

The interfaces that involve a mechanical load are listed in Table 11-2. Only the RF building is listed. There are no specific loads associated with this interface (except seismic) and there are no other interfaces that lead to loads.

13.3 Thermal Loads

The thermal loads are independent from the plasma operation as it depends on the operation of the IC HVPS. Note that the Transformer are emitting heat even if there is no load.

The thermal load seen by the IC HVPS transformers is produced by itself. The thermal analysis is conducted by the IC HVPS team and the industrial suppliers to ensure safe operation regimes. The transformer shall be able to operate under the thermal load generated by its operation under the normal, specified, operation conditions.

A maximum value of 45kW (average heat load with duty cycle 25%) should be considered (for 4 transformers within a fence).

13.4 Assembly and Pretension Loads

The only assembly to be considered on site is the fixation of the transformer to the building ground.

The pre-load has to be calculated considering the applicable code in the seismic event to satisfy both normal operation requirement and the seismic event requirements.

13.5 Not Significant Load Cases

13.5.1 Mechanical loads

The following mechanical loads are not applicable to the IC transformers:

- Tests loads: There is no specific tests load in addition to dead weight loading mentioned in 13.1.1 that applies to the IC HVPS transformers.
- Coolant Pressure: There is no coolant pressure load that applies to the IC HVPS transformers.
- Electromagnetic Loads: There is no Electromagnetic loads due to plasma scenarios or EM transient that applies to the IC HVPS transformers.
- Structural Loads due to Component Operation: There is no Structural Loads due to component operation that applies to the IC HVPS transformers.

13.5.2 Loads in Incident and Accident Events

The following accidental loads are not applicable to the IC transformers:

- B15 fire: The IC HVPS transformers shall not support the loads caused by a fire in B15 as Cast Resin Transformer are F1 grade. They will be damaged in case of fire in B15.
- Loss of Off-site electrical Power (LOOP): During a loss of electrical power, there are no particular loads applicable to the IC HVPS transformers. IC HVPS would not able to operate in case of loss of PPEN or SSEN supply.
- Load Drop: Load drop are accidental events that could lead to an impact on the HVPS transformers. Due to their nature, the IC HVPS transformers are not expected to take any measures to ensure the integrity of their design following a load drop.

13.5.3 Nuclear Loads

There is no nuclear load that applies to IC HVPS Transformers.

14 Load combinations

All system load combinations must be consistent with [4], which provides a baseline list of combinations to be considered and is based on the probability of conditions considered to present loads to the system. These conditions are considered “probable” if their probability of occurrence is at least 1%, or higher. Those with a probability lower than 1% but still plausible, based on historical experience or other physical bases, are “conceivable”.

Loading Category	Category I: Operational/ Design Loading	Category II: Likely Loading	Category III: Unlikely Loading	Category IV: Extremely Unlikely Loading
IC transformer	Normal	Upset	Emergency	Faulted

The codes specified are not-nuclear standards. As such, they are not formulated in terms of service levels. Typically used in the nuclear industry (A, C, D) corresponding to normal, emergency and faulted conditions. The document [18] sets guidelines for defining allowable stress values for service levels C and D in cases like this one, in which the applicable standard does not indicate specific values.

14.1 Categorization of Load Combinations

In the absence of more comprehensive probabilistic analysis, conditions are categorized as follows:

- Category I, for a combination of:
  - All Category I conditions when occurring at the same time or "Probable" to be triggered by the initiating condition.
- Category II, for a combination of:
  - The above Category I combinations with other Category I conditions also when they are “Conceivable” to be triggered by the initiating condition.
  - A Category II condition with other Category I and II conditions which are present or “Probable” to be triggered by the initiating condition.
- Category III, for a combination of:
  - The above Category II combinations with other Category I or II conditions also when they are “Conceivable” to be triggered by the initiating condition.
  - A Category III condition with other Category I, II and III conditions which are present or “Probable” to be triggered by the initiating condition.
- Category IV, for a combination of:
  - The above Category III combinations with other Category I, II or III conditions also when they are “Conceivable” to be triggered by the initiating condition.
  - A Category IV condition with other Category I, II, III and IV conditions which are present or “Probable” to be triggered by the initiating condition.

A simpler way to describe these categories is as follows.

Category I: Operational Loading Conditions

Category II: Likely Loading Conditions

Category III: Unlikely Loading Conditions

Category IV: Extremely Unlikely Loading Conditions

14.2 List of Load combinations

The load cases applying to the IC HVPS Transformers are listed in the Table 14-1:

Table 14-1: Load cases

	Operating conditions	Initiating event	Cat	Number of events
Operating	DW, Th		I	-
Installation	DW, Th		I	-
Operating	DW	SL-1	II	5**
Operating	DW	EC8	IV	1
Operating	DW	SL-2	IV	1*

* IC HVPS transformers not required to withstand

** 10 cycles per events

14.3 Fatigue cycles / Ageing effects

The structural analyst will verify fatigue based on the chosen code and the above table (50 cycles of SL-1).