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Technical Specifications (In-Cash Procurement)

Technical Specification for the Supply of 4 CVBD Inlet Filters (26CVBD-FI-5303, FI-5304, FI-5490 and FI-5497) and 2 CVBD Resin Traps (26CVBD-FI-5803 and FI-5150)

The purpose of the Services described in this Specification is to provide the design, fabrication, inspection, examination, testing, preparation for delivery and shipment of the following CVBD filters:4 CVBD Inlet Filters (26CVBD-FI-5303, FI-5304, FI-5490 and FI-5497) 2 Resin traps (26CVBD-FI-5803 and FI-5150)

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1 Preamble

This Technical Specification is to be read in combination with the General Management Specification for Service and Supply (GM3S) – Ref [39] that constitutes a full part of the technical requirements.

In case of conflict, the content of the Technical Specification supersedes the content of Ref [39].

2 Purpose

The purpose of the Services described in this Specification is to provide the design, fabrication, inspection, examination, testing, preparation for delivery and shipment of the following CVBD Filters:

- 4 CVBD Inlet Filters (26CVBD-FI-5303, FI-5304, FI-5490 and FI-5497)
- 2 Resin Traps (26CVBD-FI-5803 and FI-5150)

The Contractor shall take all the necessary provisions to comply with the requirements imposed by the PED [1] and ESPN [3]. In case of non-conformity or in case of divergence of interpretation between the provision of this technical specification and the Regulation, the Contractor is requested to ask the IO for decision.

3 Acronyms & Definitions

3.1 Acronyms

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

For a complete list of ITER abbreviations, see ref. [40].

Table 1 – List of abbreviations

Abbreviation	Description
ACP	Activated Corrosion Products
ANB	Agreed Notified Body
ALARA	As Low As Reasonably Achievable
ASME	American Society of Mechanical Engineers
ASNR	Autorité de Sûreté Nucléaire et Radioprotection (French Authority for Nuclear Safety and Radiation Protection)
BPVC	Boiler and Pressure Vessel Code
CAD	Computer Aided Design
CCPR	Components Contributing to the Pressure Resistance
CE	Conformité Européenne
CFD	Computational Fluid Dynamics
CLAP	Comité de Liaison des Appareils à Pression
CMM	Configuration Management Model
CMTR	Certified Material Test Report
CVBD	Chemical & Volume Control System for IBED PHTS
CVCS	Chemical & Volume Control System
DN	Nominal Diameter
DNRE	Dimensions Necessary for Compliance with regulatory requirements
DS	DataSheet
DT	Deuterium Tritium
DYS	DrYing System
ELM	Edge Localized Mode
EP	Embedded Plate
EPMN	Evaluations Particulières de Matériaux propres au domaine Nucléaire (Nuclear Particular Material Appraisal)
ESP	Equipement Sous Pression (Pressure Equipment)
ESPN	Equipement Sous Pression Nucléaire (Nuclear Pressure Equipment)
ESR	Essential Safety Requirement of the applicable regulation
EU	European Union
GM3S	General Management Specification for Service and Supply [39]
HFIP	Human Factor Integration Plan
HRA	Hazard and Risk Analysis
HSE	Health, Safety and Environment
ICE	Ingress of Coolant Event
IDM	ITER Document Management (system)
IO	ITER Organization
ITER	International Thermonuclear Experimental Reactor
IBED	Integrated loop of Blanket, ELM-VS, and Divertor PHTS
KOM	Kick Off Meeting

MPBP	Main Pressure Bearing Parts
MRR	Manufacturing Readiness Review
MSNR	Mission de la Sûreté Nucléaire et de la Radioprotection (Office of the Ministries in charge of nuclear safety and radioprotection)
NB	Notified Body
NBI	Neutral Beam Injection
NCR	Non-Conformance Report
NDT	Non-Destructive Testing
NPE	Nuclear Pressure Equipment
NPMA	Nuclear Particular Material Appraisal
PBS	Plant Breakdown Structure
PED	Pressure Equipment Directive
PHTS	Primary Heat Transfer System
PIA	Protection Important Activity
PIC	Protection Important Component
PP	Pressurized Parts
PR	Project Requirements document [41]
QA	Quality Assurance
QAP	Quality Assurance Program
QC	Quality Class
RAMI	Reliability, Availability, Maintainability, and Inspectability
REP	Réacteur à Eau Pressurisée
RCC-M	Règles de Conception et de Construction des matériels Mécaniques des ilôts nucléaires REP
RTPO	Recognised Third Party Organisation
SIC	Safety Important Class
SMDD	System for the Management of Diagrams and Drawings
SO	Supply Order
SRD	System Requirements Document
SRO	Start of Research Operation
SSC	System, Structure and Component
TCWS	Tokamak Cooling Water System
VCI	Vapour Corrosion Inhibitor
VCT	Volume Control Tank
VS	Vertical Stabilization
VV	Vacuum Vessel
WPQR	Welding Procedure Qualification Record
WPS	Welding Procedure Specification

3.2 Definitions

ANB: Notified Body approved by ASNR to perform the conformity assessment of NPE.

As Low as Reasonably Achievable (ALARA): means making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical, consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of

improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

Contract: An all-inclusive term used to cover all legal obligations between the IO and the Contractor for the performance of part or whole work defined in the present document. These obligations are enforceable immediately at its date of entry into force, including any amendment(s). Refer to contract conditions for more details.

Contractor: Economic operator who have signed the Contract in which this document is referenced. The Contractor is responsible for the performance of a portion of the work or the whole work defined in the present document.

Contractor's Premises: Any location, apart from the Site, where the Contractor or Subcontractors carry out any work defined in the present document.

Delivery Location: Location specified by the IO where the supplies will have to be delivered by the Contractor.

Documentation: The procedures, test reports, certifications, manuals, instructions, and other data specified to be delivered by the Contractor.

Nuclear Particular Material Appraisal (EPMN French Acronym): Specific Assessment of Nuclear Material. - French Environmental Code article L557 and R557 ref. [2], concerning equipment at risk which is a transposition of PED (2014/68/UE) ref. [1].

French ESPN Order related to NPE: French Order dated 30 December 2015 concerning nuclear pressure equipment ref. [3]. The ESPN follows a pressure classification and conformity assessment procedure that is in many cases based on PED assessment modules. It is the responsibility of the Manufacturer to comply with all requirements of this Order.

Heat: a generic term denoting a specific lot of steel, based up on steelmaking and casting considerations.

Heat number: the alpha, numeric, or alphanumeric designator used to identify a specific heat of steel.

INCOTERM Named Place: A location specified for the collection/delivery location of the goods.

ITER Organization (IO): As used in this specification, IO is the owner and Operator of the ITER research facility. Also, in accordance with PED and ESPN definitions, IO is the Manufacturer of the component procured per this technical specification.

ITER Site: ITER construction site located at the following address: ITER WORKSITE RD 952-Entrée Nord - CS 80 001 -13066 Saint Paul les Durance Cedex.

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Manufacturer: The Manufacturer is the Legal entity to which the Contract is awarded and to which the supply order is addressed. It is also called “Contractor”. The Manufacturer is the legal entity which assumes responsibility for the design and manufacture of a product to be marketed under its name or trademark following [1] and [3].

Notified Body (NB): Technical organization approved in an EU state, either for approval and monitoring of the Manufacturer’s quality assurance system or for direct product inspection.

Nuclear Regulatory Authorities/ Nuclear Regulator: referred to in this Specification are mainly MSNR (Office of the Ministries in charge of nuclear safety and radioprotection) and ASNR Autorité de Sûreté Nucléaire et de Radioprotection, French Authority for Nuclear Safety and Radiation Protection).

Operator: the IO is the Operator of the CVBD Filters. For nuclear pressure equipment, the Operator is the person holding the permission of creation of the nuclear basic installation in which the nuclear pressure equipment is installed or intended to be installed.

Plant Breakdown Structure (PBS): The PBS is the hierarchical breakdown of the ITER Plant into distinct ITER elements. The PBS identifies the links between parent/child elements, so that there is only one rooting between a parent element and one of its child elements (and vice versa).

Pressure Equipment Directive (PED): European Directive 2014/68/UE related to Pressure Equipment

Product: Any type of deliverable, goods and services resulting from the Technical Specification.

Protection Important Component (PIC): component important for protecting the interests of public security (including nuclear safety, radioprotection and prevention and fight against malevolent acts and civil security actions in the case of an accident), health and sanitation, the protection of nature and of the environment, i.e. any structure, equipment, system (programmed or not), material, component or software that is present in the basic nuclear installation or that is under the responsibility of the nuclear operator and that implements a function required for the demonstration mentioned under the second paragraph of Article L. 593-1 of the Environmental Code or that ensures that this function is implemented per articles 1.3 and 2.5.1 of Order 7th February 2012 ref. [4].

Quality Assurance Program: A controlled system of planned and systematic actions required to provide adequate confidence that an item designed and constructed is in accordance with Code requirements. - Quality Assurance Manual: A written document that describes a Quality Assurance Program.

Safety Importance Class (SIC): a classification scheme for structures, systems, and components of ITER that perform a safety function and contribute towards meeting the General Safety Objectives at IO during incident/ accident situations.

Subcontractor: An entity furnishing services, materials, or components required to perform the work to the Contractor.

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Supplier: See definition of “Contractor”.

Supply Order: Instrument produced by the IO to request supplies from the Contractor. Refer to contract conditions for more details.

Third Party: Is someone who may be indirectly involved but is not a principal party with a vested interest in carrying out the requirements of this Specification.

4 Applicable Documents & Codes and standards

The following documents are to be respected on the understanding that they prevail on each other in the following order:

- Decrees and Ministerial Orders,
- Standards and Rules whose application has been made mandatory by a Ministerial decision,
- Specific quality rules from the IO,
- Standards and Rules whose application has not been made mandatory by a Ministerial decision.

In the case where the codes, standards and the relevant regulations would be modified after the base date of the economic conditions of this contract, the Manufacturer has the obligation to inform IO immediately to define by mutual agreement the following decision to take.

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

In case of conflicting information, this is the responsibility of the Contractor to seek clarification from IO.

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

4.1 Applicable Regulations Requirements

[1]. Directive 2014/68/UE of the European Parliament and Council dated 15 May 2014 on the harmonization of the laws of the member states relating to the market availability of pressure equipment (PED)

[2]. French Regulation for Pressure Equipment (ESP) (transposition of PED in French law), French Environmental Code, Articles L557 and R557

[3]. French Order dated 30 December 2015 on Nuclear Pressure Equipment (ESPN), modified by order dated 03 September 2018

[4]. French Order dated 7 February 2012 setting the general rules relative to basic nuclear installations

4.2 Applicable Codes and Standards

This is the responsibility of the Contractor to procure the relevant Codes and Standards applicable to that scope of work.

For each European standard, the latest version issued by the European Committee for Standardization on the date of contract notification is applicable.

[5]. ASN Guide No. 8, Conformity Assessment of Nuclear Pressure Equipment

[6]. ASN Guide No. 19, Application of the order of the 12 December 2005 relative to the nuclear pressure equipment

[7]. ASME Boiler and Pressure Vessel Code, Section VIII - Rules for the Construction of Pressure Vessels, Division 2 — Alternative Rules, ASME BPVC.VIII.2-2017

[8]. EN 13555:2021 – Flanges and their joints – Gasket parameters and test procedures relevant to the design rules for gasketed circular flanges

[9]. EN1591-1:2014 flanges and their joints. Design rules for gasketed circular flange connection. Calculation Method

[10]. Process Piping, ASME B31.3-2010

[11]. ASME Boiler and Pressure Vessel Code, Section II, Materials, Part A – Ferrous Material Specifications and Part C – Specifications for Welding Rods, Electrodes, and Filler Metals, ASME BPVC.II.A-2017 and ASME BPVC.II.C-2017

[12]. ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications, ASME BPVC.IX-2017

[13]. EN 15164-1:2017 - Specification and qualification of welding procedures for metallic materials — Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys

[14]. EN 9606-1:2017 - Qualification testing of welders - Fusion welding - Part 1: steels

[15]. RCC-M 2012, Section V, Annex F-III – Water quality

[16]. Quality Assurance Requirements for Nuclear Facility Applications, ASME NQA-1 2017

[17]. Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard, ASME B16.5-2020

[18]. Stainless Steel Pipe, ASME B36.19M-2018

[19]. Metallic Products—Types of Inspection Documents, EN 10204:2005

[20]. Standard Practice for Cleaning, Descaling, and Passivation of Stainless-Steel Parts, Equipment, and Systems, ASTM A380/A380M 17

[21]. Test Uncertainty, ASME PTC 19.1-2018

[22]. NF EN ISO 9712:2022 “Non-Destructive Testing – Qualification and Certification of NDT Personnel”

[23]. EN 1991-1-2: 2004 “Eurocode 1: Actions on structures – Part 1-2: General actions – Actions on structures exposed to fire”

[24]. Sequence of Tests for Verifying Performance Characteristics of Filter Element, ISO 11170_2013 Edition

[25]. Verification of Collapse/Burst Pressure Rating, ISO 2941_2019 Edition

[26]. Verification of Fabrication Integrity and Determination of the First Bubble Point, ISO 2942_2018 Edition

[27]. Verification of Material Compatibility with Fluids, ISO 2943_2015 Edition

[28]. Method for End Load Test, ISO 3723_2015 Edition

[29]. Determination of Resistance to Flow Fatigue using Particulate Contaminant, ISO 3724_2017 Edition

[30]. Evaluation of Differential Pressure Versus Flow Characteristics, ISO 3968_2017 Edition

[31]. Hydraulic Fluid Power- Filters – Performance Evaluation by Closed Circuit Filtration Method, ISO 16889_2017 Edition

[32]. ASTM C177-19 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus

[33]. ASTM C303-21 - Standard Test Method for Dimensions and Density of Preformed Block and Board–Type Thermal Insulation

[34]. EN 13501-1:2018 - Fire classification of construction products and building elements - Part 1 : classification using data from reaction to fire tests

[35]. ASTM E84-21a - Standard Test Method for Surface Burning Characteristics of Building Materials

[36]. International Chamber of Commerce (ICC). Incoterms® 2020. ICC Publication No.723, 2020 Edition

[37]. ASME Boiler and Pressure Vessel Code, Edition 2017, Section V, Article 10

[38]. CLAP Files - https://www.afiap.org/informations-clap

4.3 Applicable Documents

The version of the following documents is added for information. The applicable version is actually the last approved version available at the signature of the contract subject of this Technical Specification.

[39]. General Management Specification for Service and Supply, ITER_D_82MXQK v1.4

[40]. ITER Abbreviations, ITER_D_2MU6W5 v1.19

[41]. Project Requirements, ITER_D_27ZRW8 v7.1

[42]. Safety Requirement Room book, ITER_D_KF63PB v2.17

[43]. Defined Requirement for PBS26, ITER_D_ M369M3 v2.1, (Section 6.2.1 only)

[44]. Overall Surveillance Plan of External Interveners Chain for Protection Important Components, Structures and Systems and Protection Important Activities, ITER_D_4EUQFL v8.2

[45]. Surveillance Plan for PBS 26 - Cooling Water System, ITER_D_CAJTAL v3.1

[46]. Annex 2 - Detailed list of PIAs, ITER_D_Q8B5C4 v1.2

[47]. Propagation of the Defined Requirements for Protection Important Components Through the Chain of External Interveners, ITER_D_BG2GYB v3.3

[48]. System Requirement (SRD) Document SRD-26-PH,-CV,-DR,-DY (TCWS) from DOORS, ITER_D_2823A2 v7.0

[49]. Quality Requirements for IO Performers, ITER_D_22MFG4 v6.4

[50]. ITER Radiation Protection Professional Guidelines for the Nuclear Pressure Equipment in Application of Order dated 12 December 2005, ITER_D_2LTQ96 v2.5

[51]. Allowable Values and Limits in Service Level C and D of ITER Mechanical Components, ITER_D_3G3SYJ v3.1

[52]. Codes and Standards for ITER Mechanical Components, ITER_D_25EW4K v5.0

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[53]. Chemical composition and impurity requirements for materials, ITER_D_REYV5V v3.1

[54]. Pressure equipment - ASME austenitic steel 1% yield strength for allowable stresses as per DESP 2014/68/UE and decree 30/12/2015, ITER_D_26PNE4 v3.0

[55]. Quality Classification Determination, ITER_D_24VQES v6.0

[56]. TCWS Load Specification, ITER_D_SZE5MR v2.6

[57]. Template for PE/NPE Nameplate, ITER_D_Y3AZ83 v3.2

[58]. Gap analysis ASME VIII div.2 / DESP-ESPN requirements, ITER_D_3E5HKQ v2.0

[59]. TCWS Piping & Equipment: Proof + Requalification Tests, ITER_D_YC3UR5 v4.0

[60]. Report on the effect of cold work on the corrosion behaviour of 316L(N)-IG steel ITER_D_G5MDGV v2.0

[61]. Technical Specification for TCWS Water System Vessel Fabrication Cleaning Requirements, ITER_D_33YCQ3 v1.0

[62]. 26CVBD pressure vessels ESPN Classification Evaluation, ITER_D_YWWMY9 v1.5

[63]. TCWS CVBD Process Loading Conditions, ITER_D_ 8PZBTB v.1.0

[64]. Software Qualification Policy, ITER_D_KTU8HH v2.0

[65]. Provisions for Implementation of the Generic Safety Requirements by the External Actors/Interveners, ITER_D_SBSTBM v2.3

[66]. Qualification of Protection Important Components (PIC), ITER_D_XB5ABP v2.0

[67]. Assembly drawing of PBS26 TCWS CVBD FILTER PLATFORM #31, ITER_D_7KK7VT v1.3

[68]. Procedure for ITER CAD Data Exchanges, ITER_D_2NCULZ v4.2

[69]. CAD Manual 01 - Instruction for Use and Introduction, ITER_D_AHFDDK v1.4

[70]. Technical Document Types (TDT) Cards, BFF8H7

[71]. IBED_CVBD_FILTERS_NON_SHIELDED, EF6CER rev.--F (DRAFT)

[72]. DYS_ANCHORAGE_INSTALL_DWR, 8UB3AZ rev.--D (DRAFT)

[73]. Impurity controls requirements for PBS26, ITER_D_9LPHJE v3.0

The following documents are references for information, they shall not be provided to the Contractor.

[74]. ITER Quality Assurance Program (QAP), ITER_D_22K4QX v9.3

[75]. Collection of Input Data to support Qualification Plan in charge of TCWS electro-mechanical equipment supplier, ITER_D_YST3YH v2.3

[76]. Safety Important Functions and Components Classification Criteria and Methodology, ITER_D_347SF3 v1.8

[77]. TCWS IBED CVCS (CVBD) Design Conditions Calculation, ITER_D_ 94HGS3 v2.2

[78]. Radiation Maps during Plasma Operations, ITER_D_RJLLFY v2.1,

[79]. Assessment of TCWS effluents, influents, and chronical leaks ITER_D_U7YB3K v4.0

[80]. Tokamak Complex Magnetic Field L4, ITER_D_2MS9EV v4.1

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[81]. TCWS System Description Document (SDD), ITER_D_94WLDK v6.2

[82]. TCWS IBED CVCS (CVBD) Hydraulic Sizing Calculation, ITER_D_ WEP5KL v2.2

[83]. Document Management Procedure, ITER_D_22K5JQ v10.1

[84]. Floor response spectra report for PBS TCWS DYS filter PL30 platform and CVBD filter PL31platform in B11-L4-04, ITER_D_7QXUZV v1.3

[85]. TCWS Heat Loads per Room, ITER_D_2MLP8A v2.2

[86]. Structure analysis report for PBS TCWS DYS filter PL30 and CVBD filter PL31 in B11-L4-04, ITER_D_7E98BB v1.3

[87]. PBS 26 - System Human & Organizational Factors Requirements, ITER_D_ E3YF7E v1.1

[88]. Static and Transient Magnetic Field Maps in Tokamak Building, ITER_D_3BQBVY v3.1

[89]. ITER Seismic Nuclear Safety Approach, ITER_D_2DRVPE v1.6

[90]. EDH Part 5: Earthing and Lightning Protection, ITER_D_4B7ZDG v3.0

[91]. HIRA analysis for TCWS, ITER_D_T6X8RE v1.1

[92]. Procedure for Identification and Controls of Items, ITER_D_U344WG v2.2

[93]. ITER Numbering System for Components and Parts, ITER_D_28QDBS v5.1

[94]. Design Review Procedure, ITER_D_2832CF v7.0

[95]. ITER Structural Design Code for Buildings (I-SDCB) Part I: Design Criteria, ITER_D_283B24 v3.4

[96]. Load Specifications (LS), ITER_D_222QGL v6.3

[97]. Heat and Nuclear Load Specifications, ITER_D_2LULDH v3.1

[98]. Static and Transient Magnetic Field Maps in Tokamak Building, ITER_D_3BQBVY v3.1

[99]. Load Specification Annex – Internal Explosions: Hydrogen Deflagration in Tokamak Complex, ITER_D_BMQ9XM v3.1

5 Scope of Work

This Specification defines the material, design, fabrication, inspection, examination, testing, certification, preparation for delivery and shipment of 6 CVBD Filters (tag numbers 26CVBD-FI-5303, FI-5304, FI-5490, FI-5497, FI-5803 and FI-5150).

The Contractor as Manufacturer is the legal entity which assumes responsibility for the design and manufacture of the CVBD Filters to be marketed under its name or trademark following [1] and [3]. The Contractor shall hire an ANB to ensure the conformity assessment of the nuclear pressure equipment under module G. The IO is the Operator of the CVBD filters.

The Contractor is in charge of the design, the supply and the manufacturing of:

- The CVBD filters with all their constitutive elements (vessel, heads, nozzles, flanges, counter flanges, bolts, gaskets, cartridge filter element components, …),
- The supports including the pallet and the rollers,
- The pipe extensions to be connected to the pipes on site,
- The handling devices for the inspection openings (if any),
- The liftings lugs and trunnions (if any),
- The transport supports,
- The nameplate and its supports,
- The insulation and its supports,
- The grounding,
- The tapes, gaskets and all temporary devices for the hydrostatic test,
- The CVBD transportation skid and devices (accelerometer, nitrogen blanketing if any),
- The spare parts.

The services to be provided under the contract are the following:

- The global contract management including reporting and efficient resource allocation,
- The design studies and associated documentation,
- The required documentation including all the documentation following PED and ESPN requirements from the design to the commissioning to be approved first by the IO (including HRA, ESR, DNRE drawings, in-service inspection drawings and instruction manuals) as well as the final Declaration of Conformity.
- The delivery of materials following the requirements defined in the NPMA and material purchase specification,
- The manufacture and associated controls,
- The insulation qualification and supply,
- The regulatory hydrostatic tests in workshop,
- The packaging for the transport from the Contractor’s premises to IO site,
- The shipping,
- A storage procedure,
- An installation manual (including the recommended equipment), assembly, adjustment, connection and commissioning.

5.1 Scope of Supply

5.1.1 Description

5.1.1.1 CVBD System

The CVBD system provides purification of the coolant and volume control for the IBED PHTS. The CVBD system shall be located within the secondary confinement building boundary. The CVBD system shall:

- Control the chemistry of cooling water provided to the IBED PHTS.
- Control the concentration of ACPs in the cooling water provided to the IBED PHTS.
- Control the volume of cooling water inside the IBED PHTS during plasma and baking operations.

The CVBD system shall be considered first barrier of the first confinement system.

5.1.1.2 CVBD Filters

4x25% CVBD Inlet Filters (26CVBV-FI-5303, FI-5304, FI-5490 and FI-5497) are provided to remove suspended solids.

2x50% CVBD Resin Traps (26CVBD-FI-5803 and FI-5150) remove entrained particles in the process fluid to protect the degasified membranes.

CVCS filters without shielding will be used from the initial operation phase (SRO-early DT1) to an irradiation level threshold that will be defined during SRO phase. This first phase will help IO understanding the clogging phenomena (due to non-activated corroded products) of the filters during operation and the impact on the pressure drop. This phase will also help collecting input data for the design of the filter shielding during DT2 phase.

In a second phase (late DT1), some removable shielding will be added on the original filters based on the irradiation level to extend the use of the original filters procured for SRO-early DT1 phase.

Then, in a third phase (DT2), new shielded filters will be procured to limit the dose rate in the vicinity of the CVCS filters.

The scope of supply of this technical specification is limited to the non-shielded filters that will be used in phases 1 and 2.

The 4 Inlet Filters (26CVBD-FI-5303, FI-5304, FI-5490, and FI-5497) are used in parallel and protect the demineralizer bed from fouling and abrasion (1 µm or 5 µm mesh). The 2 Resin Traps (26CVBD-FI-5150 and FI-5803) remove resin debris released from demineralizer beds (200-300 µm mesh) and prevent their release into the degasifiers, VCT, and ultimately IBED PHTS. Both Resin Traps are used in parallel.

Each CVBD Filter shall consist of a filter housing, a set of filter elements, nozzles, bolts, supports, handling and lifting lugs, and gasket as described within this Specification and appendices.

The classification parameters are summarized in **Table 2**:

Table 2 – CVBD Classification Parameters

No.	Classification/Parameter	Source
1	Pressure Category **III**[a]	Ref. [62]
2	ESPN level 3 – **N3**[b]	Ref. [62]
3	**Fluid Group 2**	Ref. [62]
4	Safety Important Class 1 **SIC-1**	Ref. [56]
5	Fluid Type — Demineralized Water[c]	Ref. [48]
6	Seismic Classification – **SC1(S)**	Ref. [56]
7	Quality Class 1 – **QC-1**	Ref. [56]
8	No code stamp[d]	Ref. [3]

[a] Filter volume shall not exceed 170 L. Pressure is cat 3 because the filter may be flushed with nitrogen (gas) with a PS=10 barg.
[b] Filter volume shall not exceed 200 L
[c] See **Table 8** for IBED PHTS water chemistry
[d] Nameplate shall have an ANB stamp. See Section 5.1.3.24 for nameplate requirements.

5.1.2 Process Requirements

5.1.2.1 Sizing requirements and design conditions are shown in Table 6 and Table 7 of Appendix A – CVBD Filters Datasheet.

5.1.2.2 Water Chemistry requirements are shown in Table 8 of Appendix A – CVBD Filters Datasheet.

5.1.2.3 Corrosion allowances needed for the requested material choice and water chemistry shall be selected by the Contractor and clearly justified for the lifetime for this technology.

5.1.3 Design requirements

5.1.3.1 The CVBD Filters shall be designed for conditions specified and the required operational characteristics, filling, draining, testing, and applicable loading conditions defined within this Specification and associated Appendices.

5.1.3.2 A summary of applicable classification, including classification level, category, fluid group, and seismic class designations, is provided in Table 2.

5.1.3.3 The reference code of construction is **American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 2** ref. [7]. The CVBD Filters shall be designed, fabricated, examined, and tested in accordance with this code with supplemental requirements per this Specification and outputs from the HRA. In case of allowable value and limits in service, it shall be applied ref. [52]. Other codes and code case per Codes and Standards for ITER Mechanical Components ref. [52] may be selected by the Contractor to complete the design, fabrication, examination but must be approved in writing by the IO prior to use.

5.1.3.4 The allowable stresses of the Code of Construction for the design of pressure parts has also to comply with the formulas provided in the Chapter 7.1 of annex 1 of the Directive ref. [1].

5.1.3.5 A single design should be used for all 6 CVBD filters (inlet filters and resin traps) in order to simplify the design work as well as the manufacturing activities. If difference in design are required, they shall be fully justified and approved by IO before implementation.

5.1.3.6 If the Code of Construction specifies two allowable stresses for the design of pressure parts, the lower value must be used.

5.1.3.7 The CVBD Filters will not be ASME BPVC U2 stamped. Conformité Européenne (CE) marking is not required for ESPN equipment.

5.1.3.8 Piping and piping connections shall be in accordance with ASME B31.3 ref. [10].

5.1.3.9 Flanges

Flanges (DN15 through DN600) shall be in accordance with ASME B16.5 ref. [17]

Flanges for all closed ports, including housing closure, shall be calculated according to EN 1591-1 ref. [9] and their gaskets shall comply with EN 13555 ref. [8] in order to ensure the desired leak rate. A leak rate class of $L_{0.001}$ (*specific leak rate ≤ 0.001 mg s^{-1} m^{-1}) shall be achievable following ref. [79]. In case of customized flanges that cannot be calculated with the standard EN1591 ref. [9], additional qualification and tests shall be carried out to ensure the leak rate $L_{0.001}$.

* *It shall be stipulated as kg/h when detailed design fixed. And no polymeric parts included in the O-rings, gasket, seals and other components assigned with confinement function.*

The initial tightening torque (min/max values) and bolting sequence for the flange bolts considering the seating situation as well as the operating and exceptional situations shall be well indicated in the drawings and the instruction manual to ease the use on site during installation, commissioning and maintenance.

Gasket shall be the same as for the service type, dry or coated with graphite. Use of compounds, glue, lead, is not permitted. Metallic "O"-rings gaskets shall be replaced after testing if damaged. All other gaskets shall be replaced with new ones after testing. The cover gasket or O-ring and joint shall be replaced for multiple filter element replacements and designed to stay attached during filter element replacement.

Gasketing material shall be compatible with the intended service as stated in Appendix A – CVBD Filters Datasheet and shall not include halogens.

The Contractor shall provide flanges, counter-flanges, bolts, nuts, washers and seven (7) gaskets (one installed and six spares).

5.1.3.10 The environmental conditions (i.e., pressure, temperature, humidity, magnetic field, and radiation field) for the CVBD Filters are listed in Appendix A – CVBD Filters Datasheet. The CVBD Filters shall be designed to be compatible with the environmental conditions provided in the CVBD Filters DS. The CVBD Filters design shall meet the requirements of all applicable codes.

5.1.3.11 A Design Verification and Validation Plan shall be provided to IO as deliverable following the KOM including a logical sequence of works, the methods and codes used for the design and a list of all the design activities.

5.1.3.12 The CVBD Filters shall be designed to meet nozzle loads and seismic requirements specified in Appendix C – Nozzle Loads and Appendix D – Floor Response Spectra. The CVBD Filters shall be designed to meet all load combinations as specified in TCWS Load Specification ref. [56].

5.1.3.13 The CVBD Filters shall be designed for 10 years of non-nuclear phase (including storage, installation after delivery and commissioning), 14 years of nuclear operation and 10 years of decommissioning specified in this document and in Appendix A – CVBD Filters Datasheet, excluding packing, gasket, and other normally replaceable parts.

5.1.3.14 Pressure boundary thickness shall be in accordance with the Code of Construction, as defined in Section 5.1.3.3. Sufficient allowance will be added to the wall thickness to compensate for corrosion, erosion and abrasion over the lifetime of the CVBD Filters (see Section 5.1.3.13). Wall thickness shall be verified by inspection or testing after forming.

5.1.3.15 The equipment design shall clearly identify reaction forces and moments at the equipment interface to the building and include fastener sizing for installation per Section 5.1.3.22.

5.1.3.16 The CVBD Filters design shall avoid unnecessary cavities where particles suspended in the process fluid can settle or collect (e.g., no socket welds or spare connections).

5.1.3.17 The CVBD Filters shall be designed to allow complete draining and venting without disassembly of the CVBD Filters. Draining and venting can be accomplished through the connected piping. In this case, the CVBD Filters shall be designed to allow complete draining and venting through the pipe connections. Otherwise, dedicated draining and/or venting connections shall be provided, where necessary.

5.1.3.18 The CVBD Filters shall contain sufficient lifting appurtenances in appropriate positions to guarantee safe loading, lifting, and handling.

5.1.3.19 The CVBD Filters design shall include the means for application of insulation required per 5.1.13.

5.1.3.20 Lifting lugs shall be provided on the housing closure and on the internal cartridge filter element components

5.1.3.21 Nozzles

Required nozzles, type, size and projection are indicated in Appendix A – CVBD Filters Datasheet and in general arrangement drawing ref. [71]. Orientation and location of all nozzles shall be specified on the Manufacturing design drawings, which will require review and written approval by IO prior to start of manufacturing.

The nozzle loads are provided in Appendix C – Nozzle Loads for the situation A/B (cat I and II normal situations), C (cat III exceptional situations) and D (IV highly improbable situations). They are not signed as they are the maximum values of several combinations from the pipe stress analyses. The Contractor shall consider the loads with the orientation that leads to the most penalizing results.

Each nozzle shall have its identification number, as specified in the general arrangement sketch drawing, permanently marked on the outside cylinder surface of the nozzle.

The dimensions of all nozzles shall conform to ASME B36.19M ref. [18] metric dimensions.

All nozzles shall include a pipe extra length of 100 mm on flange assemblies to facilitate welding to piping on site (see ref. [71]).

5.1.3.22 Calculation studies

GM3S ref. [39] provides the procedures for Analyses and Calculations to be followed. The Contractor shall transmit the analysis models to IO.

The CVBD filters thermal-hydraulic design shall be based on the full design load at the design clogged conditions given in Appendix A – CVBD Filters Datasheet. The CVBD Filters design shall include the required clogging factors and margins needed for the fluid and operating conditions specified in Appendix A – CVBD Filters Datasheet. The Manufacturer shall also provide the CVBD Filters performance in clean and dirty conditions.

The following mechanical analyses shall be performed:

- Perform the thickness calculation of the pressure equipment in a design calculation sheet following ASME VIII div.2 part 4
- Perform the stress analysis of the CVBD Filters. The full design code shall be followed, and the stress report shall include the assessment of protection against plastic collapse, the assessment of protection against local failure, the ratcheting evaluation and the welds and bolts assessment.
- Perform the stress analysis of the filter element and internal components. Filter internal components shall mechanically withstand at 200 % of nominal flow rate at clogged conditions (i.e. 22.5 kg/s for each inlet filter and 45 kg/s for each resin trap).
- Perform the fatigue analysis for all parts of the CVBD Filters based on process loading conditions provided in Appendix A – CVBD Filters Datasheet and Process Loading Conditions. Screening criterion as ASME VIII Div.2 § 5.5.2 (Method B) can be used as first assessment and completed by a detailed fatigue analysis if the criteria are not satisfied. The connection between the tube sheet and the cartridges shall be verified with a detailed fatigue evaluation following ASME VIII Div.2 § 5.5.3. The objective is to ensure flow-induced vibrations will not create cracks leading to a failure of the filter cartridge supporting system.
- Provide the interface loads between the equipment support system and the supporting structure. Reaction loads shall be given at each connecting point for all individual load cases and all load combinations provided in Appendix B – Loads Combinations.

Note:

Weight of the insulation shall be considered in the design of the CVBD filter (see Appendix B – Loads Combinations).

5.1.3.23 Supports

The CVBD Filters shall be designed to be self-supporting and safely withstand all loading requirements, including nozzle loads, in accordance with this Specification. Seismic and nozzle loading requirements are specified in Appendix B – Loads Combinations and Appendix C – Nozzle Loads with the combinations provided in Appendix B – Loads Combinations.

CBVD Filters will be supported on HEB300 structural steel beams as shown in ref. [71] and in Appendix E – CVBD Filters Supporting Secondary Structure.

The CVBD Filters support shall include:

- a skirt,
- the rolling system allowing installation and removal of the filter using HEB300 as rails,
- a steel pallet including U for pallet trucks,
- some items allowing proper positioning/handling of the filters.

CVBD Filters support shall not be an obstacle for the removal/introduction of the filters (No clash between the support and the platform supporting structure or the filter locking system should occur).

A filter locking system (out of the scope of this contract) will allow proper positioning and anchoring of the filters. It consists of 4 pinned connections and prevents any lift-off of the filter. DYS filter locking system drawing is provided in ref [72]. Similar locking system design will be used for the CVBD filters. This drawing shall be used to verify the absence of clash between the support and filter locking system during handling.

A minimum clearance of 30 mm between filter locking system/platform and CVBD filters support shall be guaranteed to allow proper handling of the filters with the forklift.

The installation configuration (i.e., footprint and building attachment locations) shall be determined assuming the attachment points are pinned and have adequate capacity. No credit shall be taken for friction between support and foundation.

The equipment load demand on the building, including nozzle loads, shall be provided by the Manufacturer for the attachment locations. The Manufacturer shall provide the attachment locations. The Manufacturer shall provide the attachment type that allows for removal of the CVBD Filters.

All elements of the CVBD Filters support structure are part of the scope of delivery and shall be factory mounted on the CVBD Filters when applicable.

To guarantee proper interface between the CVBD Filter support and the platform supporting structure, the filter locking system, and the forklift, some dimensions of the CVBD Filters support (pallet, rollers, U of the pallets, Pin holes) are imposed, they are shown in ref. [71]. Any modifications to these dimensions must be approved in writing by the IO prior to use.

5.1.3.24 Nameplate

The CVBD Filters shall have a nameplate marked with the unique identification number supplied by IO as TAG number “26CVBD-FI-5XXX” and a PNI number that will be defined later. A metal nameplate, suitable for the intended service and at least 0.5mm thick, shall be permanently attached to a bracket that is permanently attached to the CVBD Filters and long enough to be visible with the insulation. The nameplate and attachment shall be such that removal shall require the willful destruction of the nameplate or its attachment. The attachment weld to the CVBD Filters shall not adversely affect the integrity of the CVBD Filters.

The nameplate shall be performed according to the requirements defined in the PED [2] and ESPN [3] following the template provided in [57] and shall be made in austenitic stainless steel.

Safety signs and safety information in French related to the residual risks from the Hazards and Risks Analysis shall be indicated in warning labels on the equipment.

In addition to the information required by the design and construction codes, regulatory requirements and directives, the nameplate shall contain, as a minimum, the following information:

- Equipment name and tag number
- Equipment model and serial number

- Design and test parameters, as applicable (volume, pressure, etc.)
- Maximum allowable internal/external working pressure and associated temperature
- Weight (dry and full of process fluid)
- Manufacturer name and address
- Year of Built
- ANB stamp
- ANB number

5.1.3.25 Grounding

Each CVBD Filter shall include a minimum of two (2) pads to be used for equipment bonding and grounding (earthing) that allows connection of 4/0-AWG bare copper conductor to the plant grounding grid.

5.1.3.26 Cartridge Filter Element

The cartridge filter element components (filter media, internal support tube, end fitting and gaskets) shall be constructed of materials that can be continuously operated at the operating temperature as provided in Table 7. The cartridge filter elements shall be rated at the operating temperature and allowable pressure drop as provided in Table 7.

Cartridge filter elements shall be reusable after proper washing and removal of corrosion products.

Cartridge filter elements shall be designed without fasteners or small detachable components and shall be self-draining.

A pullout device or handle shall be incorporated in the upper side (top) of the filter element. The pullout device shall be designed to withstand the maximum weight and pullout loads without any permanent deformation.

The filter element assembly shall be designed to retain any loose sediment or solids that may fall off during operation or maintenance to ensure that the CVBD Filters housing is free of particulate after the spent filter assembly is removed.

The cartridge filter elements shall be qualified following ref. [66]. A test plan, a qualification test procedure and a qualification test report shall be submitted to IO for approval. The required tests are described in 5.1.6.6.

Quantities of cartridge filter element components to be procured:

- For Inlet Filters:
  - 6 sets of filter element components (filter media, internal support tube, end fitting) with pore size of **5 µm** (1 per inlet filter + 2 spares)
  - OPTIONAL: 6 sets of filter element components (filter media, internal support tube, end fitting) with pore size of **1 µm** (1 per inlet filter + 2 spares)
- For Resin Traps:

- 3 sets of filter element components (filter media, internal support tube, end fitting) with pore size of **200-300 µm** (1 per resin trap + 1 spare).

5.1.4 Material, welding and fabrication requirements

5.1.4.1 The CVBD Filters, including the cartridge filter element components (filter media, internal support tube, end-fitting), shall be constructed from 304L or 316L austenitic stainless steel and shall comply with the additional composition requirements shown in ref. [53] and [73] and recalled in Table 3.

Table 3 – Stainless Steel Composition

Component	Content (wt%)
Cobalt	<0.05
Niobium	<0.1
Tantalum	<0.01

For the CVBD Filters support, there is no limitation for Co, Nb and Ta content, however their concentration in the structural material needs to be measured and documented.

For the small items also called COTS (bolts, nuts, gaskets, screws, plugs, washers…), there are no Co/Ta/Nb content requirements.

5.1.4.2 For the material composing pressure parts PP, MPBP and parts contributing to pressure resistance CCPR, inspection certificates as per EN 10204:2004 ref. [19] shall be provided by the Contractor and shall be consistent with the NPMA and this technical Specification (see CLAP File X141 ref. [38]). NPMA shall be referenced in the material certificates. The editions of the material standards specified in the certificates shall be the same as specified in the NPMA.

5.1.4.3 When the materials manufacturer has an appropriate quality assurance system of at least EN ISO 9001 certified by a competent body established within the European Community, and having undergone a specific assessment for materials, an inspection document from the manufacturer is appropriate. The specific assessment of the quality system shall properly cover all the relevant processes and material properties referred to in the material specifications and attested in the material certificates. In this case, material manufacturer can issue material certificate type 3.1 according to EN 10204:2004 ref. [19] in any other case material certificate type 3.2 can only be issued. Gaskets shall be provided with certificates type 2.2.

5.1.4.4 The selection of the material in the NPMA shall demonstrate the compliance with the radioprotection guide ref. [50] as well as the ESR from PED [1] and ESPN [3]. PED ESR 7.5 shall be in particularly met:

- steel elongation after rupture shall be no less than 14%,
- steel bending rupture energy measured on an ISO V test-piece shall be no less than 27 J, at a temperature not greater than 20 °C but not higher than the lowest scheduled operating temperature.

5.1.4.5 The NPMA shall reflect the requirement to get the yield strength Rp1.0 and Rp0.2 and the tensile strength Rm at room temperature. These tests at the temperature TS of 100°C shall be provided only if the selected code of construction request them. These values shall be recorded in the material certificates of PP, MPBP and CCPR to comply with the allowable stress comparison presented in ref. [54].

5.1.4.6 Intergranular corrosion shall be avoided using low carbon content material. 304L is selected for the composition of the IBED PHTS HX (see 5.1.4.1).

5.1.4.7 All water used for cleaning and hydrostatic test shall meet the requirements in Table 4 in accordance with ASME NQA-1, Part II, Subpart 2.1, Section 304.1, *Water* [16]. For hydrostatic testing and Grade A water quality from RCC-M 2012, Annex F-III for cleaning [15].

Table 4 – Hydrostatic Test Water Quality

Parameter	Requirement	
	Cleaning	**Hydrotesting**
pH at 25°C (77°F)	6.0 – 8.0(1)	6.5 – 8.0
Specific conductivity at 25°C (77°F), uS/cm	<2	–
Chloride, ppm	<0.15	<250
Fluoride, ppm	<0.15	<2
Sulfide, ppm	n/a	<1
Silica, ppm	<0.1	–
Total solids, ppm	<0.1 (suspended)	<500 (dissolved)

(1) a drop in the minimum pH level to 5.5 is permissible on the condition that it can be shown that the drop in pH is effectively due to the carbonation of the water

5.1.4.8 The design shall address the *ITER Radiation Protection Guidelines* ref. [50] for the design and manufacturing of nuclear pressure equipment.

5.1.4.9 The Contractor shall have traceability procedures (described in material management procedure) place that will guarantee traceability between materials delivered and the EN10204 Certificates. Procedures shall be submitted to and approved by the IO prior to the start of manufacturing operations. Traceability shall be maintained by procedural methods that cover receipt, identification, storage, and transfer to production, temporary storage, and use in production.

5.1.4.10 Welding materials shall meet the requirements of the *Code of Construction.* Welding materials shall comply with the additional composition requirements shown in Table 3. Additionally, manufacturers of welding consumables shall provide test report “Type 2.2” as an inspection document in accordance with the standard EN 10204 ref. [19]. To comply with the traceability requirement of PED, Annex I, Section 3.1.5 ref. [1] for welding consumables, the Contractor shall be able to demonstrate in the procedures, test records, drawings, list of welders, WPS, WPQR and welding lists that the traceability is maintained during the manufacture.

5.1.4.11 The bolts for flange connections shall be made with the grade A453 gr 660B or other ASME grades with similar or better material properties. These bolts shall be compatible to be in contact with the 304 L stainless stell flange without risk of galvanic corrosion. Bolts of flanges are classified as PP (pressure parts) and dedicated NPMA shall be issued including the specific requirements for ESPN level N3 bolts material following [3].

5.1.4.12 Every activity of manufacturing managed by the material supplier as bending or forming shall be clearly requested in the material purchase specification and identified in the material certificates. Dimensions of raw material shall be detailed in the material certificates.

5.1.4.13 The CVBD Filters Heat Exchangers shall be fabricated in accordance with requirements of the *Code of Construction*. The ESPN ref.[3], the PED ref. [1] and project-specific quality requirements per this Specification. Any conflicts between conformance with required codes and standards and this Specification shall be brought to the attention of IO for resolution. No irreversible steps in design or manufacturing shall be taken before resolution in writing of the conflict by IO.

5.1.4.14 Thermal arc gouging processes are prohibited.

5.1.4.15 Any heat treatments performed during fabrication or after welding shall be duplicated on the qualification test coupon(s) and are subject to ANB approval before acceptance for use. All heat treatment equipment shall be calibrated and all personnel performing heat treatment shall be qualified to do so. Heat treatment procedure shall include operating method, and position of the thermocouple.

5.1.4.16 Following PED ref. [1], preparation of the component parts as forming, bending, machining activities or heat treatment must not give changes in the mechanical characteristics likely to be detrimental to the safety of the pressure equipment. Specific qualifications proposed by the Contractor and approved first by IO shall be performed after forming and bending activities to ensure the material properties of the base material are not modified. Forming and bending ratio shall be provided in the forming and bending procedure. If cold bending or cold forming is used and the deformation ratio is higher than 20% (see ref. [60]), specific means like heat treatment shall be put in place to avoid stress corrosion cracking.

5.1.4.17 Grinding, lapping, and surfacing equipment and abrasives for use on corrosion resistant materials shall be new or not previously used on carbon steel or other metals or alloys so contamination of the finished surfaces is completely avoided. All grinding or lapping on base material or welded metal shall be performed with one of the following: carbide or aluminium oxide burrs, silicon carbide, zirconia, or alumina grinding and lapping wheels. All grinding material shall be free of halogens. Any type of grinding wheel bonded with a resin, rubber, or silicate must be submitted for review and written approval of chemical content by the ANB and IO. Excessive pressure that may result in localized heating or smearing of the surface that can invalidate a subsequent liquid penetrant examination shall be avoided.

5.1.4.18 Wire brushes used for cleaning austenitic stainless steel or nickel-based alloy materials or welds shall be made from stainless steel and shall not have previously been used on carbon steel.

5.1.4.19 Expendable Material – For the purpose of this Specification, an expendable material is defined as a non-permanent material that comes in contact with the CVBD Filters during the manufacture or storage activities. Such items shall not cause degradation of the CVBD Filters. All expendable materials shall be free of halogens. Use of expendable material shall be controlled by written procedure, which shall be approved by IO and the ANB prior to use of such materials.

5.1.4.20 A list of all the product in contact with the surface of the CVBD Filters shall be provided by the Contractor.

5.1.4.21 Surface Finish

a. Internal wetted surfaces of the CVBD Filters, including welds, shall have a surface finish smoother than 3.2 μm roughness. Interior welds shall be ground flush to meet surface finish requirements.

b. Gasket sealing surfaces shall have a surface finish recommended by the gasket Manufacturer.

c. The external weld seams shall have a surface finish of 12.5 μm (500 μin) Ra or better. Surface finish shall extend a minimum distance from the edge of the weld to a distance whichever is the greater of: (i) twice the base plate thickness plus 100 mm or (ii) 150 mm.

d. All burrs and rough edges shall be removed.

5.1.4.22 Marking

a. Marking paint or ink shall not contain harmful amounts of chlorides, metals, or metallic salt, such as zinc or copper that can cause corrosive attack on heating.

b. The IO review and approval is required prior to use of any marking paint or ink.

c. Stamping shall not introduce a notching effect, therefore low stress stamping with round edges is recommended. If any method of marking other than hard-stamping or engraving is used, the Contractor shall ensure that confusion between different materials is not possible, e.g. by separate handling (time and/or place) or stamped bands.

d. The labels shall be placed in a visible location on the components.

5.1.4.23 Welding

a. Welding shall be performed in accordance with the requirements of the *Code of Construction*, as defined in Section 5.1.3.3, the ESPN, and PED (insofar as it is called upon by the ESPN). In particular, as per PED ESR 7.2, production weld test coupons are required to perform the destructive tests for the use of a weld joint coefficient equal to 1.

b. Each weld shall be identified with a unique weld identification number on the weld control record or equivalent. Weld numbers and weld location shall be shown on the Manufacturer's drawings.

c. For pressure boundary parts, drawings that show fabrication by welding shall indicate the joints, together with the joint geometry and welding process and welding procedure(s).

d. Weld seams shall not intersect nozzles or access opening locations.

e. Temporary weld attachments to the pressure boundary shall be removed upon completion of their intended purpose. Removal may be performed mechanically and must be approved by the ANB. If thermal cutting is used, the attachment shall be cut no closer than 8 mm from the surface to which it is attached, and the balance material shall be removed mechanically. Temporary attachment removal area locations shall be recorded and documented.

f. Tack welds to be incorporated into the final weld shall have a contour suitable for fusion with the root pass. Tack welds that become part of the finished weld shall be performed by a qualified welder, using a qualified procedure and filler material, and visually examined. In this case, welder and procedure shall be approved by RTPO or NB. Tack welds that have cracked or are defective shall be removed, and the area re-tacked prior to welding. Tack welds in grooves shall be kept to a minimum.

g. Weld joint preparation shall not be performed by thermal processes.

h. Welding procedure and welder performance qualification shall be in accordance with the codes, standards and requirements indicated in Section 5.1.3.3 and with ESR from PED ref. [1] and ESPN ref. [3]. Welding procedure qualification records and welder performance qualification shall be approved by a notified body and shall be verified by IO and the ANB as part of the conformity assessment.

i. The location, depth and area size of all weld repairs, regardless of the depth of the repair, shall be documented in accordance with the Contractor's quality program with the IO approval. When base metal is repaired by weld (i.e. cosmetic, buttering or build-up) shall be specified in the as-built drawing with its location and size.

j. Welding Non-Destructive Examinations (NDE) shall be performed in accordance with the requirements of the Code of Construction, as defined in Section 5.1.3.3, the ESPN, and PED (insofar as it is called upon by the ESPN).

k. If contractor wants to apply permanent joining method other than welding, the requirements shall be equivalent to the weld, especially on qualification of procedure and personnel.

5.1.4.24 Qualification of welding procedures and personnel

a. Welding procedures shall be prepared based on ASME Section IX [12] and EN 15614-1 [13], it shall be reviewed and approved by an Notified Body or a third-party recognized by a Member State.

b. Welders and welding operators shall be qualified according to ASME Section IX [12] and EN 9606-1 [14].

c. Contractor must issue a list of approved welders. This list must be certified by IO and the NB or RTPO. This list shall specify, in particular:
   - The identification number of each welder
   - The number and date of the certificate of qualification (certificate to be attached)
   - The term of validity

5.1.4.25 Qualification of NDE Personnel

Personnel for non-destructive examination (NDE) must be approved by a third-party recognized by a Member State. All NDE personnel qualifications shall conform to the following requirements:

- Personnel shall be qualified in accordance with NF EN ISO 9712 ref. [22] and approved by either a Notified Body or a Recognized Third Party Organization as per [2] art R557.4.2 point 11.a.).i or 11.a).ii.
- the IO and ANB shall check that the qualifications of the personnel responsible for NDE are valid in terms of time and appropriateness for the work to be carried out.
- All non-destructive procedures shall be validated by personnel level III.

5.1.4.26 Pickling and Passivation

Pickling and Passivation procedures shall be submitted to the IO for review and acceptance prior to the start of production and shall follow the rules of ref. [20]. All stainless-steel internal and external surfaces of the CVBD Filter shall be passivated.

5.1.4.27 Coating

Stainless steel surfaces shall not be coated but shall be clean metal and free of weld spatter, oil, dirt, and grease.

5.1.4.28 A minimum of 8 mm of base material shall be removed from any edge cut by thermal processes.

5.1.5 Quality Control Provisions

5.1.5.1 The Contractor shall provide the Quality Assurance Program (QAP) under this Specification prior to Contract implementation at least 2 weeks before the KOM. The Contractor shall ensure that their subcontractors follow the QA requirements under the relevant QA classifications (see section **9**).

5.1.5.2 The Quality Plan shall meet ref. [49] requirements and shall identify:

- The critical quality activities
- The specific allocation of resources, duties, responsibilities, and authority
- The details of all suppliers/subcontractors and how interfaces will be managed.
- The specific procedures, methods and work instructions to be applied.
- The specific methods of communication, both formal and informal, to be established between working groups.

The Quality Plan can be updated during the project to include additional requirements related to the design, the procurement, the manufacturing, or the controls.

5.1.5.3 Quality requirements to supplement the design and construction code are itemized in the appendix 2 of ref. [55] to ensure conformance with the project-specific standards for the Quality class indicated in **Table 2**.

5.1.5.4 In progress and at the end of the production of the CVBD Filters, all the operations are carried out making it possible to check the dimensions and their compatibility with the tolerances indicated on the plans. Dimensional and geometric controls allow establish the plan “as-built” of the CVBD Filters.

5.1.6 Testing requirements

5.1.6.1 Testing of CVBD Filters shall meet the requirements in ASME BPVC Section VIII, Division 2 ref. [7], ESPN ref. [3], ESP/PED ref. [2], and the additional requirements stated herein. When no code or standard applies, the acceptance criteria shall be the Manufacturer’s standard and proven suitability for service.

5.1.6.2 Proof testing (i.e., hydrostatic testing) shall be conducted on the CVBD Filters as detailed in Section 5.1.8.9.

5.1.6.3 Requalification pressure test shall be conducted periodically on the CVBD Filters as detailed in Section 5.1.12.3.

5.1.6.4 Helium leak test shall be performed on the flanged connections in accordance with ASME Section V, Article 10 (ref. [37]). This test shall demonstrate the compliance with the leak tightness class requirement of $L_{0.001}$ (see section 5.1.3.9).

5.1.6.5 All instruments used in the testing shall have a recent calibration sheet and shall have an evaluation of the measurement accuracy following *Test Uncertainty*, NGIASME PTC 19.1 ref.[21]. Another equivalent measurement uncertainty standard can be used subject to prior acceptance by the IO.

5.1.6.6 Filter elements used in the CVBD Filters shall be tested in compliance with performance qualification tests in general accordance with the following standards:

a. Sequence of Tests for Verifying Performance Characteristics of Filter Element, ISO 11170 ref. [24].
b. Verification of Collapse/Burst Pressure Rating, ISO 2941 ref. [25].
c. Verification of Fabrication Integrity and Determination of the First Bubble Point, ISO 2942 ref. [26].
d. Verification of Material Compatibility with Fluids, ISO 2943 ref. [27].
e. Method for End Load Test, ISO 3723 ref. [28].
f. Determination of Resistance to Flow Fatigue using Particulate Contaminant, ISO 3724 ref. [29].
g. Evaluation of Differential Pressure Versus Flow Characteristics, ISO 3968 ref. [30].
h. Multi-Pass Method for Evaluating Filtration Performance of a Filter Element, ISO 16889 ref. [31].

5.1.6.7 The test coupons and specimens used for acceptance per lot shall be available. The IO shall have an opportunity to acquire possession of such test samples prior to disposal.

5.1.6.8 The CVBD Filters shall be subject to a load test of the handling/lifting lugs with empty filters in accordance with the mechanical design report to ensure that no modification of the dimensions nor permanent deformation occur during the test. Each handling/lifting lug shall be designed to support 125% of the dry weight of the filter.

5.1.7 Spare Parts

As per section 5.1.3.26, for CVBD inlet filters, 2 extra sets of filter element components with a pore size of 5 μm will be delivered as spare parts for all CVBD inlet filters (OPTIONAL: as per section 5.1.3.26, for CVBD inlet filters, 2 extra sets of filter element components with a pore size of 1 μm will be delivered as spare parts for all CVBD inlet filters).

As per section 5.1.3.26, for CVBD resin traps, one extra set of filter element components (filter media, internal support tube, end fitting) with a pore size of 100-200 μm will be delivered as spare part for all CVBD resin traps.

For each CVBD Filter flange connection, six (6) gaskets shall be delivered as spare parts in addition of the gasket installed on the flange.

Bolts and nuts for flanges or for supports shall be provided with 10% as spare parts in addition of the items already mounted on the CVBD Filters.

Recommended spare part list shall be delivered according to Recommended Spare Part List (UELRTB) listing the spares recommended with quantities and associated PNIs.

5.1.8 PED/ESPN regulation requirements

5.1.8.1 The CVBD Filters shall be delivered with a Conformity Assessment under Module G. The Contractor as Manufacturer shall hire an Agreed Notify Body (ANB) to perform this conformity assessment.

5.1.8.2 The documents needed for the module G shall be forwarded to the ANB after approval from IO. If after ANB review, the documents are requested to be updated, they shall be re-submitted to IO in their last version informing the reviewers the new version is only related to the ANB review.

5.1.8.3 The manufacturer is under an obligation to analyse the hazards and risks in order to identify those which apply to the equipment on account of pressure The manufacturer shall then design and construct the equipment taking this analysis into account. This HRA shall cover all phases of equipment's life; from design to decommissioning as well as all parts of equipment.

5.1.8.4 All the formal reports issued by the ANB for the design, manufacture, and controls of the CVBD Filters shall be submitted to IO for information through IDM.

5.1.8.5 The ESR gap analysis summarizes all the harmonised standards and solutions adopted to meet the requirements of the directive ref. [1], ESPN ref. [3] (codes, technical standards, etc.) and radioprotection guide [50]. The Contractor will adapt the gap analysis ref. [58] between the construction code ref. [7] (or other codes if not harmonized) and the requirements of the PED ref. [1] and ESPN ref. [3].

5.1.8.6 The classification of the parts of an equipment is described in the CLAP File X207 ref. [38] and shall be included in the Hazard and Risk Analysis.

5.1.8.7 Hazard and Risk Analysis which lists all the risks associated with potential equipment failures during all phases of its life cycle (design, manufacture, transport, storage, exploitation, maintenance, …) and to provide responses to remove them or reduce if elimination is not possible. Risks not removed are included in the Instruction Manual which describes the specific maintenance actions to be implemented to monitor them.

5.1.8.8 The Final Inspection using the as-built drawings shall be performed according to a procedure established by the contractor and approved by IO prior to hydrostatic testing. The purpose is to assure the conformity of the CVBD Filters to all specified requirements before the Declaration of Conformity is issued. All internal and external surfaces shall be visually inspected. If some areas cannot be inspected during the Final Visual Inspection (shell surface covered with pad, internal welds of a nozzle for example), they shall be identified at the design phase and identified in the MIP. IO and the ANB shall be notified to inspect these areas as part of the formal visual inspection and the results shall be recorded in visual inspection reports.

5.1.8.9 Proof testing (i.e., hydrostatic testing) shall be conducted on the CVBD Filters in the Contractor's workshop before the shipping with the presence of the IO representative and the ANB with the value indicated in Appendix B – Loads Combinations. The Proof testing shall be conducted in accordance with a procedure established by the contractor that meet the requirements defined by the IO and approved by IO and the ANB. The hydrostatic test shall be performed with all covers and counter-flanges in place and bolts fastened with the prescribed torque or with caps welded on the nozzle pipes. Covers and counter-flanges shall be the ones that will be delivered with the CVBD Filters. If covers or counter-flanges need to be disassembled after the hydrostatic test, they will be reinstalled with new gaskets. Pressure accessories shall be used during the hydrostatic test to ensure that the value of Ptest is not exceeded during the whole test duration. The situation of proof test in workshop shall be analysed in the design report.

5.1.8.10 The CVBD Filters shall be completely filled with water and completely drained. Any water that appears to have pooled or collected in the CVBD Filters shall be clearly indicated on the test report and reported to the IO. Immediately after draining, equipment shall be dried and cleaned thoroughly. The inspection may be performed while draining the CVBD Filters after proof testing is completed.

5.1.9 Packing, preservation & shipping

5.1.9.1 The CVBD Filters packaging shall meet the Level C minimum requirements in ASME NQA-1 Subpart 2.2 section 302.3 ref. [16] for overseas shipment and the additional requirements stated in this technical specification.

5.1.9.2 The dimensions of the full packaging for the transportation of the CVBD filters and its supports as a whole shall not exceed 5m*5m*14m.

5.1.9.3 The CVBD Filters internals shall be preserved with a nitrogen gas purge and pressurization in accordance with ASME NQA-1, Part II, Subpart 2.2, Section 304.2, *Inert Gas Blankets* ref. [16]. The pressure of the nitrogen shall stay lower than 0.5 bar g during the transport and the storage. The initial value shall be selected to ensure that with slight pressure variations, the pressure will not exceed 0.5 bar g. A local manometer shall be provided and connected to allow periodic monitoring of the blanket nitrogen. Range of the manometer shall be at least 1.5* the desired pressure and no more than 3* the desired pressure with an accuracy not higher than 5%. The CVBD Filters shall be kept under nitrogen since the end of the hydrostatic test in factory until its installation and connection to its final location.

5.1.9.4 The protection of the surfaces of the various parts is ensured during manufacture and during storage before shipment. The provisions are taken to ensure the preservation of protection under nitrogen and coatings during transport and handling.

5.1.9.5 Materials intended for use in preservation, packaging and shipping such as tape, wood, plastic caps, sheet, vapour corrosion inhibitor (VCI) coverings or other covers which are applied directly to stainless steel shall be compatible with the materials to which they are applied.

5.1.9.6 During transportation, it is forbidden to let the CVBD Filters touch with materials containing Halogens. Other materials, including Cu, Pb, Zn, and carbon steel, shall not touch the CVBD Filters as well even during the lifting.

5.1.9.7 Pictograms on all sides of the packaged CVBD Filters shall be indicated to ensure the good means to transport and lift the CVBD Filters.

5.1.9.8 It is the responsibility of the Contractor to take any other precautions required to ensure that CVBD Filters arrive at the jobsite undamaged.

5.1.9.9 Weld nozzles shall be fitted with a welded cap for transportation. The nozzles shall have sufficient extra straight length to allow for the removal of the cap at the site and prepare the nozzle end for welding. Caps shall be designed and calculated for hydrostatic test and transportation loads and must be removed during installation.

5.1.9.10 Flanged nozzles shall be fitted with their counter-flange and gasket fully assembled for transportation. Alternatively, the flanged nozzles can be closed with a temporary blind flange for transportation and the counter flange with parts delivered as separate package, packaged and marked.

5.1.9.11 Covers shall be mounted in place with their gasket.

5.1.9.12 The shipping and storage of the CVBD Filters shall occur only after the completion of the conformity assessment.

5.1.9.13 The Contractor shall provide in the instruction manual all the provisions to ensure the regulatory requirements are respected during transportation, installation, and commissioning of the CVBD Filters.

5.1.9.14 The CVBD Filters are PIC, no deformations are authorized during the transportation from the manufacture phase to the delivery to IO site. Accelerometers shall be fixed on the CVBD Filters during the transport to record the accelerations. They shall be supported on a rigid part of the CVBD Filters. A maximal acceleration shall be set for the transport and confirmed by calculation in the 3 directions. A dedicated transport calculation including the means of fixation during the transport and a static acceleration acting simultaneously in the 3 directions shall be provided as deliverable to ensure the design of the CVBD Filters. Initially, this acceleration value is set at 3G in the 3 directions (per ref. [75]), but another value can be decided by the Contractor with IO approval.

5.1.9.15 The transport of the CVBD Filters shall be the responsibility of the Contractor. The delivery shall be performed as DAP Incoterms 2010 ref. [36] at ITER site. The final delivery location of the CVBD Filters is IO site:

ITER Organization - Building 89 / Warehouse Zone 2 - Route de Vinon-sur-Verdon - CS 90 046 - 13067 St Paul Lez Durance Cedex – France

5.1.9.16 The place of storage on site of the CVBD Filters between the delivery phase and the installation phase will be the Storage Area at the IO. The Contractor shall consider storage inside buildings. The CVBD Filters will be delivered with a packaging to withstand the usual weather (wind / snow) during transport provided in 5.1.3.10.

5.1.10 Cleanliness requirements

5.1.10.1 The CVBD Filters shall meet the cleanness requirements set forth in the Technical Specification for TCWS Water System Vessel Fabrication Cleaning Requirements ref. [61].

5.1.10.2 The CVBD Filters shall meet the cleanness requirements set forth in the ASTM A380 ref.[20] §7.2.1.

5.1.10.3 The CVBD filters shall meet the cleanliness requirements of ASME NQA-1 Subpart 2.1 ref. [16] Cleanness Class C for external surfaces and Class B for the internal surfaces.

5.1.10.4 The Contractor shall maintain a shop acceptable and auditable consumables list for products which may contact final, as delivered, machined surfaces. Halogenated cleaning materials are not permitted. Particular concerns are materials containing chloride or sulphur which are known to contribute to stress corrosion cracking. These materials shall not be used. The Contractor shall implement procedures that will ensure that these materials are not used during the manufacture, fabrication, testing, or preparation for shipment of the CVBD filters.

5.1.10.5 Cross-contamination of stainless steel and carbon steel is prohibited. The Contractor shall prepare a documented plan and implementing procedures employing the best practices of ASTM A380 ref.[20], §8.1 for minimizing iron contamination of stainless steels. This plan and implementing procedures are to be submitted to IO for review and approval. Manufacturing work on this contract may not begin until the plan and implementing procedures are approved.

If the shop is used to fabricate both carbon and stainless-steel components, daily checks must be completed to limit the potential for cross contamination of stainless steel and carbon steel. If limited contact of stainless-steel material with carbon steel material occurs, approved cleaning methods shall be applied for remediation of contamination.

5.1.10.6 The cleaning process shall not damage the surface finish, material properties, or the metallurgical structure. The cleaned parts shall be protected to prevent contamination until preservation or packaging is complete. This shall be achieved after the cleaning process by segregating the parts to a clean area or an enclosed container where recontamination will be prevented. Preservation or packaging of the parts shall be performed within a reasonable time after the cleaning process.

5.1.10.7 For the stainless steel material only clean stainless steel brushes, chipping hammers, and grinding wheels, not previously used on other materials shall be used.

5.1.10.8 Cleaning procedures, including pickling and passivation procedures for internal and external surfaces, shall be submitted to the IO for review and acceptance prior to the start of production and shall follow the rules of ref. [20].

5.1.11 Installation and assembly

5.1.11.1 The transport of the CVBD Filters from the storage area to the assembly area is not included in this Contract. Nevertheless, the Contractor shall provide specific means as temporary supports to ensure the transportation of the CVBD Filters which are compatible with the constraints of the site and shall describe the procedure for the in-site transportation and installation operations in an installation manual. Specific supports shall be manufactured for the transport as lugs or trunnions to lift, pull or push the CVBD Filters for their installation. Dedicated supports to use jack system for the transport may be implemented. Transport supports shall be fully designed, manufactured, controlled, and delivered to IO.

5.1.11.2 No items or devices will be manufactured on the IO site. The assembly is not included in this contract. Nevertheless, the Contractor shall provide an assembly guideline in the installation manual of the CVBD Filters especially and shall implement the needed protection to allow the good assembly achievement. The Contractor shall also provide recommendations for on-site commissioning tests needed to verify the correct operation of the CVBD Filters after installation in the instruction manual.

5.1.11.3 The installation step shall be included in the design (stress report) of CVBD Filters considering the bending moments and loads induced in the equipment and its supports. The Contractor shall include a full installation study and installation manual for the CVBD Filters.

SUPPLY

5.1.12 Maintenance and Inspection Requirements

5.1.12.1 The CVBD Filters shall be designed to meet the in service-inspection requirements of the ESPN level N3 described in [3]. In-service Inspection drawing with indication and justification of the most vulnerable areas shall be approved by IO before starting the manufacture of the CVBD Filters.

5.1.12.2 An in-service inspection up to 40 months following initial commission and every 40 months then shall be performed. In particular, visual inspection of all pressure bearing parts of the pressure vessel, for internal and external surface shall be carried out during these inspections.

5.1.12.3 Periodic requalification including a visual inspection of all pressure bearing parts of the pressure vessel, for internal and external surface and a pressure test with Prequal=120%*PS shall occur every 10 years. This requalification pressure test shall be included in the design of the CVBD Filters.

5.1.12.4 The CVBD Filters shall be designed to allow for removal and replacement of the filter elements. The CVBD Filter parts requiring adjustment, inspection, or repair shall be accessible and capable of convenient removal, cleaning, replacement, and repair.

5.1.12.5 The Contractor shall provide in the instruction manual all the provisions to ensure the proper cleaning of the CVBD Filters cartridge filter elements.

5.1.12.6 The CVBD Filters shall be designed for remote handling to minimize personnel exposure during installation and removal of the filter elements and shall be compatible with the use of equipment designed by others.

5.1.12.7 Equipment and subcomponents (including the gaskets) which are not demonstrated a design operating life covering 10 years of non-nuclear phase (including storage, installation after delivery and commissioning), 14 years of nuclear operation and 10 years of decommissioning without replacement, shall be designed with a replacement interval of no less than 24 months.

5.1.12.8 Any cutting/ welding for removal of filter's top lid, making interface disconnections, lifting of filter element etc. is prohibited.

5.1.13 Insulation and Sheathing

5.1.13.1 The CVBD Filters shall be insulated. Insulations shall be designed and procured for each filter.

5.1.13.2 The design of supports for the installation of the insulation and sheathing is included in the design and construction of the CVBD Filters.

5.1.13.3 The expected insulation shall have the same characteristics (thermal conductivity and density) as PROMAT Microtherm Overstitch 1000 in order reduce to the thickness of insulation to the minimum. Other insulation material can be used subject to written approval IO prior to use.

5.1.13.4 The insulation material and thickness shall be selected:

- to resist fire and limit the metal temperature under the insulation to maximum 200°C (2 times the design temperature, see Appendix A.2 Process Loading Conditions) for all fire loads during 2h following Eurocode 1 ref. [23] which provides a peak air temperature of 1049°C.

- to limit the heat loss at each filter insulation surface to 600W during normal operation conditions (cat I events) as per Appendix A – CVBD Filters Datasheet and Process Loading Conditions and ref. [85].

5.1.13.5 The thickness of the insulation shall be the minimum possible due to space requirements around the CVBD Filters.

5.1.13.6 The insulation and its fastening system shall be designed to be compatible with the foreseen maintenance operations. Top part of the insulation shall be easy to remove/install to allow opening of the filter and access to the cartridge filter elements.

5.1.13.7 The thermal insulation of the CVBD Filters, as well as the sheathing, is chemically neutral with respect to the walls to be protected. The sheathing shall be stainless steel sheet.

5.1.13.8 The density of the insulating material and its thickness shall be taken into account in the weight of the CVBD Filters for the design and calculations.

5.1.13.9 Insulation supports shall be designed such that the insulation remains in place during a SL-2 earthquake (see Appendix D – Floor Response Spectra).

5.1.13.10 The insulation shall be tested and qualified as per ref. [66] for these different requirements:

- Chemical analysis: Co, Ta and Nb shall be in the limits indicated in the chapter 5.1.4.1 for the insulation product and the sheathing.
- Free of Halogens (Chlorine, Fluorine, Bromine) for the insulation product and the sheathing
- Landa test (thermal conductivity) following ASTM C177 [32]
- Density following ASTM C303 [33]
- Flammability resistance: minimum classification A2L s3 d0 according to EN 13501-1 [34]. The flammability performance shall be equivalent or better than the mentioned classification in other recognized standards (as ASTM E84 [35]).
- Resistance to seismic event SL-2
- Radiation ageing qualification will be performed later by IO: coupons shall be sent by the Contractor done in the same batch of the insulation of the CVBD Filters and provided in the same preservation conditions as the insulation itself.'

An insulation qualification procedure as well as an Insulation qualification test report shall be submitted to IO for approval.

5.1.14 Software requirements

5.1.14.1 The use of computer software to perform a safety basis task activity such as analysis and/or modelling, etc. shall be reviewed and approved by the IO prior to its use, providing the software Verification and Validation (V&V) following qualification Policy ref. [64]. The software V&V shall include test cases encompassing the range of intended use for the new or revised software. Qualification testing shall be taken into consideration to demonstrate that software meets its specifications and is ready for use in its target environment or integration with its containing system. Where necessary to evaluate technical adequacy for verification, the V&V shall indicate how the results are to be evaluated. For example, the results may be compared to results from alternative methods such as:

- Analysis without computer assistance
- Other qualified software
- Experiments and tests
- Standard problems with known solutions
- Confirmed publications or correlations.

5.1.14.2 The following software and versions shall be used by the supplier:

- For CFD thermal hydraulic analyses: Ansys workbench 19.2 – Fluent 19.2 or more recent
- For mechanical structural analysis: Ansys workbench 19.2 – Mechanical 19.2 or more recent after IO approval
- For design calculation: PV Elite 2018 or more recent or other equivalent software after IO approval
- For flange calculation: TEMES 9.0.21 or more recent or other equivalent software after IO approval

5.1.14.3 GM3S ref. [39] states that the models shall be provided in a ready-to-run state. Any manual operation that is required to rerun the analyses shall be described either in the analysis report or in a document attached to the model.

5.1.14.4 Excel spreadsheet can be used for calculation by formula, but the native files shall be provided and the formula shall be readable for review.

6 Location for Scope of Work Execution

The Contractor will perform the work at their own location from the KOM to the shipment of the CVBD Filters. The list of main manufacturing activity locations shall be communicated to IO in the qualified supplier list. Change of one of location shall be timely notified to IO.

7 IO Documents

7.1 IO Documents:

Under this scope of work, IO will deliver the following documents by the stated date:

Ref	Title	Doc ID	Expected date
1	Integration studies	Presentation	after CVBD Filters drawing submission
2	Verification Compliance Matrix	Table	MRR
3	List of clarifications	List	MRR

1- After submission of assembly drawings of CVBD Filters by the Contractor, IO verify the potential clashes using the step file of the pressure equipment attached with the drawing. An integration study is created with the CVBD Filters in its environment to verify the accessibility and the remaining space to the other items in the vicinity of the Filters.

2- For the MRR, the IO will provide the Verification Compliance Matrix part 1 which lists all the main requirements from this Technical Specification and GM3S ref. [39]. The requests of clarifications raised by the Contractor and answered by IO during the design phase are also listed in this Verification Compliance Matrix.
The Contractor shall fill the part 2 and 3 of this document for the end of the Contract and provide it as a deliverable.

3- The list of clarifications is updated during the design phase by IO to record all the requests of clarifications from the Contractor and the answers from IO to complete the Technical Specifications requirements. This list is completed for the MRR.

8 Deliverables and Schedule milestones

8.1 Schedule for delivery

The contractual delivery date of the CVBD filters shall be according to the provisions set in the contract. A receipt date shall be specified sufficiently ahead of the equipment receipt date to allow adequate time to complete a review of the manual and prepare for installation. Specific delivery date will be specified in SO.

The maximum expected duration from the contract signature to the supply of the scope of work is 48 months.

The CVBD Filters design review gate shall be performed within 12 months after the KOM.

The main Deliverables/Milestones and the associated due dates are provided in Table 5:

Table 5: Main Deliverables/Milestones and associated Due Dates

CVBD Filters		
code	Deliverables / Milestones	due Date
D1	Design Review Gate Approved - All associated documents listed in ITER_D_9UVHDS - Appendix F APPROVED.	T0+12 months
D2	Procurement Review Gate Approved - All associated documents listed in ITER_D_9UVHDS - Appendix F APPROVED.	T0+17 months
D3	Manufacturing Readiness Review Gate Approved (for all filters) - All associated documents listed in ITER_D_9UVHDS - Appendix F APPROVED.	T0+20 months
D4	Raw Materials Reception (plates, forged components, bars, …)	T0+26 months
D5-1	Hydrostatic Test of 26CVBD-FI-5303	T0+35 months
D5-2	Hydrostatic Test of 26CVBD-FI-5304	T0+37 months
D5-3	Hydrostatic Test of 26CVBD-FI-5490	T0+39 months
D5-4	Hydrostatic Test of 26CVBD-FI-5497	T0+41 months
D5-5	Hydrostatic Test of 26CVBD-FI-5803	T0+43 months
D5-6	Hydrostatic Test of 26CVBD-FI-5150	T0+45 months
D6-1	Delivery of 26CVBD-FI-5303 with Declaration of Conformity	T0+38 months
D6-2	Delivery of 26CVBD-FI-5304 with Declaration of Conformity	T0+40 months
D6-3	Delivery of 26CVBD-FI-5490 with Declaration of Conformity	T0+42 months
D6-4	Delivery of 26CVBD-FI-5497 with Declaration of Conformity	T0+44 months
D6-5	Delivery of 26CVBD-FI-5803 with Declaration of Conformity	T0+46 months
D6-6	Delivery of 26CVBD-FI-5150 with Declaration of Conformity	T0+48 months
D6-7	Delivery of insulation for all filters	T0+48 months

Supplier shall prepare the Contract Implementation Schedule following GM3S section 6.1.4 Ref [39] requirements.

The contract schedule shall clearly indicate the expected workshop working time and shift schedule. Schedule shall include reasonable margin (duly identified) to cope with unexpected issues that may arise during manufacturing. It shall identify the list of critical manufacturing means in case of bottleneck risk, together with provisions in order to mitigate the risk.

The contract schedule shall be in a Critical Path Method style with logic ties that identifies each activity and is capable of tracking percentage complete for verification of progress. The schedule

must be compatible with the overall master project schedule developed by the IO and is subject to the IO's approval.

The contract schedule shall include all work activities identified within the Specification. The schedule shall include milestones for design, fabrication, shop testing, and delivery of the CVBD filters to allow for IO to monitor the progress of the Work and to schedule its interface activities with the Contractor.

The contract schedule must be provided to the IO for approval prior to implementation of any Work. The Contractor shall consider potential schedule conflicts due to previous or pending commitments to supply services or material to other customers. Anticipated deviations from the schedule must be identified to IO as soon as possible to evaluate the impact of changes on the master project schedule.

8.2 List of deliverables documentation

The Contractor shall provide IO with the documents and data required in the application of this technical specification, the GM3S Ref [39] and any other requirement derived from the application of the contract. Some other documents can be identified during the kick-off Meeting or during the project and will be added to the list presented in Appendix F – List of Deliverables.

Supplier shall prepare their document schedule based on the list in Appendix F – List of Deliverables and using the template available in the GM3S Ref [39] appendix II. This document can serve as both the list of deliverables and the document schedule.

9 Quality Assurance requirements

The Quality class under this contract is QC-1, GM3S section 8 ref. [39] applies in line with the defined Quality Class.

The Contractor's QAP shall be applied to the entire Product under this Specification and shall be submit to the IO.

9.1 Manufacturing and Inspection Plan (MIP)

A Manufacturing and Inspection Plan (MIP) shall only be prepared by the Contractor for materials that are considered fabricated materials (components made from manufacturing operations capable of altering mechanical properties).

The MIP is a listing of the chronological sequence of manufacturing operations affecting quality encompassing the whole scope of the subcontract and ranging from verification of materials, manufacture, inspection and test to delivery.

Requirements for MIP are listed in GM3S section 8.4 ref. [39] and in ref. [49].

Contractor shall issue weekly a notification schedule covering all intervention points that shall occur one month ahead. Formal notification to IO or its representative and/or ANB shall be informed at least 10 calendar days prior the operation unless a specific arrangement is defined in written between the Contractor and notified parties. The IO, its representative and ANB shall not be responsible of any manufacturing delay incurred by late notification of intervention point.

9.2 Patrolling inspection in the workshop

Contractor must implement his own patrolling inspection in the workshop. These inspections should be performed by qualified personnel and formalized into specific reports detailing the nature of inspection performed (welding parameters, heat treatment device….) and the result of the inspection.

As a strict minimum, following items shall be systematically checked. Any deviation should lead to a stop of the activity, be recorded in the inspection report and be analysed for corrective actions implementations (with potential NCR opening when needed):

- Applicable documentation is present at the workstation (including MIP and drawing)
- Traceability of material is ensured (including consumables)
- Operators are qualified/ aware of jobs
- Equipment and tooling are calibrated/ operational
- Workstation environment is safe and tidy
- Risk of carbon steel contamination is under control
- Intervention points have been correctly notified

Main findings shall be dealt with according to QA procedures and reported inside weekly report.

10 Safety requirements

TCWS CVBD system is a SIC-1 system according to Safety Important Functions and Components Classification Criteria and Methodology from Ref [76].

The IO informs the Contractor that the CVBD filters being procured are considered protection important components (PIC).

The scope under this contract covers for PIC and/or PIA and/or PE/NPE components, GM3S section 5.3 ref. [39] applies.

Under French Order 7 February 2012 ref.[4], the PICs require control and guaranty of the quality of the PICs during the design and manufacturing phase to ensure its safety functions can be maintained in all postulated situations. This is accomplished through the guidelines provided for in the Management of Propagation of Nuclear Safety Requirements in the Contractor Chain ref. [47] and Provision for Implementation of the Generic Safety Requirements by the External Interveners ref. [65], regarding:

- Policy on Protection of the Interests
- Quality management system
- Supervision
- Execution and supervision of the PIA
- Skills and qualification of the interveners
- Records
- Non-conformities
- Lesson learned
- Safety demonstration

In the contracts passed down to the subcontractors, it is clearly stated that in addition to technical requirements, defined requirements on Protection Important Components (PIC) and Protection Important Activities (PIA) must be monitored by the IO. The subcontractor must possess a quality system in agreement with the importance of the equipment being delivered and for the follow-up of the PIA corresponding to the PIC to be provided under the contract. This system shall be included in the MIP or Quality Plan.

The system requirements applicable to the CVBD Filters are presented in Appendix G – List of system requirements applicable to the CVBD Filters.

11 Special Management requirements

Requirement for GM3S section 6 ref. [39] applies completed with the below specific requirements:

11.1 Contract Gates

The contract gates are defined in [39] section 6.1.5. The Manufacturing Readiness Review (MRR) can be split in different sub-MRR to authorize the partial manufacture of the equipment. The purpose is to ensure that if the procedures are approved, raw materials received and certificates approved, some parts of the pressure equipment can be authorized to be manufactured. These sub-MRR gates are formalized in the MRR report.

11.2 Meeting Schedule

A progress review meeting is to be held **on a weekly basis** between the Contractor representative and CRO with the appropriate support of relevant stakeholders.

The Contractor shall prepare **on a weekly basis** a progress report using the template as per GM3S Appendix IV ref. [39]. This report is to be submitted at minimum one (1) day prior to the weekly progress meeting to IO.

The Contractor shall create and maintain a list of open action items assigned to the Contractor or the IO. The list shall identify the action to be taken, category (critical or non-critical), responsible Party or individual, and the date the required action is to be completed. Due dates shall be met to maintain project schedules and proper work sequence.

11.3 Subcontracting

GM3S ref. [39] chapter 6.4 applies. When a document is sub-contracted, there is no maximal versions of the documents before IO approval. The Contractor shall ensure his sub-contractor perform the work assigned with the best quality to reduce the number of versions.

11.4 Data and Documentation Management

Requirements for GM3S section 6.2 ref. [39] applies completed with the below specific requirements.

ITER Document Management Procedure ref. [83] describes the processes to be followed in order to achieve and maintain well-defined and clearly referenced documentation to be used by the ITER Organization (IO), and to control its evolution and organization.

All the manuals (Instruction Manual, Installation Manual, Transport Manual…) shall be written in French and in English.

All documents shall be clean and legible white prints with uniform background density suitable for electronic scanning and subsequent reproduction from an electronic format. Insofar as practical, documentation shall be typed and arranged in a neat and professional manner. Handwritten documents shall conform to the legibility requirements and quality requirements of this section. Any pen and ink changes necessary after printing will be performed by drawing a single strike through line, preserving the original information, with neat ink text initialled and dated. Material certificates with white correction fluids on it will not be accepted.

Documents not meeting the quality requirements specified herein will be returned to the Contractor without IO review for correction and resubmission. Rejected documents will not be a basis for approving schedule extensions or cost increases.

There is no limitation to the number of revisions of a document needed to receive IO approval.

All documents shall use SI units as primary dimensions. Drawings shall follow all normal ISO conventions and standards, in particular those standards used in the power industry, for orientation and rotation of drawings, plan views, dimensioning, symbols, etc.

The step files (format AP214) of the pressure equipment, supports and insulation shall always be attached to the drawings submitted to IO (one step file per equipment). Step files shall be revised and submitted at each drawing revision.

Deliveries of 3D CAD files shall be managed according to Procedure for ITER CAD Data Exchanges ref. [68]. CAD files corresponding to drawings delivered in SMDD shall be attached to it as specified.

The contractor shall meet the project requirements in term of standard and content of deliverables (e.g. ISO conventions and standards, orientations, views, etc...) set forth in CAD Manual ref. [69] and TDT Cards ref. [70].

CVBD filters drawings shall, as a minimum, include the following information:

- A Bill of Materials (BOM) with a description of the individual component and the component identified on the drawing
- Loads on nozzles
- Drawing number
- IO TAG number and IO PNI number
- All information related to PE/NPE
- Interface dimensions identified (external dimensions, nozzles, supports…)
- Manufacturing stage and sequence (unitary, assembly, as-built, transportation…)
- IO approval status (i.e. whether the drawing is “approved for construction” or not)

11.5 Access to Contractor’s Premises

The Contractor shall grant access rights to the IO to its facilities, records, proprietary processes and/or information and those of its Subcontractors for the purposes of surveillance of defined requirements during the construction/manufacturing of a PIC. This surveillance shall also include the examination of all protective-important actions and the follow-up and verification of all corrective actions which are to be implemented.

In the frame of the conformity assessment, the Contractor shall grant access rights to its facilities and documentations to the IO PE/NPE Network and the ANB for their inspections and audits at all level all the supply chain.

Contractor shall ensure its subcontractors and suppliers (if any) will grant the IO and its representatives and the ANB the same access to their facilities. The Contractor shall ensure an acceptable level of safety at any time for the IO and ANB representatives. Special provisions shall be taken to secure work at height, work in confined space, radiological protection. The Contractor shall provide the necessary training and safety apparatus to IO and ANB representatives whenever required by inspection activity.

The IO and ANB reserve the right to visit and inspect the manufacturing facilities prior to the signature of the contract with the successful tenderer. After KOM, PE/NPE network of the IO will plan an evaluation audit for the Contractor and its subcontractors and/or supplier and in all main premises where the construction activities will take place. Evaluation audit could be repeating in case of contractual or regulatory changes or extension of contract with Contractor.

12 Appendices

Appendix A – CVBD Filters Datasheet and Process Loading Conditions

A.1 CVBD Filters Datasheet

All pressures are absolute pressures unless specifically noted otherwise.

A1.1 Sizing Requirements and Design Conditions

Table 6: Nominal Performance and Design Conditions – Cartridge Filter Housing

Parameter	Value
Fluid type	Demineralized water(1)
Min/max mass flowrate, kg/s	1.2/11.3 (each inlet filter) 2.5/22.5 (each resin trap) (3)
Normal operating conditions temperature, °C	10-90(2)
Max. normal operating conditions pressure, MPa	1.8(2)
Design pressure, MPa	1.8(4)
Design temperature, °C	100(4)

*Nozzles(4)		
Service	***ID***	***DN / Schedule***
Filter Inlet	N1	65 / 40S
Filter Outlet	N2	65 / 40S
Drain	N3	25 / 40S

* All nozzles are welded connection.

Table 7: Nominal Performance and Design Conditions – Cartridge Filter Elements

Parameter	Value
Fluid type	Demineralized Water(1)
Min/max mass flowrate, kg/s	1.2/11.3 (each inlet filter) 2.5/22.5 (each resin trap) (3)(5)
Min/max volumetric flowrate, L/min at operating conditions	75.8/683 (each inlet filter) 151.6/1366 (each resin trap) (3)
Normal operating conditions temperature, °C	10-90(2)
Max. normal operating conditions pressure, MPa	1.8(2)
Allowable pressure drop, MPa	0.32(3) at 11.5 kg/s flowrate (inlet filter) 0.32(3) at 22.5 kg/s flowrate (resin trap)
Filter element pore size (absolute), µm	5.0 (inlet filters) (OPTIONAL: 1.0) 200-300 (resin traps)
Filtration efficiency, %	98
Minimum dirt-holding capacity, kg	2.3 (for each inlet filter)
End cap configuration	Prefer to be recommended by Supplier
Max cartridge length, mm	Prefer to be recommended by Supplier

*(1) See **Table 8** for IBED PHTS water chemistry*

(2) TCWS CVBD Process Loading Conditions, ref. [63]
(3) TCWS IBED CVCS (CVBD) Hydraulic Sizing Calculation, ref. [82]
(4) TCWS IBED CVCS (CVBD) Design Conditions Calculation, ref. [77]
(5) The filter element and internal components shall mechanically withstand at 200 % of nominal flow rate at clogged conditions (i.e. 22.5 kg/s for each inlet filter and 45/kg/s for each resin trap).

A1.2 Water Chemistry Requirements

The table below gives the requirements on the IBED PHTS water chemistry ref. [48]. The IBED PHTS water only comes in contact with stainless steel.

Table 8: IBED PHTS Water Chemistry Limits

Parameter	Value
Conductivity @ 25°C, μS/cm	≤0.2
pH @ 25°C	7.0–9.0
Sodium, ppb	≤5
Chloride, ppb	≤5
Hydrogen, ppb	≤80
Catalyzed Hydrazine, ppb	≤30
Ammonia, ppb	≤1000
Oxygen, ppb	≤10
ORP @ 25°C, mV	(-400)-(-100)
Iron, ppb	≤10
Copper, ppb	≤13

A1.3 Environmental Conditions

Environmental conditions for the CVBD Filters are given in: *Radiation Maps during Plasma Operations* ref. [78] (Figure 20 & 28 only) *Defined Requirement for PBS26* ref. [43] (Section 6.2.1 only), *Safety Requirement Roombook* ref. [42] (Room 11-L4-04), and TCWS CVBD System Process Loading Conditions ref. [63].

- **Normal Operating conditions (cat I events – Service Level A)**

Pressure: -0.08 to -0.14 kPa gauge (slightly below atmosphere)
Temperature: 18–35°C
Relative Humidity: max 60%
Note: nuclear operating life is 14 years, but total irradiation time is only 4,700 h.

- **Usual operational incidents conditions (cat II events – Service Level A)**
    - Loss of HVAC:
        - Pressure: 0.2 MPa
        - Temperature: Min 5°C, Max 100°C
        - Relative Humidity: 100%

- **Exceptional situations conditions (cat III events – Service Level C)**
    - DEG2 Highly Degraded Environmental Conditions:
        - Pressure: Min 0.095 MPa – Max 0.2 MPa
        - Temperature: Min 5°C, Max 130°C
        - Relative Humidity: 100%

- **Highly improbable situations conditions (cat IV events – Service Level D)**
    - Fire

For the fire situation (category IV event), the detail temperature distribution per room elevation is not available and the fire to be modelled is following the "Nominal Temperature-Time curves" according Eurocode 1 for a duration of 2h, leading to a final temperature of 1049°C in the air ref. [23].

- **Test situations conditions**
    - Containment Leak Tightness Tests
        - Pressure: 0.2 MPa
        - Temperature: 18-35°C
        - Relative Humidity: 60%

- **Transport/storage situations conditions**

For the transport/storage weather conditions, the document ref.[75] provides the following data:

- The external temperatures are -25°C / +45°C.
- The maximal solar flux is 1kW/m^2
- The extreme winds are 166 km/h.
- The extreme absolute humidity is 30 g/kg.
- The exceptional mass of snow is 150 daN/m^2

A1.5 Radiation

During the design lifetime, the CVBD Filters will be subject to both neutron and gamma radiation. The accumulated dose rate in silicon is ≤ 10 kGy@4700 h, silicon dose (Figure 20 ref. [78]). The nuclear operating life is 14 years, but total irradiation time is only 4700 h.

According to ref. [78], Figure 28, the maximum neutron flux is 1 000 n/cm^2/s. The fusion power level for the neutron flux data corresponds to 700 MW.

The CVBD Filters shall be suitable for satisfactory operation in the installed environment per this Specification.

A1.6 Magnetic Field

Magnetic Field: ≤ 35 mT (ref. [80])

A.2 Process Loading Conditions

The process loading conditions of the CVBD Filters are provided hereafter and can be extracted from the CVBD process loading conditions ref. [63] from the zone PT2. These loading conditions shall be combined with mechanical loading conditions according to TCWS Load Specification ref.[56] as seismic effect and nozzle loads (see Appendix C – Nozzle Loads).

The fatigue analysis shall include the number of cycles describes in this appendix A.2 Process Loading Conditions. The thermal conditions indicated in this appendix can be used for the fatigue analysis to optimise the design and the minimum required thickness.

SUPPLY

Case	Description	Cycles	Process Pressure & Temperature
I.S0	Design Conditions	-	1.8 MPa 100 °C
I.S1	Standby Mode (Low flow)	-	See I.S6
I.S2	Water Baking Operation at 240 °C	-	1.5 MPa 50 °C
I.S3	Idle Mode	-	1.2 MPa Tamb
I.S4	Off Mode	-	0.3 MPa Tamb
I.S5	Maintenance Mode	-	0.1 MPa Tamb
I.S6	Standby Mode (Nominal Flow)	-	1.5 MPa 50 °C
I.S8	Water Baking Operation at 18 °C	-	1.5 MPa 18 °C
I.T1	Plasma Operation	30000	1.5 MPa 50 °C
I.T2	Standby Mode (Low Flow) to Water Baking Operation	500	[0.19, 1.6] MPa 50 °C
I.T14	Idle Mode to Water Baking Operation		[0.1, 1.5] MPa [10, 50] °C
I.T3	Water Baking Operation to Standby Mode (Low Flow)	500	[0.19, 1.5] MPa 50 °C
I.T15	Water Baking Operation to Idle Mode		[0.1, 1.5] MPa [10, 50] °C
I.T4	Standby Mode (Low Flow) to Idle Mode	500	[0.1, 1.5] MPa [10, 50] °C
I.T5	Idle Mode to Standby Mode (Low Flow)	500	
I.T6	Off Mode to Maintenance Mode	500	[0.1, 0.6] MPa Tamb
I.T7	Maintenance Mode to Off Mode	500	
I.T8	Off Mode to Idle Mode	500	[0.1, 1.2] MPa [10, 35]
I.T9	Idle Mode to Off Mode	500	
I.T16	Standby Mode (Low Flow) to Standby Mode (Nominal Flow)	4000	1.5 MPa 50 °C
I.T17	Standby Mode (Nom. Flow) to Standby Mode (Low Flow)	4000	

SUPPLY

Case	Description	Cycles	Process Pressure & Temperature
II.S1	DEG1 Degraded Environmental Conditions	-	Environmental pressure: [95, 200] kPaEnvironmental temperature: [5, 100] °CEnvironmental air humidity: [0, 100] %
II.T1	Short-Term LOOP	50	[0.2, 1.8] MPa [10, 90] °C
II.T2	Cat. II Break within In-Vessel LOCA Boundaries	50	[1.5, 1.8] MPa 18 °C
II.T4	Loss of HVAC Incident	50	[-0.2] MPa [18, 100] °C
II.T5	SL-1 Seismic Event	50	1.5 MPa 50 °C
II.T6	WH Pump Trip	50	Primary pumps: I.T1 + PL-19x0 common trip (Impulse case 4 from TYHFYX v2.1) Baking pump: I.S2 + PL-1900 trip (Impulse case 13 from TYHFYX v2.1)
II.T9	WH Spurious LOCA Isolation Valve Closure	5	For in-vessel LOCA valves: During plasma: I.T1 + simultaneous closure of in-vessel LOCA isolation valves (Impulse case 1b from TYHFYX v2.1) During baking: I.S2 + simultaneous closure of in-vessel LOCA isolation valves (Impulse case 5 from TYHFYX v2.1) For ex-vessel LOCA valves: During plasma: I.T1 + simultaneous closure of ex-vessel LOCA isolation valves (Impulse case 2 from TYHFYX v2.1) During baking: I.S2 + simultaneous closure of ex-vessel LOCA isolation valves (Impulse case 6 from TYHFYX v2.1)
II.T11	OPP Category II	50	[0.8, 1.8] MPa 100 °C
II.T12	HX Tube Leakage	1	[0.8, 1.8] MPa [50, 100] °C

SUPPLY

Case	Description	Cycles	Process Pressure & Temperature
III.S1	DEG2 Highly Degraded Environmental Conditions	-	Environmental pressure: [95, 200] kPaEnvironmental temperature: [5, 130] °CEnvironmental air humidity: [0, 100] %
III.T1	Long-Term LOOP + Failure of DHR Operation	1	0.2 → 1.8 → 1.5 MPa 50 → 10 → 190 °C
III.T2	Short-Term LOOP + Loss of HVAC Incident	1	II.T1 → II.T1 + II.S1 → II.T1
III.T3	LOCA Outside Cryostat	1	[-0.2] MPa 18 → 130 → 18 °C
III.T4	WH Pump Seizure	1	Baking pump: I.S2 + 1 ms PL-1900 seizure (Impulse case 10 from TYHFYX v2.1)
III.T5	SMHV Seismic Event	1	1.5 MPa 50 °C
III.T9	WH Break Propagation	1	Pipe break upstream VK-0183 (divertor loop): I.S8 + Pipe break upstream VK-0183 (Impulse case 7 from TYHFYX v2.1) Pipe break upstream VK-0477 (EQ port loop): I.S8 + Pipe break upstream VK-0477 (Impulse case 8 from TYHFYX v2.1) Pipe break upstream VK-0253 (FW/BLK loop): I.S8 + Pipe break upstream VK-0253 (Impulse case 9 from TYHFYX v2.1) Baking supply header break: I.S8 + Baking supply header break (Impulse case 15 from TYHFYX v2.1) Baking pump discharge break: I.S8 + Baking pump discharge break (Impulse case 17 from X9AZZL v5.1) Linear return header break: I.T1 + Linear return header break (Impulse case 16 from TYHFYX v2.1 & Impulse case 10 from X9AZZL v5.1) Linear supply header break: I.T1 + Linear supply header break (Impulse case 11 from X9AZZL v5.1) FW/BLK loop main supply break: I.T1 + FW/BLK loop main supply break (Impulse case 17 from TYHFYX v2.1) Primary pump discharge break: I.T1 + Primary pump discharge break (Impulse case 9 from X9AZZL v5.1)
III.T10	OPP Category III	1	0.1 → 1.98 MPa 100 °C
III.T11	WH Spurious & Simultaneous LOCA Isolation Valves Closure with a Single Failure	1	I.T1 + simultaneous closure of all LOCA isolation valves except one (Impulse case 1a from X9AZZL v5.1)
III.T12	Cat. III Pipe Break within In-Vessel LOCA Boundaries	1	0.1 → 1.8 → 0.1 MPa 18 °C

SUPPLY

Case	Description	Cycles	Process Pressure & Temperature
IV.S1	Fire Design Basis	1	The fire design basis event is based on Eurocode 1 EN 1991-1-2:2002. Environmental temperature increases up to 1049 °C for a fire duration of 2 hr.IBED PHTS fire insulation is sized to ensure that the maximum process temperature in case of fire never exceeds the saturation temperature at design pressure.
IV.T1	Fire Exposure	1	0.6 → 2.06 → 0.6 MPa 18 → 200 → 18 °C
IV.T2	SL-2 Seismic Event	1	1.5 MPa 50 °C
IV.T5	Cat. IV Pipe Break within In-Vessel LOCA Boundaries	1	0.1 → 1.98 → 0.1 MPa 18 °C
IV.T6	WH Severe Pump Seizure	1	Baking pump: I.S2 + 1 ms PL-1900 seizure (Impulse case 10 from TYHFYX v2.1) => Same as III.T4

SUPPLY

Case	Description	Cycles	Process Pressure & Temperature
U.S1	Storage Env. Conditions	-	OUTDOORS Environmental pressure: atmospheric Environmental temperature: [-25, 45] °C Environmental air humidity: 30 g/kg (=> 100% at 32 °C and 50% at 45 °C) Extreme winds up to 166 km/hr Maximum mass of snow: 150 daN/m2 INDOORS Environmental pressure: atmospheric Environmental temperature: [-8, 45] °C Environmental air humidity: 30 g/kg (=> 100% at 32 °C and 50% at 45 °C)
U.T1	Hydrostatic Pressure Test	10	0.1 → 2.7 → 0.1 MPa [5, 45] °C
U.T2	Containment Leak-Tightness Test	10	Environmental pressure: [95, 200] kPaEnvironmental temperature: [18, 35] °CEnvironmental air humidity: [0, 60] %

Appendix B – Loads Combinations

B.1 Classification

This appendix describes all the combinations of loads to be used for the normal, exceptional, and highly improbable conditions needed for the design of the CVBD Filters.

The CVBD Filters safety important classification is SIC-1 as per ref. [56], loading conditions from categories I & II shall remain within normal damage limits (service level = A), loading conditions from category III shall remain within emergency damage limits (service level = C) with the allowable values from ref. [51], and loading conditions from category IV shall remain within faulted damage (service level = D) with the allowable values from ref. [51].

From the ESPN classifications, according to the ASN guide 19 ref. [6] the events are classified into 4 categories:

- Normal operating conditions (corresponding to cat I and II),
- exceptional situations (cat III)
- highly improbable situations (cat IV)
- testing conditions

Table 9 below summarizes the classification and the requirements and criteria for the maximum allowable pressure and the maximum allowable temperature.

Table 9 - Situations Classification and associated requirements

<table>
<tr><th colspan="3">classification of the situation following the harmonised standards</th><th>PS/TS</th></tr>
<tr><td rowspan="4">conditions of use which can be reasonably foreseen</td><td rowspan="2">normal situations</td><td>normal situations during normal operating conditions</td><td rowspan="2">T≤TS
P≤PS</td></tr>
<tr><td>situations corresponding to usual operational incidents</td></tr>
<tr><td colspan="2">exceptional situations</td><td>P≤110%PS and short time excess
- verification of the equipment (except if adequate design defined)
- adequate protection device when T>TS</td></tr>
<tr><td colspan="2">test situations</td><td>Proof test pressure carried out at the final assessment (envelop of all the pressure tests during operation)</td></tr>
<tr><td colspan="3">highly improbable situations</td><td>avoid the risk of loss of integrity in case of excess of PS ad TS related to the requirements defined in the safety report.</td></tr>
</table>

B.2 Units

The following units are used:

- Pressures, stresses are given in kPa abs, MPa abs and bar g
- Temperatures are given in Celsius degrees ºC
- Dimensions and displacements are in meters or mm
- Mass is in kilograms kg
- Acceleration is in m/s^2 or in g

B.3 Coordinate system

The ITER global reference axes are used for the global reference coordinate system of the CVBD Filters.

For the ITER plant the reference axes are:

- X = East
- Y = North
- Z = Vertical

B.4 Loads

The loads acting on the CVBD Filters can be divided into 5 independent categories:

- Pressure loads: these include the internal pressure and the water height pressure on the vessel
- Inertial loads: these are caused by accelerations due to gravity and seismic events on the equipment itself, the internals and on the contained water (sloshing).
- Thermal loads: stresses caused by fluctuations of temperature applied to the vessel and its support and stresses caused by temperature differences including transient conditions and by differences in coefficients of thermal expansion.
- Nozzle loads: the connected pipes provide loads at the connection nozzles.
- Maintenance loads: the transportation, lifting, installation and in-site inspection during the lifetime of the pressure equipment provides additional loads and stresses.

The TCWS Load specification ref. [56] indicates many types of loads for the TCWS systems. However, the CVBD Filters are not subject to the following loads:

- Vertical displacements events
- Major disruptions
- Helium leak outside cryostat
- CrICE event (leak of Cryogenic pipes inside Cryostat)
- VV ICE (ingress of coolant inside the Vacuum vessel)

B.5 Nozzle Loads

See Appendix C – Nozzle Loads.

B.6 Seismic Loads

Following the loads specification ref. [56], the CVBD Filters are subject to seismic loads.

Three different seismic events have to be considered for the CVBD Filters:

- SL-1 (event category II)
- SMHV (event category III)
- SL-2 (event category IV)

The numbers of occurrences for the seism events during the lifetime of the CVBD Filters are (see Appendix A – CVBD Filters Datasheet and Process Loading Conditions):

- 50 for SL1,
- 1 for SMHV,
- 1 for SL2.

The values for the Floor Response Spectra are provided in Appendix D – Floor Response Spectra.

B.7 Fire case

Fire is a cat. IV event (service level D).

The CVBD Filters are insulated.

The fire design basis event is based on Eurocode 1 EN 1991-1-2 ref. [23]. Environmental temperature increases up to 1049 °C for a fire duration of 2 hours.

CVBD Filters fire insulation is sized to ensure that the metal temperature under the insulation does not exceed 200°C (see case IV.T1 in appendix A).

Platform #31 supporting CVBD Filters 26CVBD-FI-5150 and 26CVBD-FI-5803 has been qualified for a fire temperature of 290 °C (ref. [86]). A temperature of 400 °C shall be conservatively considered for the CVBD Filters supports.

Per reference [56], a seism SL-2 can trigger a fire which is not concomitant, should occur as an event category IV (highly improbable situation). Then, a replica SMHV concomitant to the fire shall occur.

When the fire is cumulated with SMHV, it shall be verified that, after the deformations, the nozzles can withstand the service level C nozzles loads provided in Appendix C – Nozzle Loads.

B.8 Summary of the loading combinations

The individual load cases are listed in Table 10 while the load combinations to consider for the CVBD Filters design are listed in

Table **11**.

Table 10 – Individual load cases

Load	Description
P	Internal and external specified pressure (including static height pressure from liquid)
Ptest	Test Pressure
Dw	Dead weight including all sustained loads (piping, insulation, stainless steel jacket, fluid, etc)
Dt	Same as Dw, except for conditions during pressure test. This can be different from Dw in case of no insulation during the test
T	Temperature or Thermal Loads due to: - piping thermal expansion/contraction when subjected to maximum temperature differences between the fluid and the surrounding environment, - anchor movements due to thermal movements of the equipment
SL1	Seismic event level 2 due to operating basis earthquake, SL-2 x 0.34
SMHV	Seismic event level 3 due to operating basis earthquake, SL-2 x 0.73
SL2	Seismic event level 4 due to safe shutdown earthquake
Nozzle loads	The nozzle loads at the flange with the pipe connected provided for the levels A/ B (normal situation), C (exceptional situations) D (highly improbable situations).

Table 11 – Load Combinations

		NORMAL SITUATIONS			EXCEPTIONAL SITUATIONS		HIGHLY IMPROBABLE SITUATIONS			TEST SITUATION
Event Category		I/II	I/II	LIFTING	III	III	IV	IV	IV	TEST
Load Combination		N1	N2 (II.T4)	L1	E1	E2 (III.T3)	HI1	FIRE1	FIRE2	T1
Static Loads	Dead Weight(3)	Yes	Yes	Yes (125% incl. th. Insulation)	Yes	Yes	Yes	Yes	Yes	Yes
	Pressure (barg)	17	-2	0	19.6	-2	19.6	19.6	19.6	25.5(2)
	Water Volume (m^3)	TBD(1)	0	0	TBD(1)	0	TBD(1)	TBD(1)	TBD(1)	TBD(1)
	Water Height Pressure ?	Yes	/	/	Yes	/	Yes	Yes	Yes	Yes
	Vessel Temperature (°C)	100	100	amb	190	130	190	200	200	amb
	Supports Temperature (°C)	100	100	amb	190	130	190	400	400	amb
	Restrained thermal expansion	Yes	Yes	/	Yes	Yes	Yes	Yes	Yes	/
	Service Levels A/B Nozzle loads	Yes	Yes	/	/	/	/	/	/	/
	Service Levels C/D Nozzle loads	/	/	/	Yes	Yes	Yes	Yes	Yes	/
Dynamic Loads	SL1	Yes	Yes	/	/	/	/	/	/	/
	SMHV	/	/	/	Yes	/	/	/	Yes	/
	SL2	/	/	/	/	/	Yes	/	/	/

Notes:

(1) Volume shall be determined by the Contractor

(2) The pressure test shall be confirmed by the Contractor. It is stated in this table following the document ref. [59].

(3) *The wet dead weight is considered for each loading combination (including thermal insulation). For the lifting case, 125% of the dry weight is considered (including thermal insulation).*

Appendix C – Nozzle Loads

The nozzle loads are provided for the Service Levels A/B (cat I and II normal situations) and for the Service Levels C/D (cat III exceptional situations and cat IV highly improbable situations).

The nozzle loads are provided in the coordinates systems shown on Figure 1 and Figure 2.

The nozzle loads are to be applied at the NPE equipment limit (at the weld between nozzle and connecting pipe). They shall NOT be applied at the connection between the nozzle and the vessel.

All nozzle loads (forces and moments) are unsigned. The Contractor shall consider the loads with the orientation that leads to the most penalizing results.

On flat head, radial force and radial moment F_R and M_R shall be considered with the most penalizing angular direction in the stress analysis.

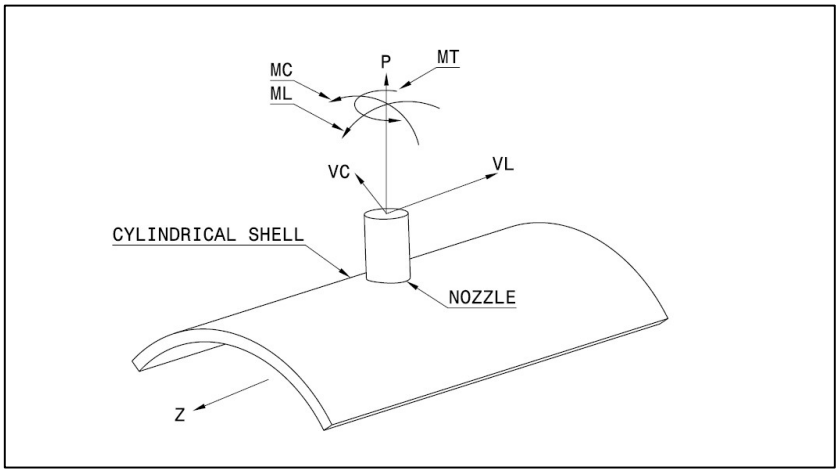

Figure 1: Cylindrical Shell Nozzle loads Coordinate System

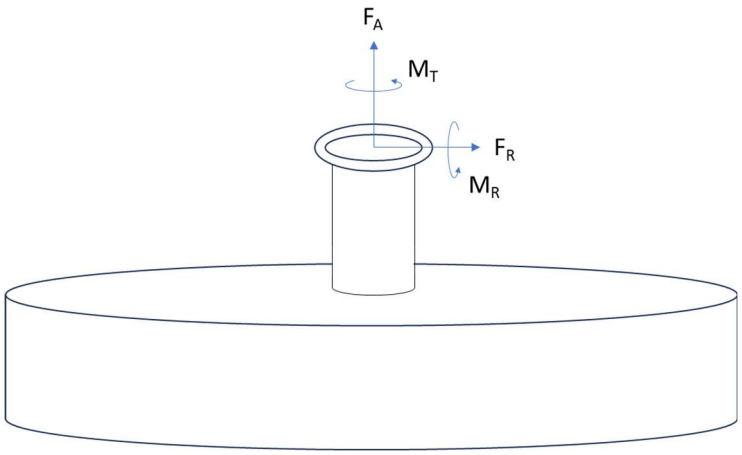

Figure 2: Flat Head Nozzle loads Coordinate System

Table 12: Nozzle Loads

Equipment type	Nozzle #	Nozzle DN	Service Level	Nozzle Loads							
				F_L	F_A	F_C	M_C	M_T	M_L	F_R	M_R
				N	N	N	Nm	Nm	Nm	N	Nm
Inlet Filters (26CVBD-PI-5303, 5304, 5490 and 5497) Resin Traps (26CVBD-PI-5803 and 5150)	N1 (Filter inlet)	65	A/B	N/A	5000	N/A	N/A	2500	N/A	8700	2500
			C/D	N/A	6600	N/A	N/A	3300	N/A	11600	3300
	N2 (Filter outlet)	65	A/B	6200	6200	6200	2500	2500	2500	N/A	N/A
			C/D	8200	8200	8200	3300	3300	3300	N/A	N/A
	N3 (Filter drain)	25	A/B	4200	4200	4200	1200	1200	1200	N/A	N/A
			C/D	5600	5600	5600	1500	1500	1500	N/A	N/A

Appendix D – Floor Response Spectra

CVBD Filters 26CVBD-FI-5150 and 26CVBD-FI-5803 are supported on Platform #31. Platform #31 FRS is available in ref. [84].

CVBD Filters 26CVBD-FI-5303, 26CVBD-FI-5304, 26CVBD-FI-5490 and 26CVBD-FI-5497 will be supported on another steel structure, not designed yet.

Platform #31 FRS accelerations, increased by 20%, provided in Figure 3, Figure 4, Table 13, Table 14, Table 15 and Table 16, shall conservatively be used for all filters.

The damping value for CVBD Filters is 3% for SL-2 and SMHV and 2% for SL1 according to the Load Specification [56].

The 3% damping values ($a_{3\%}$) can be calculated from available 2% and 4% damping values ($a_{2\%}$ and $a_{4\%}$), using the following equation:

$$a_{3\%} = a_{2\%} - (a_{2\%} - a_{4\%})*[\ln(2/3)]/[\ln(2/4)]$$

Since the orientation of the CVBD Filters may vary, the X & Y spectra are grouped and shall be used for both horizontal directions. The Z-spectra are the vertical floor responses.

SL-1 can be taken as 0.34 times SL-2 (calculated with 3% damping) and SMHV is 0.73 times SL-2 (calculated with 3% damping).

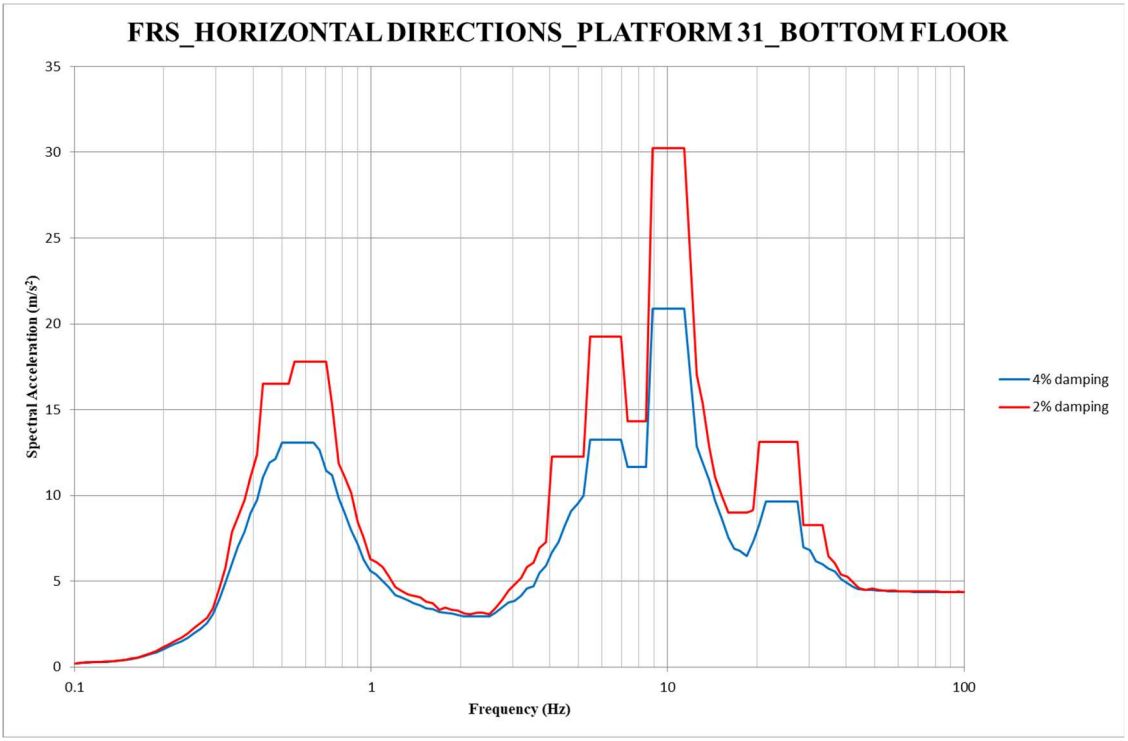

Figure 3: FRS – SL2 – Horizontal Directions

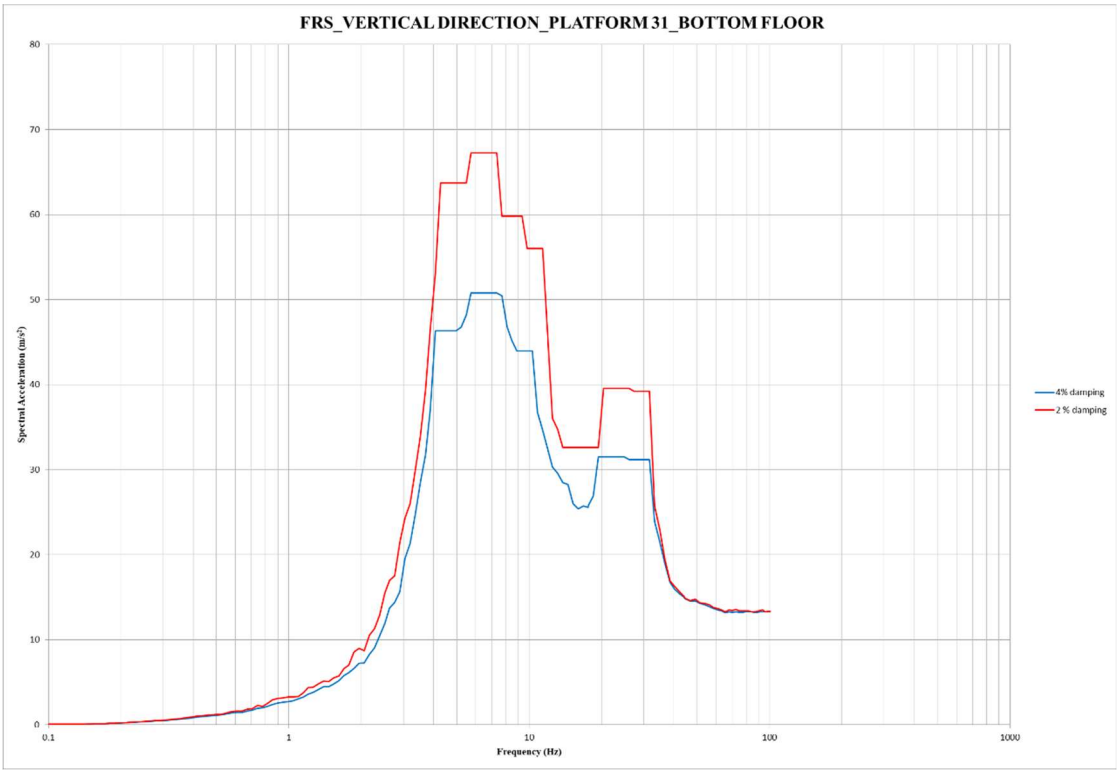

Figure 4: FRS – SL2 – Vertical Direction

Table 13: FRS – SL2 –Horizontal Directions – 2% damping

Frequency	SL2 Design FRS - 2% Damping Horizontal Directions
[Hz]	[m/s^2]
0.1	0.22204
0.105	0.24978
0.1103	0.2695
0.1158	0.27797
0.1216	0.29199
0.1276	0.31709
0.134	0.34518
0.1407	0.37509
0.1478	0.42475
0.1551	0.48847
0.1629	0.56887
0.171	0.68008
0.1796	0.81854
0.1886	0.93507
0.198	1.14873
0.2079	1.33347
0.2183	1.53389
0.2292	1.712
0.2407	1.95471
0.2527	2.26227
0.2653	2.54533
0.2786	2.85264
0.2925	3.41069
0.3072	4.60878
0.3225	5.79237
0.3386	7.86396
0.3556	8.74674
0.3734	9.70908
0.392	11.076
0.4116	12.3716
0.4322	16.4971
0.4538	16.4971
0.4765	16.4971
0.5003	16.4971
0.5253	16.4971
0.5516	17.804
0.5792	17.804
0.6081	17.804
0.6386	17.804
0.6705	17.804
0.704	17.804
0.7392	15.3037
0.7762	11.8788

SUPPLY

Frequency	SL2 Design FRS - 2% Damping Horizontal Directions
0.815	11.0805
0.8557	10.1714
0.8985	8.42747
0.9434	7.5455
0.9906	6.29088
1.0401	6.13092
1.0921	5.80485
1.1467	5.32188
1.2041	4.68169
1.2643	4.45469
1.3275	4.25698
1.3939	4.16501
1.4636	4.06866
1.5367	3.78781
1.6136	3.70293
1.6943	3.34631
1.779	3.46125
1.8679	3.35001
1.9613	3.30211
2.0594	3.13736
2.1624	3.08707
2.2705	3.14921
2.384	3.17598
2.5032	3.09032
2.6284	3.44364
2.7598	3.90922
2.8978	4.45391
3.0426	4.78723
3.1948	5.18153
3.3545	5.81574
3.5222	6.09896
3.6984	6.92343
3.8833	7.29158
4.0774	12.2389
4.2813	12.2389
4.4954	12.2389
4.7201	12.2389
4.9561	12.2389
5.204	12.2389
5.4642	19.2514
5.7374	19.2514
6.0242	19.2514
6.3254	19.2514
6.366	19.2514
6.6417	19.2514
6.9738	19.2514

SUPPLY

Frequency	SL2 Design FRS - 2% Damping Horizontal Directions
7.3225	14.3344
7.6886	14.3344
8.073	14.3344
8.4767	14.3344
8.9005	30.2197
9.3456	30.2197
9.8128	30.2197
9.963	30.2197
10.251	30.2197
10.304	30.2197
10.819	30.2197
11.36	30.2197
12.524	17.018
13.15	15.3849
13.808	12.8052
14.498	11.0604
15.223	10.0064
15.984	9.00817
16.783	9.00817
17.547	9.00817
17.622	9.00817
18.504	9.00817
19.392	9.10834
19.429	9.23542
20.4	13.0992
21.42	13.0992
22.491	13.0992
23.616	13.0992
24.797	13.0992
26.036	13.0992
27.338	13.0992
28.705	8.28297
30.14	8.28297
31.647	8.28297
33.23	8.28297
34.891	6.44705
36.636	6.04725
38.468	5.37782
40.391	5.27655
42.411	4.90513
44.075	4.64476
44.531	4.59329
46.758	4.49817
49.095	4.56134
51.432	4.4911
53.769	4.45949

SUPPLY

Frequency	SL2 Design FRS - 2% Damping Horizontal Directions
56.106	4.45094
58.443	4.44136
60.78	4.42687
63.117	4.41333
65.454	4.41476
67.791	4.38875
70.128	4.38795
72.465	4.39428
74.802	4.43045
77.139	4.4057
79.476	4.41425
81.813	4.3932
84.15	4.37717
86.487	4.3733
88.824	4.3653
91.161	4.37578
93.498	4.38075
95.835	4.40727
98.172	4.3711
100.509	4.35618

Table 14: FRS – SL2 –Horizontal Directions – 4% damping

Frequency	SL2 Design FRS - 4% Damping Horizontal Directions
[Hz]	[m/s^2]
0.1	0.21936
0.105	0.24154
0.1103	0.25842
0.1158	0.27538
0.1216	0.28645
0.1276	0.30347
0.134	0.34015
0.1407	0.36954
0.1478	0.41366
0.1551	0.47454
0.1629	0.54113
0.171	0.62431
0.1796	0.75199
0.1886	0.86293
0.198	1.0211
0.2079	1.18457
0.2183	1.34964
0.2292	1.4763
0.2407	1.71123
0.2527	1.96543
0.2653	2.22837
0.2786	2.55012
0.2925	3.08334
0.3072	3.96232
0.3225	4.92507
0.3386	6.05246
0.3556	7.02857
0.3734	7.88861
0.392	8.93982
0.4116	9.7452
0.4322	11.0402
0.4538	11.9231
0.4765	12.1506
0.5003	13.0939
0.5253	13.0939
0.5516	13.0939
0.5792	13.0939
0.6081	13.0939
0.6386	13.0939
0.6705	12.6533
0.704	11.4554
0.7392	11.1707
0.7762	9.84852

SUPPLY

Frequency	SL2 Design FRS - 4% Damping Horizontal Directions
0.815	8.99327
0.8557	7.99075
0.8985	7.17227
0.9434	6.25973
0.9906	5.62777
1.0401	5.37886
1.0921	4.99523
1.1467	4.67687
1.2041	4.21359
1.2643	4.07704
1.3275	3.90481
1.3939	3.73225
1.4636	3.60293
1.5367	3.41569
1.6136	3.36924
1.6943	3.20203
1.779	3.15517
1.8679	3.10908
1.9613	3.03411
2.0594	2.95884
2.1624	2.95044
2.2705	2.95745
2.384	2.9348
2.5032	2.96424
2.6284	3.18362
2.7598	3.47083
2.8978	3.77031
3.0426	3.84447
3.1948	4.13365
3.3545	4.57845
3.5222	4.69277
3.6984	5.4858
3.8833	5.88933
4.0774	6.67397
4.2813	7.28295
4.4954	8.16679
4.7201	9.07681
4.9561	9.53244
5.204	10.0003
5.4642	13.2377
5.7374	13.2377
6.0242	13.2377
6.3254	13.2377
6.366	13.2377
6.6417	13.2377
6.9738	13.2377

SUPPLY

Frequency	SL2 Design FRS - 4% Damping Horizontal Directions
7.3225	11.6419
7.6886	11.6419
8.073	11.6419
8.4767	11.6419
8.9005	20.8795
9.3456	20.8795
9.8128	20.8795
9.963	20.8795
10.251	20.8795
10.304	20.8795
10.819	20.8795
11.36	20.8795
12.524	12.84
13.15	11.9002
13.808	10.8962
14.498	9.69268
15.223	8.64098
15.984	7.53872
16.783	6.89355
17.547	6.77045
17.622	6.74107
18.504	6.47334
19.392	7.2589
19.429	7.31188
20.4	8.29388
21.42	9.65111
22.491	9.65111
23.616	9.65111
24.797	9.65111
26.036	9.65111
27.338	9.65111
28.705	6.99112
30.14	6.7918
31.647	6.16813
33.23	5.981
34.891	5.7288
36.636	5.55028
38.468	5.14583
40.391	4.89874
42.411	4.64636
44.075	4.55624
44.531	4.55115
46.758	4.49769
49.095	4.50574
51.432	4.467
53.769	4.43846

SUPPLY

Frequency	SL2 Design FRS - 4% Damping Horizontal Directions
56.106	4.41251
58.443	4.39899
60.78	4.40283
63.117	4.40283
65.454	4.39623
67.791	4.3813
70.128	4.37387
72.465	4.36093
74.802	4.38548
77.139	4.38627
79.476	4.38627
81.813	4.38075
84.15	4.37274
86.487	4.37026
88.824	4.36226
91.161	4.36778
93.498	4.3733
95.835	4.37026
98.172	4.36474
100.509	4.3537

Table 15: FRS – SL2 –Vertical Direction – 2% damping

Frequency	SL2 Design FRS - 2% Damping Vertical Direction
[Hz]	[m/s^2]
0.1	0.047088
0.105	0.054936
0.1103	0.05886
0.1158	0.062784
0.1216	0.070632
0.1276	0.074556
0.134	0.07848
0.1407	0.090252
0.1478	0.0981
0.1551	0.113796
0.1629	0.125568
0.171	0.141264
0.1796	0.160884
0.1886	0.184428
0.198	0.21582
0.2079	0.25506
0.2183	0.290376
0.2292	0.337464
0.2407	0.35316
0.2527	0.3924
0.2653	0.45126
0.2786	0.494424
0.2925	0.517968
0.3072	0.54936
0.3225	0.596448
0.3386	0.655308
0.3556	0.72594
0.3734	0.839736
0.392	0.914292
0.4116	0.984924
0.4322	1.035936
0.4538	1.122264
0.4765	1.192896
0.5003	1.200744
0.5253	1.23606
0.5516	1.365552
0.5792	1.546056
0.6081	1.624536
0.6386	1.62846
0.6705	1.808964
0.704	1.910988
0.7392	2.299464
0.7762	2.169972

SUPPLY

Frequency	SL2 Design FRS - 2% Damping Vertical Direction
0.815	2.495664
0.8557	2.943
0.8985	3.09996
0.9434	3.15882
0.9906	3.252996
1.0401	3.280464
1.0921	3.343248
1.1467	3.74742
1.2041	4.347792
1.2643	4.402728
1.3275	4.818672
1.3939	5.156136
1.4636	5.097276
1.5367	5.536764
1.6136	5.756508
1.6943	6.639408
1.779	7.027884
1.8679	8.530776
1.9613	8.997732
2.0594	8.719128
2.1624	10.54771
2.2705	11.32466
2.384	12.92173
2.5032	15.47233
2.6284	16.96345
2.7598	17.50104
2.8978	21.40934
3.0426	24.30918
3.1948	26.00042
3.3545	29.9362
3.5222	33.96222
3.6984	39.45974
3.8833	46.46408
4.0774	53.1545
4.2813	63.69829
4.4954	63.69829
4.7201	63.69829
4.9561	63.69829
5.204	63.69829
5.4642	63.69829
5.7374	67.25344
6.0242	67.25344
6.3254	67.25344
6.366	67.25344
6.6417	67.25344
6.9738	67.25344

SUPPLY

Frequency	SL2 Design FRS - 2% Damping Vertical Direction
7.3225	67.25344
7.6886	59.79784
8.073	59.79784
8.4767	59.79784
8.9005	59.79784
9.3456	59.79784
9.8128	55.98371
9.963	55.98371
10.251	55.98371
10.304	55.98371
10.819	55.98371
11.36	55.98371
12.524	36.01447
13.15	34.75487
13.808	32.60844
14.498	32.60844
15.223	32.60844
15.984	32.60844
16.783	32.60844
17.547	32.60844
17.622	32.60844
18.504	32.60844
19.392	32.60844
19.429	32.60844
20.4	39.57354
21.42	39.57354
22.491	39.57354
23.616	39.57354
24.797	39.57354
26.036	39.57354
27.338	39.21253
28.705	39.21253
30.14	39.21253
31.647	39.21253
33.23	25.74536
34.891	22.98679
36.636	19.46304
38.468	16.92814
40.391	16.28068
42.411	15.61752
44.075	15.11917
44.531	14.89943
46.758	14.60513
49.095	14.77386
51.432	14.32652
53.769	14.26374

SUPPLY

Frequency	SL2 Design FRS - 2% Damping Vertical Direction
56.106	14.13032
58.443	13.78894
60.78	13.69476
63.117	13.47894
65.454	13.30628
67.791	13.49071
70.128	13.46717
72.465	13.53388
74.802	13.36907
77.139	13.38476
79.476	13.42008
81.813	13.38476
84.15	13.27097
86.487	13.30628
88.824	13.31806
91.161	13.43578
93.498	13.49856
95.835	13.29844
98.172	13.31413
100.509	13.33768

Table 16: FRS – SL2 –Vertical Direction – 4% damping

Frequency	SL2 Design FRS - 4% Damping Vertical Direction
[Hz]	[m/s^2]
0.1	0.054936
0.105	0.05886
0.1103	0.062784
0.1158	0.070632
0.1216	0.074556
0.1276	0.07848
0.134	0.086328
0.1407	0.090252
0.1478	0.102024
0.1551	0.11772
0.1629	0.129492
0.171	0.145188
0.1796	0.160884
0.1886	0.17658
0.198	0.207972
0.2079	0.239364
0.2183	0.270756
0.2292	0.2943
0.2407	0.321768
0.2527	0.357084
0.2653	0.404172
0.2786	0.439488
0.2925	0.459108
0.3072	0.514044
0.3225	0.561132
0.3386	0.60822
0.3556	0.66708
0.3734	0.74556
0.392	0.812268
0.4116	0.875052
0.4322	0.926064
0.4538	1.02024
0.4765	1.083024
0.5003	1.106568
0.5253	1.149732
0.5516	1.2753
0.5792	1.41264
0.6081	1.4715
0.6386	1.424412
0.6705	1.585296
0.704	1.699092
0.7392	1.92276
0.7762	1.973772

SUPPLY

Frequency	SL2 Design FRS - 4% Damping Vertical Direction
0.815	2.166048
0.8557	2.358324
0.8985	2.566296
0.9434	2.6487
0.9906	2.738952
1.0401	2.837052
1.0921	3.0411
1.1467	3.260844
1.2041	3.614004
1.2643	3.821976
1.3275	4.171212
1.3939	4.465512
1.4636	4.449816
1.5367	4.818672
1.6136	5.163984
1.6943	5.819292
1.779	6.129288
1.8679	6.643332
1.9613	7.212312
2.0594	7.286868
2.1624	8.248248
2.2705	9.06444
2.384	10.48885
2.5032	11.92504
2.6284	13.72615
2.7598	14.36184
2.8978	15.63322
3.0426	19.57684
3.1948	21.33479
3.3545	24.74867
3.5222	28.52356
3.6984	31.80794
3.8833	37.01509
4.0774	46.31497
4.2813	46.31497
4.4954	46.31497
4.7201	46.31497
4.9561	46.31497
5.204	46.75446
5.4642	48.21419
5.7374	50.75302
6.0242	50.75302
6.3254	50.75302
6.366	50.75302
6.6417	50.75302
6.9738	50.75302

SUPPLY

Frequency	SL2 Design FRS - 4% Damping Vertical Direction
7.3225	50.75302
7.6886	50.46264
8.073	46.84079
8.4767	45.19271
8.9005	43.93703
9.3456	43.93703
9.8128	43.93703
9.963	43.93703
10.251	43.93703
10.304	43.93703
10.819	36.75611
11.36	34.64892
12.524	30.27366
13.15	29.57519
13.808	28.49609
14.498	28.27242
15.223	25.98473
15.984	25.40398
16.783	25.75321
17.547	25.58056
17.622	25.81207
18.504	26.89902
19.392	31.51364
19.429	31.51364
20.4	31.51364
21.42	31.51364
22.491	31.51364
23.616	31.51364
24.797	31.51364
26.036	31.16048
27.338	31.16048
28.705	31.16048
30.14	31.16048
31.647	31.16048
33.23	23.89716
34.891	21.53884
36.636	18.96077
38.468	16.7594
40.391	15.90005
42.411	15.39778
44.075	14.96614
44.531	14.83664
46.758	14.56196
49.095	14.55412
51.432	14.25589
53.769	14.08716

SUPPLY

Frequency	SL2 Design FRS - 4% Damping Vertical Direction
56.106	13.91058
58.443	13.67122
60.78	13.49464
63.117	13.38084
65.454	13.19641
67.791	13.2592
70.128	13.24742
72.465	13.29844
74.802	13.2435
77.139	13.21211
79.476	13.29844
81.813	13.27489
84.15	13.26312
86.487	13.25527
88.824	13.23565
91.161	13.27882
93.498	13.29451
95.835	13.27489
98.172	13.28274
100.509	13.29844

Appendix E – CVBD Filters Supporting Secondary Structure

CVBD Filters will be installed in B11-L4 Vault on secondary steel structures as shown on Figure 5 and Figure 6.

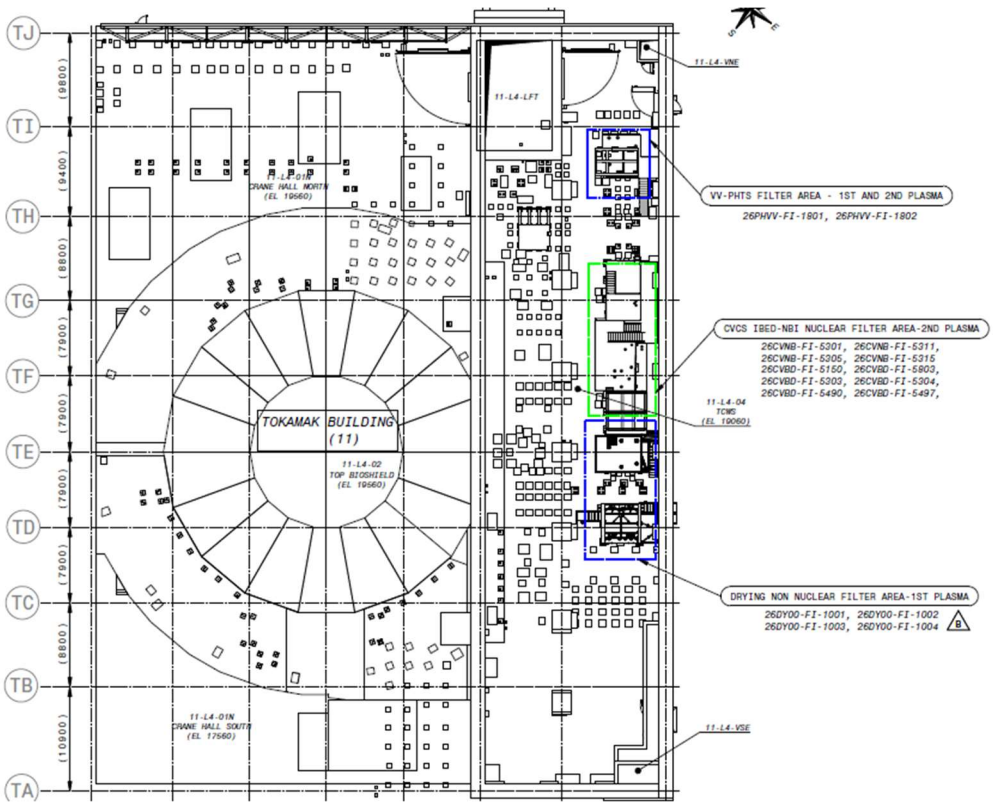

Figure 5: CVBD Filters installation area (in green)

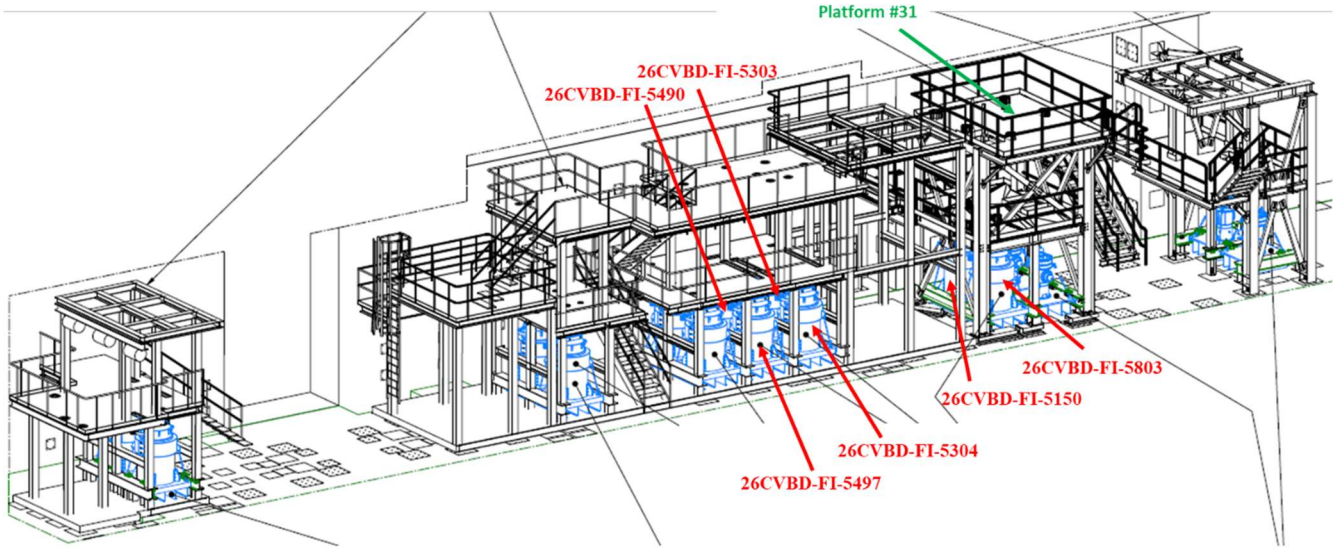

Figure 6: CVBD Filters Secondary Steel Structures

Notes:

These figures are shown for information only. Secondary steel structure supporting CVBD Filters 26CVBD-FI-5303, 26CVBD-FI-5304, 26CVBD-FI-5490 and 26CVBD-FI-5497 is not designed yet. Shielded versions of the nuclear filters are represented on the figure while the present contract concerns non-shielded versions of the filters.

Interfaces between the CVBD filters and the supporting secondary steel structure are shown on the CVBD Filters General Arrangement Drawing ref. [71].

CVBD Filters 26CVBD-FI-5150 and 26CVBD-FI-5803 are supported on Platform #31. As shown on platform #31 drawing (ref. [67]), the filters will be supported on 2 EU-HEB300 beams that will act as rails for the filters.

CVBD Filters 26CVBD-FI-5303, 26CVBD-FI-5304, 26CVBD-FI-5490 and 26CVBD-FI-5497 will be supported on another secondary steel structure with a similar interface configuration (2 EU-HEB300 beams).

The design of the CVBD filters supporting structure (pallet, rollers system, tie-rods, …) shall be compatible with the platform interface.

Typical filter locking system (ref. [72]) designed for DYS filters is shown on Figure 7 (preliminary design). The filter locking system is not in the scope of this contract.

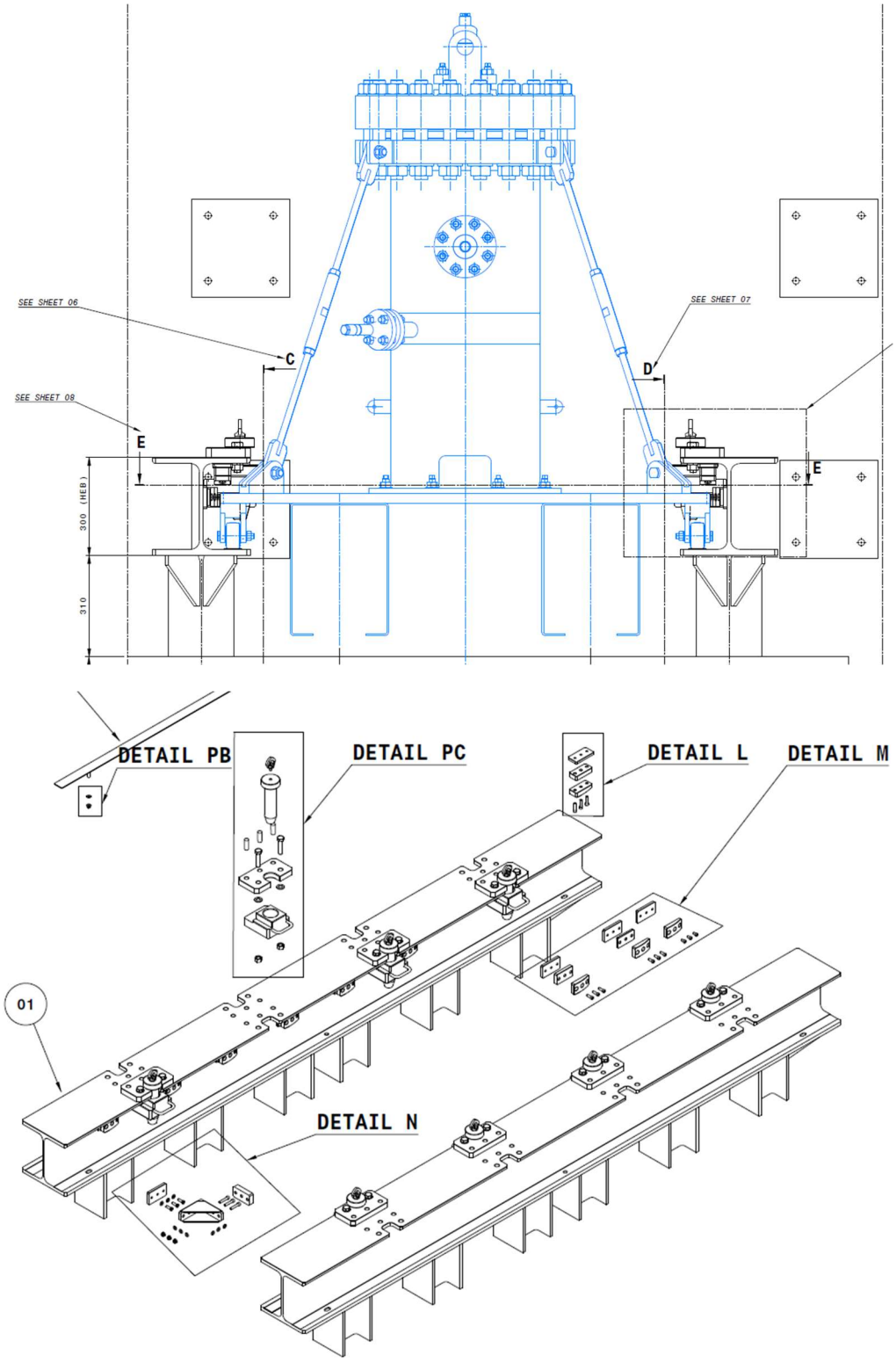

Figure 7: Typical Filter locking system details (ref. [72])

Notes:

- *Steel Supporting structure and filter locking system are shown in black,*
- *Filter is shown in blue.*

The filters will be pinned at four connecting points. Positions of the holes (Ø 62 mm) on the filter pallet for the pinned connections shall be as shown on Figure 8.

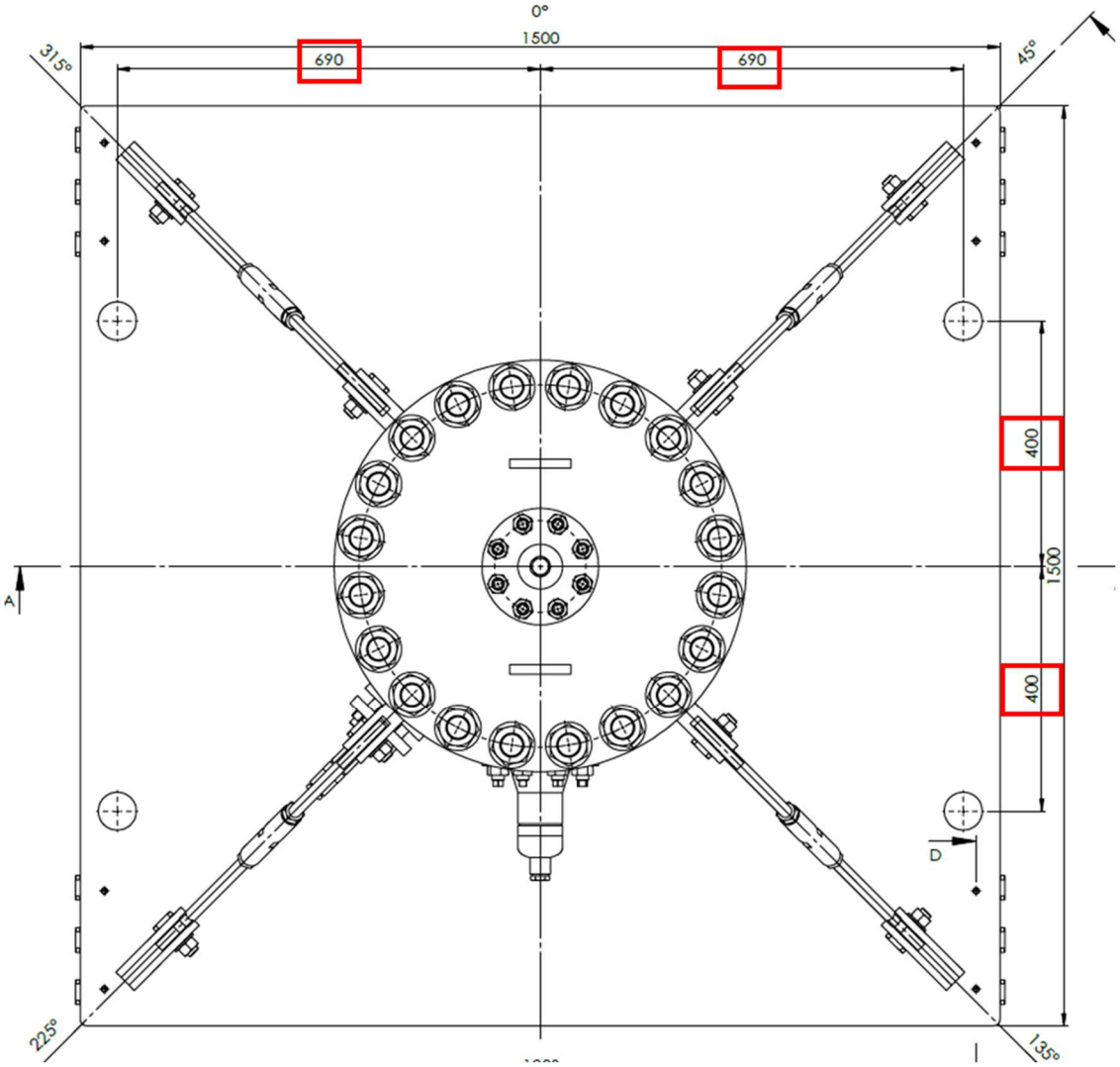

Figure 8: Interface dimensions for pinned connections

Appendix F – List of Deliverables

The Contractor shall issue the documents (for IO review) indicated in Table 17. The missing required time for completion expressed in weeks before or after the gate will be decided during the KOM.

Additional documents can be identified during the kick-off Meeting or during the project and will be included to the list presented in this appendix.

The documents are not specified to be relevant for one or several CVBD Filters. The information shall be indicated in the title and the metadata of the document if applicable to one or several CVBD Filters (example: drawings or stress reports).

The documents for the insulation are presented in a separately in Table 18 can be managed concomitantly with the CVBD Filters main project progress.

Table 17 – Applicable documents for CVBD Filters

IO Documentation ID		Documentation Planning Requirement	
Technical Design Family (TDF)	**Generic Document Title (GTD)**	**Gate/Stage - Approved Document**	**Weeks before (-) or after (+) the gate**
CONTRACT MANAGEMENT	Contract Management Plan	1.Kick off meeting	-2
CONTRACT MANAGEMENT	KOM Minutes	1.Kick off meeting	-2
CONTRACT MANAGEMENT	progress meeting minutes	1.Kick off meeting	-2
CONTRACT MANAGEMENT	Contract Schedule	1.Kick off meeting	-2
CONTRACT MANAGEMENT	Bank Guarantee	1.Kick off meeting	-2
CONTRACT MANAGEMENT	Quality Assurance Plan (QAP)	1.Kick off meeting	-2
CONTRACT MANAGEMENT	List of deliverables / Document schedule	1.Kick off meeting	-2
DESIGN	Design Verification and Validation Plan	2.Design review	
DESIGN	Thermal-Hydraulic calculation report	2.Design review	
DESIGN	3D models	2.Design review	
DESIGN	Drawings (assembly and components)	2.Design review	
DESIGN	Design calculation sheet	2.Design review	
DESIGN	Stress report (FEM analysis)	2.Design review	
DESIGN	Fatigue analysis	2.Design review	
DESIGN	Vibration analysis	2.Design review	
DESIGN	Software qualification	2.Design review	
DESIGN	Transport calculation	2.Design review	

SUPPLY

IO Documentation ID		Documentation Planning Requirement	
Technical Design Family (TDF)	**Generic Document Title (GTD)**	**Gate/Stage - Approved Document**	**Weeks before (-) or after (+) the gate**
DESIGN	Flanges calculation with EN1591-1	2.Design review	
PED/ESPN	Hazard and Risk Analysis	2.Design review	
PED/ESPN	Essential Safety Requirements Gap Analysis	2.Design review	
MATERIAL	Purchase Specification	3.Procurement review	
MATERIAL	Part list	3.Procurement review	
PED/ESPN	NPMA	3.Procurement review	
CONTRACT MANAGEMENT	MRR plan	4.Manufacturing Readiness Review	-2
INSTALLATION	Installation drawing	4.Manufacturing Readiness Review	
INSTALLATION	Installation manual	4.Manufacturing Readiness Review	
DESIGN	Drawings (manufacturing)	4.Manufacturing Readiness Review	
MANUFACTURING	Hydrostatic test procedure	4.Manufacturing Readiness Review	
MANUFACTURING	Cleanliness control procedure	4.Manufacturing Readiness Review	
MANUFACTURING	Leak test procedure	4.Manufacturing Readiness Review	
MANUFACTURING	Liquid penetrant procedure	4.Manufacturing Readiness Review	
MANUFACTURING	Manufacturing and Inspection Plan (MIP)	4.Manufacturing Readiness Review	
MANUFACTURING	Manufacturing Process	4.Manufacturing Readiness Review	
MANUFACTURING	Lifting test procedure	4.Manufacturing Readiness Review	
MANUFACTURING	Coating procedure	4.Manufacturing Readiness Review	
MANUFACTURING	Dimension inspection procedure	4.Manufacturing Readiness Review	
MANUFACTURING	Picking and passivation procedure	4.Manufacturing Readiness Review	
MANUFACTURING	Cleaning procedure	4.Manufacturing Readiness Review	
MANUFACTURING	Material management procedure	4.Manufacturing Readiness Review	
MANUFACTURING	Ultrasonic testing procedure	4.Manufacturing Readiness Review	
MANUFACTURING	Radiographic examination procedure	4.Manufacturing Readiness Review	
MANUFACTURING	Rolling and forming procedure	4.Manufacturing Readiness Review	
MANUFACTURING	Heat treatment procedure	4.Manufacturing Readiness Review	

SUPPLY

IO Documentation ID		Documentation Planning Requirement	
Technical Design Family (TDF)	**Generic Document Title (GTD)**	**Gate/Stage - Approved Document**	**Weeks before (-) or after (+) the gate**
MANUFACTURING	tooling list	4.Manufacturing Readiness Review	
MANUFACTURING	NDE operator list	4.Manufacturing Readiness Review	
MANUFACTURING	Visual examination procedure	4.Manufacturing Readiness Review	
MANUFACTURING	repair manufacturing procedure	4.Manufacturing Readiness Review	
MANUFACTURING	list of products in contact with the stainless steel	4.Manufacturing Readiness Review	
MANUFACTURING	Test Plan for Filter Element	4.Manufacturing Readiness Review	
MANUFACTURING	Qualification Test Procedure for Filter Element	4.Manufacturing Readiness Review	
MATERIAL	Material Certificates	4.Manufacturing Readiness Review	
MATERIAL	Gasket certificates	4.Manufacturing Readiness Review	
PED/ESPN	DNRE drawing	4.Manufacturing Readiness Review	
PED/ESPN	In-service inspection drawing	4.Manufacturing Readiness Review	
QUALITY	Quality assurance plan	4.Manufacturing Readiness Review	
QUALITY	Quality plan from sub-contractors	4.Manufacturing Readiness Review	
QUALITY	Qualified supplier list	4.Manufacturing Readiness Review	
QUALITY	PIA control procedure	4.Manufacturing Readiness Review	
QUALITY	Organization chart	4.Manufacturing Readiness Review	
WELDING	List of qualified welders	4.Manufacturing Readiness Review	
WELDING	welding data package (WPS and PQR)	4.Manufacturing Readiness Review	
WELDING	weld defect repairing procedure	4.Manufacturing Readiness Review	
WELDING	welding map	4.Manufacturing Readiness Review	
MANUFACTURING	test records – helium leak	5.FAT readiness review	
MANUFACTURING	test records - lifting test	5.FAT readiness review	
MANUFACTURING	test records - hydrostatic pressure test	5.FAT readiness review	
MANUFACTURING	test records - surface finish test	5.FAT readiness review	
MANUFACTURING	test records - dimensions and thicknesses	5.FAT readiness review	

SUPPLY

IO Documentation ID		Documentation Planning Requirement	
Technical Design Family (TDF)	**Generic Document Title (GTD)**	**Gate/Stage - Approved Document**	**Weeks before (-) or after (+) the gate**
MANUFACTURING	test records - test coupon weld inspection report	5.FAT readiness review	
MANUFACTURING	test records - UT	5.FAT readiness review	
MANUFACTURING	test records - PT	5.FAT readiness review	
MANUFACTURING	test records - RT	5.FAT readiness review	
MANUFACTURING	test records - VT	5.FAT readiness review	
MANUFACTURING	Qualification Test Report for Filter Element	5.FAT readiness review	
MANUFACTURING	Test records - welding check list	5.FAT readiness review	
MANUFACTURING	End of manufacturing Report (EOMR)	5.FAT readiness review	
MANUFACTURING	Drawings (as-built)	5.FAT readiness review	
PED/ESPN	ANB review reports (for information only)	5.FAT readiness review	
QUALITY	Verification Compliance Matrix	6.Delivery Readiness Review (DRR)	
PED/ESPN	Instruction Manual	6.Delivery Readiness Review (DRR)	
PED/ESPN	Declaration of Conformity of the Manufacturer	6.Delivery Readiness Review (DRR)	
PED/ESPN	Certificate of Conformity from ANB	6.Delivery Readiness Review (DRR)	
QUALITY	Closed NCR	6.Delivery Readiness Review (DRR)	
QUALITY	Closed Deviation requests	6.Delivery Readiness Review (DRR)	
QUALITY	Contract release note	6.Delivery Readiness Review (DRR)	
TRANSPORT	Transportation quality plan	6.Delivery Readiness Review (DRR)	
TRANSPORT	package and packing list	6.Delivery Readiness Review (DRR)	
TRANSPORT	delivery report	6.Delivery Readiness Review (DRR)	
START-UP, OPERATION AND MAINTENANCE	Recommended Spare Parts List	6.Delivery Readiness Review (DRR)	

SUPPLY

Table 18 – Applicable documents for CVBD Filters insulation

IO Documentation ID		Documentation Planning Requirement	
Technical Design Family (TDF)	**Generic Document Title (GTD)**	**Gate/Stage - Approved Document**	**Weeks before (-) or after (+) the gate**
DESIGN	Insulation calculation sheet	4.Manufacturing Readiness Review	
DESIGN	Analysis report for insulation support	4.Manufacturing Readiness Review	
QUALITY	Quality plan for insulation	4.Manufacturing Readiness Review	
MATERIAL	Procurement specification of insulation	4.Manufacturing Readiness Review	
DESIGN	Insulation drawings	4.Manufacturing Readiness Review	
MANUFACTURING	MIP for insulation	4.Manufacturing Readiness Review	
MANUFACTURING	Dimensions inspection procedure for insulation	4.Manufacturing Readiness Review	
MATERIAL	Insulation material certificates	4.Manufacturing Readiness Review	
MANUFACTURING	Insulation qualification procedure	4.Manufacturing Readiness Review	
MATERIAL	Part list for insulation	4.Manufacturing Readiness Review	
MANUFACTURING	Insulation qualification test reports	5.FAT readiness review	
MANUFACTURING	Dimensions inspection reports	5.FAT readiness review	
MANUFACTURING	Insulation as-built drawings	5.FAT readiness review	
INSTALLATION	Insulation installation manual	6.Delivery Readiness Review (DRR)	
MANUFACTURING	EOMR for insulation	6.Delivery Readiness Review (DRR)	
TRANSPORT	Transportation quality plan	6.Delivery Readiness Review (DRR)	
QUALITY	Closed NCR	6.Delivery Readiness Review (DRR)	
QUALITY	Closed Deviation requests	6.Delivery Readiness Review (DRR)	
QUALITY	Contract release note	6.Delivery Readiness Review (DRR)	
TRANSPORT	Delivery report	6.Delivery Readiness Review (DRR)	

Appendix G – List of system requirements applicable to the CVBD Filters

The TCWS SRD ref. [48] lists all the functional, design, safety, operational and quality requirements for the Tokamak Cooling Water System (TCWS).

The following system requirements are applicable to the CVBD Filters.

H-1 Functions, basic configuration, classification, and system boundaries

[26PHs586-R;Defined Requirement] The CVCS shall:

- Control the chemistry of cooling water provided to the IBED and NBI PHTSs
- Control the concentration of ACPs in the cooling water provided to the IBED and NBI PHTSs
- Control the volume of cooling water inside the IBED and NBI PHTSs during plasma and baking operations.

H-2 Design requirements

[26PHs1317-R;Defined Requirement] The TCWS shall be designed in accordance to its System Human Factor Requirements (SHFR) document [87] and recommendations from the suppliers.

[26PHs1355-R] ITER system elements within the Tokamak Complex (Tokamak Building, Diagnostics Building, and Tritium Plant Building) shall conform to the space envelope constraints and interface characteristics specified in the CAD assemblies, parts, and drawings in the CMM.

[26PHs1353-R;Defined Requirement] The TCWS shall be designed, operated, and maintained in compliance with the zoning requirements of the rooms/areas where its components are installed. The types of zonings to consider include: Ventilation, Radiological, Anti-deflagration, Beryllium, Magnetic, Radiofrequency, Fire, Waste. For the Tokamak Complex, the zonings are identified in the Safety requirement Roombook [42], ITER radiation maps [78], ITER Magnetic Maps [88]

[26PHs650-R] TCWS components in contact with cooling water provide primary confinement of radioactive inventories of tritium and ACPs. The TCWS shall facilitate leak detection and leak localization for TCWS components and client systems.

[26PHs321-R] CVCS: The CVCS provides purification of the coolant and volume control for IBED and NBI PHTSs. In accordance with the PCR-184, the provisions shall be made for water

chemistry (including ACP) monitoring in VV PHTS loops during the operation phase by sampling water from the VV PHTS for on-line and/or grab analysis. If deemed necessary during operation, a VV CVCS will be installed.

[26PHs1293-R] CVCS shall be located within the secondary confinement building boundary.

[26PHs355-R] The TCWS shall be designed to protect the SIC components against abnormal over-pressurization during the plasma power operation, standby, baking and idle operations.

[26PHs103-R;Defined Requirement] The TCWS equipment, piping and supports shall be designed for load conditions and various combined loads as specified in the TCWS *Load Specification [56]*, which shall consider in particular environmental conditions defined in:

- Load Specifications (LS) [96],
- Heat and Nuclear Load Specification [97],
- Radiation maps [78],
- Safety Requirement Roombook [42],
- Static and Transient Magnetic Field Maps in Tokamak building [98],
- Load Specification Annex - Internal Explosions: Hydrogen Deflagration in Tokamak Complex [99],
- Specific loads from interfacing Structures, Systems and Components, as defined in the applicable Interface Documentation.

[26PHs968-R] Classification of the TCWS Nuclear Pressure Equipment shall be in accordance with the requirements of the *French Order dated 30th December 2015 concerning Nuclear Pressure Equipment [3]*.

[26PHs115-R;Defined Requirement] The TCWS shall be designed to comply with the requirements provided in the *ITER Seismic Nuclear Safety Approach [89]*.

[26PHs597-R] The TCWS shall be designed to maintain SIC function during and after a SL-2 seismic event.

[26PHs973-R;Defined Requirement] Fire resistance material with no or low flammability shall be selected for TCWS to the extent practical.

[26PHs724-R] Electrical equipment and metallic structures susceptible to holding a fault current flow shall be earthed. The earthing conductors are interconnected to form the ITER Site Earthing Grid (ISEG). Earthing of equipment and structures shall follow the guidelines of *EDH Part 5: Earthing and Lightning Protection*, *[90]*.

[26PHs105-R] Insulation on piping and equipment shall be determined based on industrial practice to ensure industrial safety and also the relevant metallic protective shield shall be provided around insulation.

[26PHs568-R;Defined Requirement] Halogenated insulating materials shall be forbidden in areas served by the detritiation systems.

SUPPLY

[26PHs683-R;Defined Requirement] The design of TCWS shall accommodate nuclear shielding as to ensure that worker exposures to radiological and other hazards are ALARA during operation, maintenance, and repair.

[26PHs394-R;Defined Requirement] The TCWS cooling water chemistry shall be controlled within specified limits, as detailed in the paragraphs below, for all modes of operation with water filled loops including conditioning, plasma operation, baking, and hot and cold standby states. Chemistry control shall already be available during commissioning as required by the installed parts of TCWS.

Table 2.16.1: Cooling Water Chemistry Specification for Plasma Operation*

Parameter	VV PHTS**	IBED PHTS	NBI PHTS
Conductivity @25°C, µS/ cm	<=1.0	<= 0.2	<= 0.1
pH @25°C	6.5 - 8.0	7.0 - 9.0	6.5 - 7.5
Sodium, ppb	<= 25	<= 5	<= 5
Chloride, ppb	<= 25	<= 5	<= 5
Hydrogen***, ppb	-	<= 80	<= 60
Catalyzed Hydrazine****, ppb	-	<= 30	-
Ammonia****, ppb	<= 300	<= 1,000	-
Oxygen, ppb	<= 100	<= 10	<= 10
ORP @25°C, mV	Info	(-400) - (-100)	(-400) - (-100)
Iron*****, ppb	<= 12	<= 10	<= 10
Copper*****, ppb	<= 10	<= 13	<= 10

[26PHs570-I] * The water chemistry specifications given in this table are valid for plasma operation only. Specifications for baking operation will be established and refined on the basis of operational experience.

[26PHs639-I] *** The decision on the use of hydrogen for chemistry/radiolysis control is pending.

[26PHs1239-I] **** The use of controlling chemicals (ammonia, catalyzed hydrazine) is based on chemistry control needs.

[26PHs1240-I] ***** The iron and copper limits are tentative and subject to change.

[26PHs982-R] These limits shall be achieved and maintained with the use of equipment and controlling chemicals that are part of the CVCSs and/or PHTSs.

[26PHs405-R;Defined Requirement] The CVCS shall be designed for charging fresh resin and filter media as well as for transferring spent resin and filter media to Radwaste (PBS 66). The design of the TCWS CVCS shall take advantage of standard components and radioactive waste transfer equipment where possible, however, the design of standard waste transfer equipment is not within the scope of PBS 26. Specialized equipment, casks and/or other components needed to transfer fresh or spent resin and/or filter media shall be designed to conform to ALARA principles.

SUPPLY

[26PHs173-R;Defined Requirement] The main structural material for piping and equipment shall be austenitic stainless steel, with a grade appropriate for pressure and temperature of TCWS operation.

[26PHs1027-R;Defined Requirement] ESPN/ESP compliance for pressure equipment shall be assured in the TCWS design.

[26PHs573-R;Defined Requirement] Halogenated materials shall be forbidden in areas served by the detritiation systems. Exceptions must be approved by the Responsible Officer for PBS 32.

[26PHs1241-R;Defined Requirement] Ion exchange resins and filter media shall be compatible with nuclear environment. Their efficiency shall be maximized. Efficiency of filters is typically above 98% for particle size above 5μm.

[26PHs1242-R;Defined Requirement] In order to minimize cobalt isotopes, components shall use steels with a low cobalt impurity level when exposed to the neutron flux (for example, maximum cobalt impurity is specified at 0.05% for stainless steel inside Cryostat) in accordance with [53]. Reducing this content has no impact on the steel properties (particularly mechanical properties) and limits the formation of these cobalt isotopes.

[26PHs188-R] Manufacturing for the TCWS shall follow the INB order of 7th February 2012, the ESP/ESPN, and other appropriate codes and standards.

[26PHs1325-R] The limitations in size and weight of the components (including packages and frames) shall be as follows:

- Maximum length: 19 m with an exception for crane beams: 47 m on a single line
- Maximum width: 9 m
- Maximum height: 9.1 m
- Maximum weight: 600 t

[26PHs195-R] The TCWS shall be designed to allow assembly that is consistent with the ITER construction schedule, environmental constraints, and handling, and conserve its mechanical integrity.

[26PHs1243-R] The TCWS shall be designed to allow the maximum pre-assembly at the manufacturer site, thereby minimizing the assembly work at the ITER site.

[26PHs197-R] The TCWS shall be designed to allow installation that is consistent with the ITER construction schedule, environmental constraints, and handling, and conserve its mechanical integrity.

[26PHs1244-R] Sufficient space shall be provided around TCWS non-piping components (with the exception of piping) to permit safe and convenient access for assembly, installation, maintenance, and replacement while minimizing the need to remove other ITER plant equipment.

[26PHs199-R;Defined Requirement] Factory and final acceptance testing shall be specified for TCWS equipment based on relevant codes and standards.

[26PHs1228-R;Defined Requirement] All welded connections shall be inspected as required by the applicable codes and standards.

[26PHs1245-R] After completion of installation, each piping system, or subsystem within the TCWS shall be pressure tested, according to the applicable rules for pressure vessels under ESPN.

[26PHs1246-R] At intervals prescribed by ESPN, periodic in-service inspection of the TCWS shall be performed to ensure leak tight integrity of the pressure boundary components.

[26PHs985-R;Defined Requirement] Design option shall be selected for installations (such as smooth surfaces and exemption of retention zones, continuous welds, and sumps at low points) to facilitate decontamination processes.

[26PHs207-R] TCWS has the primary confinement function of the ACPs and tritium. To reduce the potential risk of releasing these radioactive or hazardous material during gas phase (drying or gas baking), a gas leak test shall be performed before commissioning.

[26PHs686-R;Defined Requirement] The total leak rate of TCWS shall meet the requirement specified in the PR document and in the Vacuum Handbook.

H-3 Safety design requirements

[26PHs509-R;Defined Requirement] The TCWS shall provide primary confinement for tritium and ACPs in the cooling water.

[26PHs500-R;Defined Requirement] SIC SSCs shall be designed to be protected from internal and external hazards to ensure adequate performance of their safety function. SIC systems and components shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods without losing the capability to perform their safety functions.

[26PHs501-R;Defined Requirement] The design of SIC SSCs shall include all loading events for which the component performs a safety function. This shall include, as necessary, the ageing effect of the environmental conditions and loads to which a SIC is exposed during its expected service life, followed by the incidental/accidental conditions and loads during/after which the SIC must perform its required safety function.

[26PHs502-R;Defined Requirement] SIC SSCs shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including pipe break accidents, in accordance with the safety requirements roombook [42]. These structures, systems, and components shall be appropriately protected against dynamic effects of high-energy fluids including the effects of

missiles, pipe whipping, and discharging fluids that may result from piping failures. However, such a protection of SIC SSCs may be excluded if an alternative approach shows that the piping failure hazard can be managed and mitigated effectively.

[26PHs503-R] The PHTSs and associated auxiliary, control, and protection systems shall be designed to ensure that the design conditions of the PHTS pressure boundary are not exceeded during any condition of normal operation.

[26PHs212-R;Defined Requirement] Tritium and ACP accumulation shall be limited.

[26PHs226-R] Testing and inspection of safety-related components shall be performed at a frequency that takes into account the expected failure rate of the component and subsystems.

[26PHs512-R] The inspection shall include components that affect the safety function.

[26PHs230-R;Defined Requirement] SICs shall be qualified for the seismic and environmental conditions under which they are required to perform.

[26PHs514-R;Defined Requirement] SIC systems and components shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed in accordance with the *Quality Requirements for IO Performers [49]*.

[26PHs1223-R] Moreover, TCWS Items shall comply with the *Quality Requirements for IO Performers [49]*.

[26PHs1036-R] A quality assurance program shall be established and implemented in order to provide adequate assurance that these structures, systems, and components will satisfactorily perform their safety functions.

[26PHs1037-R] Appropriate records of the design, fabrication, erection, and testing of structures, systems, and components important to safety shall be maintained by or under the control of the ITER licensee throughout the life of the plant.

[26PHs232-R;Defined Requirement] Safety-related operations and procedures shall be prescribed and shall meet safety requirements.

[26PHs1309-R;Defined Requirement] The design of the TCWS shall also consider the occupational safety requirement identified in HIRA analysis for TCWS [91].

[26PHs1038-R;Defined Requirement] The ALARA principle shall be considered in the system design in order to minimize radiological risks. To implement this,

- As a general principle:
    - The dose rate shall not exceed the target of 100 μSv/h in yellow radiological zones and 10 μSv/h in green radiological zones. For radiological zones close to the Tokamak: this dose rate is to be estimated up to 1E+06 s (about 12 days) after shutdown of the Tokamak Machine.

  - The dose rate in port cells (with the exception of the Neutral Beam injectors cell), with the bioshield plug in place, shall not exceed the target of 10 μSv/hr at 24 hours after shutdown of the Tokamak Machine.
  - In both cases, the dose rates are to be estimated at 30 cm from the nearest accessible surface, taking into account (as relevant) the surface contamination, airborne tritium and activated materials.
- Subsequently, the ALARA principles shall be applied to minimize occupational doses to workers (including both individual and collective doses).

[26PHs1039-R] System design shall take into account anticipated routine maintenance, inspection, and testing activities.

[26PHs1041-R;Defined Requirement] As a minimum, the following shall be considered in the design of the TCWS:

- Personnel exposure to radiation from ACPs and tritium which have permeated into and/or leaked from the water system.
- Radiation shielding of high dose rate components inside the TCWS vaults and pipe chases.
- Decisions regarding component placement must consider human access for inspection, testing, and maintenance activities.
- Allocation of adequate space for TCWS maintenance.
- Selection of CVCS decontamination factor and associated radiation dose rate during maintenance.
- Impact of spent resin transfers generated by CVCS operations on adjacent, accessible areas.

[26PHs1305-R;Defined Requirement] TCWS shall minimize its eventual releases of hydrogen (tritium, deuterium, protium, and/or mixtures of these isotopes) into areas/rooms, in order to ensure that (in integration with HVAC and other hydrogen contributors) the concentration of hydrogen in air in these areas/rooms does not exceed 1%, to stay below 1/4 of the inferior inflammability limit.

[26PHs520-R;Defined Requirement] The safety system shall be designed for high functional reliability and in-service testability commensurate with the safety functions to be performed.

H-4 Operation and Maintenance

26PHs474-R] The TCWS shall provide the capability to drain and dry (if necessary) client systems so that leak localization and maintenance can be performed.

[26PHs523-R] The system shall be designed for a minimum operational lifetime of not less than 20 years. ITER shall be designed for an active (D-T) phase lasting at least 14 years.

[26PHs705-R] TCWS components shall be designed in such a way as to reduce the time to detect, identify, locate, and repair any failure or sign of impending failure. To the extent possible,

components and subsystems shall be integrated in such a way that those requiring the most frequent maintenance shall be the most readily accessible.

[26PHs1052-I] Short-term maintenance provides corrective maintenance of TCWS components in case of malfunction or actuation resulting in the expenditure of consumable parts or replacement of highly contaminated filters and mixed bed ion exchanger in the CVCS.

[26PHs254-R] The frequency for changing filters shall be based on radiological protection and operational parameters.

[26PHs1310-R] ESP / ESPN classification regulatory periodic inspections (internal and external) could be necessary and shall be performed during major shutdowns. Maintenance plan shall also integrate regulatory periodic inspection requirements.

[26PHs691-R] Recommendation for spares provisioning shall be provided as a result of the RAMI analysis, both for scheduled and unscheduled maintenance, taking into account operating conditions.

[26PHs692-R] To minimize on-site inventory, it shall be recommended to make maximum use of off-the-shelf equipment and components.

[26PHs699-R] Any special tool and test equipment needed for maintenance of the system's equipment on site must be provided to the ITER Organization. Any such equipment, that would be additional to items delivered as manufacturing means, installation means, test and commissioning means shall be fully justified.

[26PHs700-R] Special pieces of equipment needed for packaging, handling, storage and transportation are also in the scope of the requirement. The supplier shall also state the degree of protection for any packaging equipment.

[26PHs248-R;Defined Requirement] The reliability, availability, maintainability, and inspectability (RAMI) requirements of TCWS shall be in compliance with the requirements specified in the PR document. The expected reliability and availability of TCWS should meet the requirement specified in the PR document. That is to say, to contribute to an overall availability target of 94.0% for the whole PBS 26, TCWS shall meet its availability target associated to its main function, "to cool and bake Tokamak components": 97.8% for both H phase and D-T phase.

[26PHs709-R] The warranty period shall also be used as a validation period for the reliability characteristics of the system equipment. Deviations from requirements will be identified and compensating/correcting actions identified and implemented.

[26PHs710-R;Defined Requirement] Maintainability characteristics shall be demonstrated by the supplier as part of the qualification process. Critical on-line controls or replacements will be realized during integrated commissioning. These demonstrations shall ensure accuracy of elapsed times and efficiency of support equipment needed for task performance.

H-5 Quality requirements

[26PHs266-R;Defined Requirement] The TCWS shall be designed, manufactured, and tested in compliance with the ITER *Quality Classification Determination* [55].

H-6 Applicable codes and standards

[26PHs1226-R;Defined Requirement] The design of the ITER Site and Buildings shall be in accordance with the following codes, standards and design criteria:

- Code and standards listed in the following sections
- French standards and rules applicable or affecting:
- Safety (nuclear and personnel safety)
- Fire prevention, fire detection and/or fire fighting
- Guidelines and rules for installations
- Applicable building codes
- The INB order of 7th February 2012
- European Directives.
- Codes, standards and design criteria mutually agreed between the ITER Organization and the Domestic Agencies during the execution of the design work.

If a code and/or standard has been already approved by the issuing body/authority and it shall be expected to become in force during the construction phase of ITER, the ITER Organization may decide to immediately apply the new code and/or standard version.

[26PHs271-R] Structural supports and attachments for TCWS components shall be designed in accordance with codes and standards which are used for ITER buildings (*ITER Structural Design Code for Buildings* [95]).

[26PHs273-R] Pressure equipment for the TCWS shall be designed in accordance with applicable requirements in the *Codes and Standards for ITER Mechanical Components [52]*. The referenced codes and standards also specify requirements for in-service inspection and quality.

[26PHs1216-R;Defined Requirement] The TCWS shall be designed in accordance with the requirements of ESP and ESPN.