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VERSION CREATED ON / VERSION / STATUS
29 Jul 2026 / 1.6 / Approved

EXTERNAL REFERENCE / VERSION

Technical Specifications (In-Cash Procurement)

Technical Specification for the Development, Manufacture, Qualification and Supply of the VVPSS Bleed Valve Assembly, thermal enclosures, trolley Frames and Main Frame

Specifies the technical requirements for the development, manufacture, qualification and supply of the Bleed Valve Assembly, thermal enclosures, trolley Frames and Main Frame including all accessories for the Vacuum Pressure Suppression System

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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) [R1] that constitutes a full part of the technical requirements.

In case of conflict, the content of the Technical Specification supersedes the content of GM3S[R1].

2 Purpose

The purpose of this document is to describe the technical requirements for the design, equipment qualification, manufacturing and delivery of the Bleed Valves Assembly and Support Frame for the Vacuum Vessel Pressure Suppression System.

2.1 Background

The pressure suppression system maintains the pressure rise below the design pressure of the ITER Vacuum Vessel in the case of an incidental/accidental event, such as the ingress of coolant or loss of vacuum from a failed in-vessel component. The Vacuum Vessel Pressure Suppression System (VVPSS) shall limit pressurisation of the vacuum vessel to a maximum of 0.15 MPa absolute.

The VVPSS is formed of a steam condensation system (known as the Vapour Suppression Tanks), a non-condensable gas scrubbing system (the Hydrogen Mitigation System, HMS) and two relief pipes that convey hot gas from the VV to one of the above systems. The smaller DN300 relief line is activated by the opening of valves within a Bleed Valve Assembly (BVA) and the larger DN500 relief line is activated when a bursting disc opens within a Rupture Disc Assembly (RDA).

Figure 1 below indicates the major components of the VVPSS.

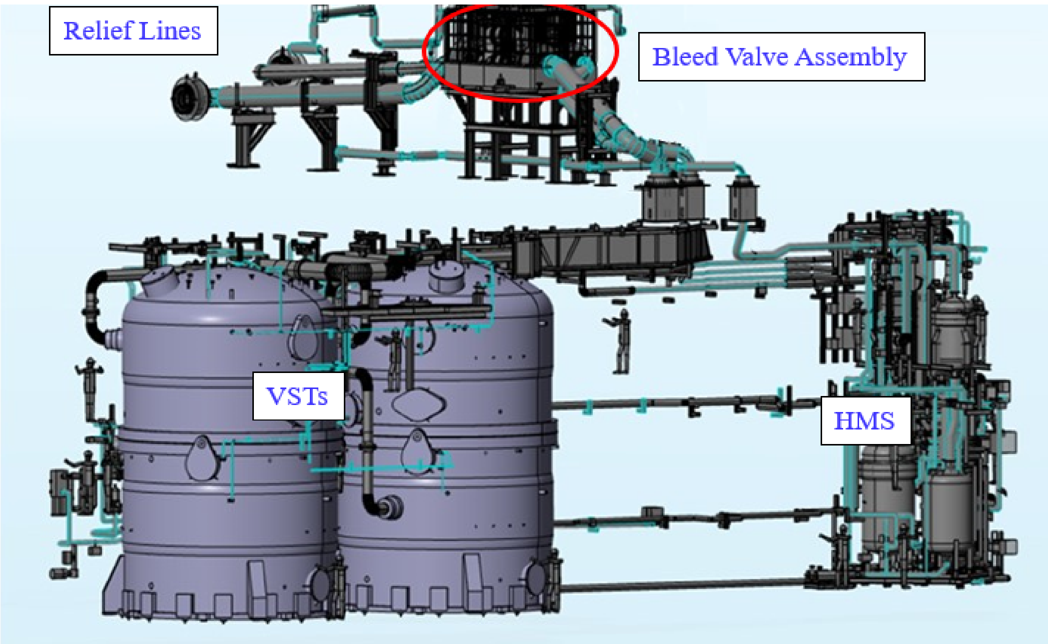

Figure 1 - Major components of the VVPSS with the BVA highlighted

The BVA is a device installed on the DN300 relief line that opens when the pressure within the VV reaches a threshold pressure, enabling the flow of gas from the VV into the VVPSS.

The BVA will be located within a high neutron and gamma radiation zone that necessitates full remote handling operations to perform maintenance activities. The BVA shall be designed to interface with the existing Remote Handling systems and facilitate remote installation and removal.

The ITER Organization (IO) has developed a preliminary design of the BVA based on the functional requirements and physical constraints of the environment in which it will be installed. A general arrangement of the principal parts of the preliminary design is shown in Figure 2.

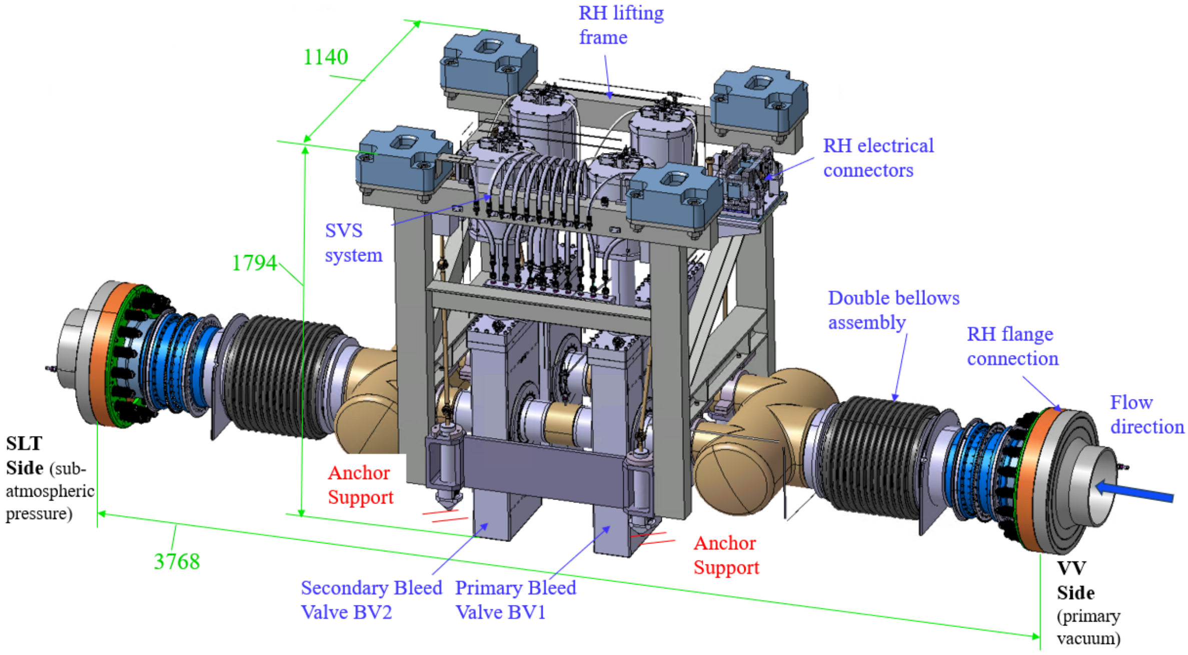

Figure 2-Preliminary VVPSS Bleed Valve Assembly (without housing or supports for clarity)

The principal components within the Bleed Valve Assembly are a set of Ultra-High Vacuum (UHV) gate valves. These gate valves, known as the Bleed Valves (BV), form the boundary of the vacuum chamber and undertake the safety function of opening to release excess pressure within the VV.

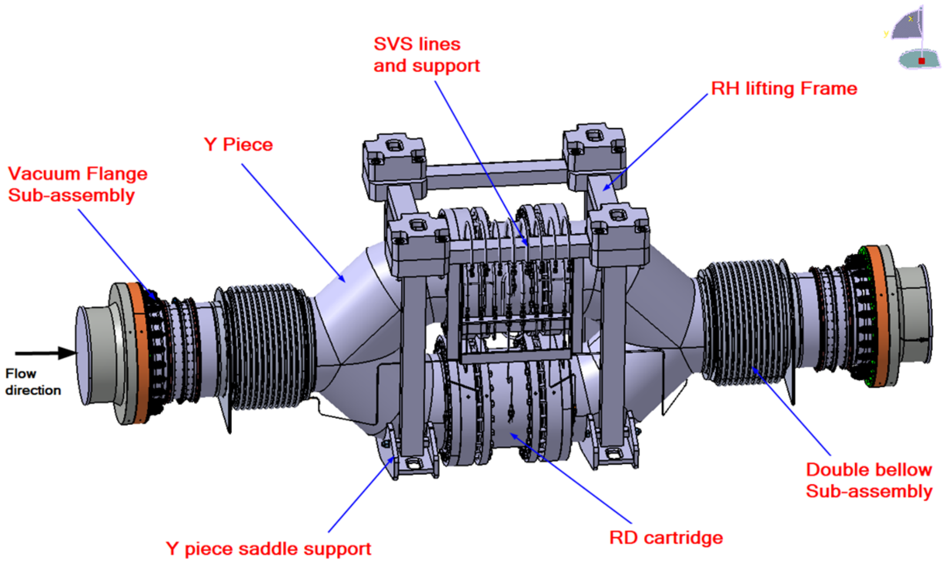

Figure 3- Preliminary VVPSS Rupture Disc Assembly (without housing or supports for clarity)

The RDA is a non-reclosing pressure relief device installed on one of the VVPSS relief lines that opens when the pressure within the VV reaches a threshold pressure, enabling the flow of gas from the VV into the VVPSS. The RDA and BVA will share the same Support Frame and are both equipped with a double-bellows and vacuum-flanges configuration. The RDA and BVA are designed to interface with the existing Remote Handling systems.

A general layout of the main components of the RDA design is provided in Figure 3.

The general assembly model of the RDA and BVA with trolley frames and thermal enclosures outside on the main support frame is shown in Figure 4.

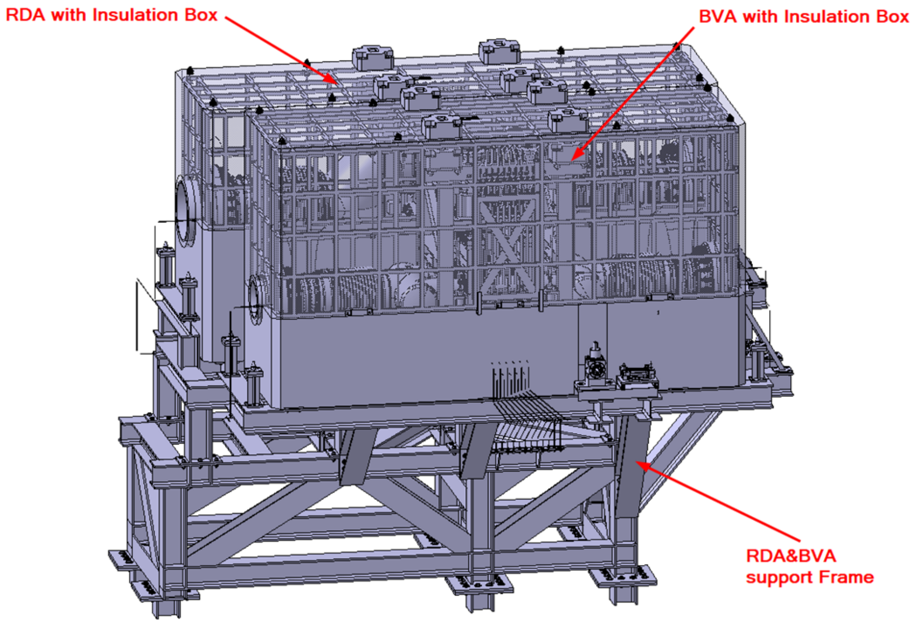

Figure 4- Assembly of all components included supported on the Main Frame

3 Acronyms & Definitions

3.1 Acronyms

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

Abbreviation	Description
ASME	American Society of Mechanical Engineers
ASNR	French Nuclear Safety Authority (from French l'Autorité de sûreté nucléaire et de radioprotection)
ASTM	American Society for Testing and Materials
BDBA	Beyond Design Basis Accident
BVA	Bleed Valve Assembly
CAD	Computer Aided Design
CRN	Contractor Release Note
CRO	Contract Responsible Officer
CSFI	Counterfeit, Suspect and Fraudulent item
DN	Nominal Diameter
DR	Deviation Request
DTR	Drain Tank Room
EN	European Norm
ESPN	Équipement Sous Pression Nucléaire (Nuclear Pressure Equipment)
FAT	Factory Acceptance Test
FEA	Finite Element Analysis
FRS	Floor Response Spectra
GM3S	General Management Specification for Service and Supply

HSCC	Hardened Safety Core Component
HP	Hold Point
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
ITER	International Thermonuclear Experimental Reactor
IO	ITER Organization
LOCA	Loss of Coolant Accident
LOVA	Loss of Vacuum Event
MIP	Manufacturing & Inspection Plan
MTO	Material Take Off
NB	Notified Body
NB Cell	Neutral Beam Cell
NCR	Nonconformity Report
NDE	Non-Destruction Examination
PED	Pressure Equipment Directive
PIA	Protection Important Activity
PIC	Protection Important Component
PIE	Postulated Initiating Event
PMUC	Label of products approved for use nuclear power plants
PNI	Part Number of ITER
PRO	Procurement Responsible Officer
PS	Maximum Allowable Pressure
QC1	Quality Class 1
QP	Quality Plan
RDA	Rupture Disc Assembly
RH	Remote Handling
SL-1	Seismic Level 1 – Defined by ITER for investment protection
SL-2	Seismic Level 2 – equivalent to Safe Shutdown Earthquake
SL-3	SL-3 or SND Seismic Noyau Dur
SMHV	Séismes Maximaux Historiquement Vraisemblables = Maximum Historically Probable Earthquake
SRSS	Square Root of the Sum of the Squares
SVS	Service Vacuum System
TIB	Thermal Insulation Box
TRO	Technical Responsible Officer
TC2A	Tritium Class 2A
VQC	Vacuum Quality Class
VST	Vapour Suppression Tank
VV	Vacuum Vessel
VVPSS	Vacuum Vessel Pressure Suppression System
VVICE	Vacuum Vessel Ingress of Coolant Event
WPS	Welding Procedure Specification
WPQR	Welding Procedure Qualification Record

3.2 Definitions

Term / acronym	Definition
Contractor	An economic operator who has signed the Contract in which this document is referenced

4 Applicable Documents & Codes and standards

4.1 Applicable Documents

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

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

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

Ref	Title	IDM Doc ID	Version
[R1]	General Management Specification for Service and Supply (GM3S)	82MXQK	1.4
[R2]	ITER Quality Classification Determination	24VQES	7.1
[R3]	Safety requirement Roombook	KF63PB	2.17
[R4]	ITER Vacuum Handbook	2EZ9UM	2.5
[R5]	ITER Quality Assurance Program	22K4QX	9.3
[R6]	ITER Hard Core Components – Summary Report	PQR228	1.1
[R7]	Loads Specifications (LS)	222QGL	6.3
[R8]	Codes and Standards for ITER Mechanical Components	25EW4K	5.0
[R9]	Quality Requirements for IO Performers	22MFG4	6.4
[R10]	Work Instruction for Producing of the Manufacturing and Inspection Plan	UKQG8M	1.7
[R11]	Inspection Plan (IP) Template	QV7GQF	1.3
[R12]	Provisions for Implementation of the Generic Safety Requirements by the External Actors/Interveners	SBSTBM	2.3
[R13]	PBS 24 VVPSS for Defined Requirements	Q9DVN3	2.1
[R14]	List of ITER-INB Protections Important Activities	PSTTZL	2.2
[R15]	Procedure for the management of Deviation Request	2LZJHB	8.1
[R16]	Procedure for management of Nonconformities	22F53X	9.1
[R17]	Procedure for Identification and Controls of Items	U344WG	2.2
[R18]	Delivery Report Template	WZPYVZ	3.0
[R19]	Working Instruction for the Delivery Readiness Review	X3NEGB	3.0
[R20]	Procedure for Reception of Components at the ITER Site	RXCTBZ	3.2
[R21]	Procedure for Transportation of Components to IO Site	RY5C6Q	3.1
[R22]	Template - Equipment Storage & Preservation Requirements Form	WU9636	4.3
[R23]	Package & Packing List Template	XBZLNG	2.2
[R24]	Procedure for Labelling on Physical Items	VYJ7U2	1.4
[R25]	Release Note Template	QVEKNQ	3.1

[R26]	Allowable values and limits in Service level C and D for ITER mechanical components	3G3SYJ	3.1
[R27]	Loads Case Specification VVPSS -RL	UXX829	2.7
[R28]	Report on Stress Analysis of VVPSS Relief Lines	YWLH59	1.2
[R29]	Technical note - update of the VVPSS Relief Line piping analysis	8R9Z9Y	1.0
[R30]	Stress Test Detailed Methodology for Hard Core Components of ITER Plant	R5389R	2.1
[R31]	Technical Specification strategic agreement of the supply of Spring Energised Metallic Seals for ITER vacuum systems	2LKJ2E	3.4
[R32]	Vacuum Handbook Appendix 3 Materials	27Y4QC	1.20
[R33]	Vacuum Handbook Appendix 4 Accepted Fluids	2ELN8N	1.14
[R34]	Vacuum Handbook Appendix 8 Demountable Vacuum Flanges for use on the ITER Projects	2DJYQA	2.7
[R35]	Vacuum Handbook Appendix 12 Leak Testing	2EYZ5F	1.4
[R36]	Vacuum Handbook Appendix 15 Vacuum Baking	2DU65F	1.3
[R37]	ITER Vacuum Handbook Attachment 1 - Welding	2FMM4B	1.5
[R38]	ITER Remote Handling Code of Practice	2E7BC5	1.2
[R39]	Bellows Design Report for DN 300	C8UULR	1.1
[R40]	Vacuum Flange Analysis Report	C9MEH5	1.4
[R41]	Design Seismic Floor Response Spectra in the Tokamak Complex	SVBRJZ	1.1
[R42]	SL-3 Floor Response Spectra for Tokamak Complex	SFSN7Q	1.1
[R43]	Qualification of Protection Important Components (PIC)	XB5ABP	2.1
[R44]	Guidelines for Qualification of Mechanical Equipment	ADCXXD	1.0
[R45]	Guidelines for Qualification by Analysis	AKFUMQ	1.2
[R46]	Guideline for Structural Integrity Report	35QTKD	2.1
[R47]	Procedure for Analyses and Calculations	22MAL7	6.8
[R48]	Instructions for Structural Analyses	35BVV3	4.1
[R49]	Instructions for Seismic Analyses	VT29D6	2.1
[R50]	Template for Qualification Plan	B9HR4D	1.0
[R51]	Template for Structural Integrity Report	4GDQM6	1.1
[R52]	Template for Seismic Analysis Reports	VAET99	1.0
[R53]	Project Requirements (PR)	27ZRW8	7.1
[R54]	Qualification Plan PBS-31 All Metal Valves Types 1,2,4,5 & 6	UP2K8Y	4.1
[R55]	Qualification guidelines for thermal ageing	BY279M	1.0
[R56]	IS-23-24.VP-002 Interface between Bleed Line Valve Assembly and RH System	LZU7Q6	2.6
[R57]	INT_DRW_CRANE_ALIGNMENT_MARKER	CR7EHC	Rev.B
[R58]	IS-23-24.VP-001 Interface between Rupture Disc Assembly and RH System	LZNFH5	2.6
[R59]	Installation Sequence and EWP Planning for PBS24 VVPSS Components in NB-Cell	CBR6XY	1.0
[R60]	Technical specification for Coating and Tagging	S9YVVG	1.0

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.

Ref	Title	Doc Ref.	Version
[CS1]	ASME BPVC.VIII.2-2025. Division 2. Alternative Rules		2023 Ed.
[CS2]	Order dated 7 February 2012 relating to the general technical regulations applicable to INB - EN	7M2YKF	1.7
[CS3]	Standards of the Expansion Joint Manufactures Association, Inc.	EJMA	10th Ed., 2023
[CS4]	RCC-M Section VI Design and Construction Rules for Mechanical Components of PWR Nuclear Islands, Volume Q Qualification of Active Mechanical Equipment (Pumps and Valves) Requirements Qualification to Accident Conditions		2022 Ed.
[CS5]	ASME B31.3 Process Piping		2020 Ed.
[CS6]	ASME B&PV Code Section II, Materials, Part A		2023 Ed.
[CS7]	ASME B&PV Code Section II, Materials, Part D Properties (metric)		2023 Ed.
[CS8]	ASME B&PV Code Section V, Nondectructive Examination		2023 Ed.
[CS9]	ASME Section IX Welding, Brazing and Fusing Qualifications		2019 Ed.
[CS10]	ASME B36.19 Stainless Steel Pipe		2004 Ed.
[CS11]	ASME B16.25 Buttwelding Ends		2012 Ed.
[CS12]	ASME NQA-1 Quality Assurance Requirements for Nuclear Facility Applications, (Subpart 2.1, Class B for internal surfaces; Class C for external surfaces; Level D for packaging)		2022 Ed.
[CS13]	ASTM A240/A240M Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications		2022 Ed.
[CS14]	ASTM A312/A312M Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes		2022 Ed.
[CS15]	ASTM A380/A380M Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems		2017 Ed.
[CS16]	ASTM A453/A453M Standard Specification for High-Temperature Bolting, with Expansion Coefficients Comparable to Austenitic Stainless Steels		2017 Ed.
[CS17]	ASTM B308/B308M Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles		2020 Ed.
[CS18]	ASTM ANS/ISO 17025-2005 General Requirements for the Competence of Testing and Calibration Laboratories		2005 Ed.
[CS19]	ISO 9001 Quality management systems — Requirements		2015
[CS20]	ISO 17025 General requirements for the competence of testing and calibration laboratories		2017
[CS21]	EN 10204 Metallic products - Types of inspection documents		2004 Ed.
[CS22]	EN 10168 Steel Products – Inspection documents – List of information and description		2004 Ed.
[CS23]	ISO 9712 Non-destructive testing - Qualification and certification of NDT personnel		2021 Ed.

[CS24]	ISO 21920 Geometrical product specifications (GPS) – Surface texture: Profile – Part 1: Indication of surface texture		2020 Ed.
[CS25]	ASME B46.1 Surface Texture (Surface Roughness, Waviness, and Lay)		2019 Ed.
[CS26]	ISO 2768-1 General Tolerances for linear and angular dimensions. The precision here is defined as fine, medium, coarse, and very coarse.		1989
[CS27]	ISO 2768-2 Geometrical tolerances for features Precision levels or tolerance classes here are H, K, and L.		1989
[CS28]	ISO 286 Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 1: Basis of tolerances, deviations and fits		2010
[CS29]	ISO 13920 Welding — General tolerances for welded constructions — Dimensions for lengths and angles, shape and position		2023
[CS30]	IEC 60068 Environmental testing - Part 3-3: Supporting documentation and guidance – Seismic test methods for equipment		2019
[CS31]	ANSI/AISC N690-18 Specification for safety-related steel structures for nuclear facilities		2018
[CS32]	AISC-360 2016 Specification for Structural Steel Buildings Supersedes the Specification for Structural Steel Buildings		2016

5 Scope of Work

This section defines the specific scope of work, in addition to the contract execution requirements as defined in GM3S[R1].

This Technical Specification defines the technical requirements for the material grades, stress assessment, fabrication, inspection, examination, testing and qualification, quality assurance (QA), cleaning, preservation, packaging, storage, delivery, and other requirements to deliver BVA, trolley frames, insulation boxes and the main Support Frame. Above all other requirements of this technical specification, the Contractor is responsible for all necessary design development, qualification and manufacturing activities that ultimately enable the delivery of the VVPSS Bleed Valve Assembly, the Support Frame and Trolley Frames, the Thermal Insulation Boxes and associated components that have been demonstrated to fulfil all the applicable requirements.

The Contractor shall develop the final component design using the CATIA software to deliver a 3D model with a significant level of detail to enable manufacturing and installation. The IO has developed 3D models and preliminary drawings as input to the contractor and has performed structural analyses of the BVA and its support structure, including thermal enclosure. The IO BVA design is the preliminary design elaborated by the IO in compliance with the ITER project and VVPSS system defined requirements.

The contractor shall perform the assembly and testing of all the components in this scope of supply within a 50km radius of the IO site, with a strong preference for the work to be performed within the IO site.

The Contractor shall perform the following activities:

- Develop the detailed design;
- Perform structural integrity analyses and seismic assessments of components not already fully designed;
- Manufacture of the components;

- Design and manufacture two bellows Assembly Clamps;
- Design and manufacture auxiliary systems (SVS line, electrical connectors, air supply line, cable and cable trays);
- Perform testing and qualification activities;
- Packaging and delivering the components;
- Pre-assembly at IO Site.

It shall be noted that IO has developed the design and built full-scale prototypes of the key components that make up the Bleed Valve Assembly. The contractor shall use these designs in their supply of the final Bleed Valve Assembly. Any necessary deviation from the already produced designs shall be justified and agreed by IO prior to their implementation.

6 Scope of Supply

The components in the scope of supply are listed below:

1) Bleed valve assembly with Lifting Frame
2) BVA Trolley Frame
3) RDA Trolley Frame
4) BVA thermal insulation box (including all the connections and insulation material)
5) RDA thermal insulation box (including all the connections and insulation material)
6) Main Support Frame (including all the fasteners, small tubing connections)

Refer to the picture below, which presents a 3D model of each component.

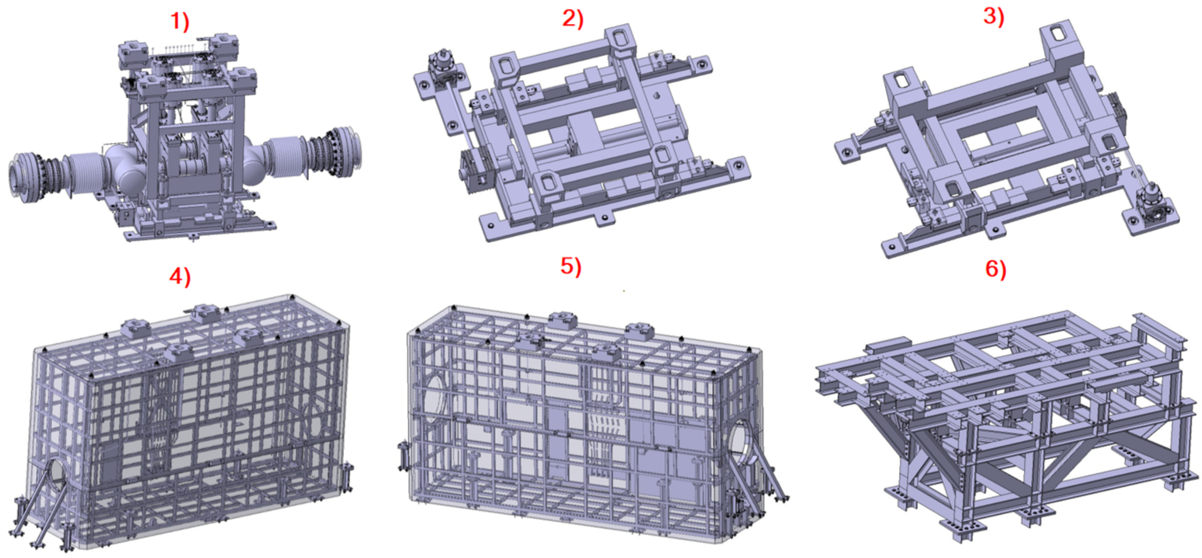

Figure 5-3D model of each component in the scope of supply including Bleed Valves for clarity

7 Free issue items

The following components are excluded from the scope of supply, and they will be free issued to the contractor for this scope of work.

- Four VAT Type 6 UHV Gate Valves (the Bleed valves)
- The Rupture Disc Assembly prototype (available end-2027)
- The DN300 bellow compression Tool prototype

These components are planned to be delivered to IO site, and IO will coordinate with the contractors for these components to meet the pre-assembly schedule.

8 Location for Scope of Work Execution

Except the Bleed valve assembly, the other five components as listed in Figure 5 can be manufactured, pre-assembly, and tested partially or entirely according to the assembly plan of the contractor at the contractor's premises. The assembly of the bleed valves and the final pre-assembly of the 6 components together shall be performed on either the ITER site or within a 50km radius of the IO site .

It is preferable that the contractor has a workshop on ITER site to perform the site pre-assembly and test activities, if the work is to be performed in an area managed by CMA, according to GM3S, the General Management Specification for Executing Entities at the ITER Site (YX55YY) shall be followed for the onsite activity.

9 Design Requirements

9.1 Room Classification

The VVPSS BVA is located in NB Cell. In accordance with the Safety requirement Roombook [R3] the following requirements are specified in Table 1 for NB Cell:

Room Tag	Confinement zone for accidental events	Internal Fire event ΔP(Pa)	Leak rate max at 300 Pa (vol/day)	NB Cell internal explosion (Hydrogen-dust explosion in VV)	Dynamic confinement of Tritium	Fire sectorisation
11-L1-CNB	NB Cell	+-5000	0.055	P=200000 Pa T=345°C	PIC/SIC-1	11-FS-05

Table 1. NB Cell room classification

9.2 Component Classification

The classification of VVPSS relief piping system is defined in the Load Case Specification VVPSS-RL[R27]. The classification of the components is given in Table 2:

Component	PIC/ Safety Class	Quality Class	PED Class	ESPN Class	Seismic Class	Vacuum Class	Tritium Class	RH Class
Upstream of Primary BVs	PIC/ SIC-1	QC1	N/A	N/A	SC1	VQC-1A	TC 2A	Class 1
Downstream of Primary BVs	PIC/ SIC-1	QC1	N/A	N/A	SC1	VQC-3A	TC 2A	Class 1
Upper insulation BOX (RDA and BVA)	PIC/ SIC-1	QC1	N/A	N/A	SC1	N/A	N/A	Class 1
Lower insulation BOX (RDA and BVA)	PIC/ SIC-1	QC1	N/A	N/A	SC1	N/A	N/A	Class 3*
Trolley Frame (RDA and BVA)	PIC/ SIC-1	QC1	N/A	N/A	SC1	N/A	N/A	Class 3
Main Support Frame	PIC/ SIC-1	QC1	N/A	N/A	SC1	N/A	N/A	N/A

* Not all the assemblies of Lower TIB are RH class 3. RH Class 3 items are defined in Section 8.17.

Table 2. Classification of the BV Assembly

9.3 Hardened Safety Core Component

The VVPSS Relief Pipes and RDA are qualified as Hardened Safety Core Components (HSCC) in Section 5.7.2 of the ITER Hard Core Components – Summary Report[R6]. As a part of the VVPSS relief pipe system, the BVA confinement is also defined as HSCC. In line with requirements of [R6], the seismic qualification of the ITER HSCC components shall be performed for the SL3 seismic event additionally.

It is important to note that the bleed valves are stated to be qualified for confinement purposes only; specifically, they are required to retain integrity under the SL-3 scenario, as defined in the ITER HARD CORE COMPONENTS – SUMMARY REPORT, Section 5.7.2 [R6]. Consequently, only structural integrity needs to be demonstrated for SL-3 seismic conditions.

The Thermal Insulation Boxes, Trolley Frames and the Main Frame are also required to be designed and qualified to SL-3 Seismic for structural integrity.

9.4 Design Codes and Standards

The BVA and Trolley Frames shall be designed and manufactured in accordance with the ASME VIII Div.2 standards [CS1].

The Thermal Insulation Box, the main Support Frame and connections shall be designed and manufactured according to AISC N690[CS31] and AISC 360 standards [CS32].

The interfacing relief pipes were designed in accordance with the ASME B31.3 Process Piping[CS5]. Bellows and piping components of the BVA shall be in accordance with the EJMA standard [CS3] and the ASME B31.3 code[CS5], respectively.

Qualification of mechanical equipment shall demonstrate the nuclear safety functions in compliance with the RCC-M Section VI, Volume Q - Qualification of Mechanical Equipment[CS4].

The Contractor may propose alternative design codes where it believes adequate justification may be made. The alternative codes shall be agreed with the IO.

The design features not specifically addressed in this specification, and codes and standards specified herein, shall be performed in accordance with the Codes and Standards for ITER Mechanical Components [R8] and good engineering practice.

9.5 Principal Design Parameters

- BVA interfacing process pipe size: DN300, Schedule 80S
- RDA interfacing process pipe size: DN500, Schedule 80S
- Max. design temperature: 250°C
- Min. design temperature: 0°C
- Normal operating temperature: 35°C
- Baking operating temperature: 180°C
- Maximum Allowable Pressure (PS): 0.5 bar(g)
- Min. design pressure: full vacuum (~1x10^{-5} Pa)
- Normal operating pressure between the primary and secondary BVs: 30-50 Pa(a)
- Normal operating downstream pressure of the secondary BV2: 6 - 10 kPa(a)
- Abnormal operating downstream pressure of the Secondary BV2: 100 kPa(a)
- Maximum differential pressure across a closed BV: 200 kPa
- Differential pressure across the BV at opening: <100 kPa
- Process fluid: steam, air or air-steam mixture with up to 5%v/v hydrogen and low concentration of tungsten dust (average particle 2.1µm)

9.5.1 Pressure Withstand Capability

Regardless of the above defined maximum design pressure, the BVA components shall have the following pressure withstands:

- Process pressure boundary of the BV: 250 kPa (damage to the internal bellows is permitted during this event, but the pressure boundary shall retain its structural integrity)

- The BVA shall be designed to exclude deformation and collapse due to full vacuum conditions inside the BVA (0 Pa) and an external pressure of 200 kPa(a) outside the BVA.

9.6 Equipment Integration

The BVA will be installed into the Neutral Beam Cell (NBC) on Level 1 of the Tokamak Building. The NBC is a highly congested area with large quantities of equipment. The hostile radiological conditions require maintenance by Remote Handling (RH) equipment and systems.

The BVA shall be designed so that it is well integrated into the NBC without impacting the surrounding equipment and enabling all remote operations.

Figure 6 give dimensions of the envelope into which the BVA will be installed.

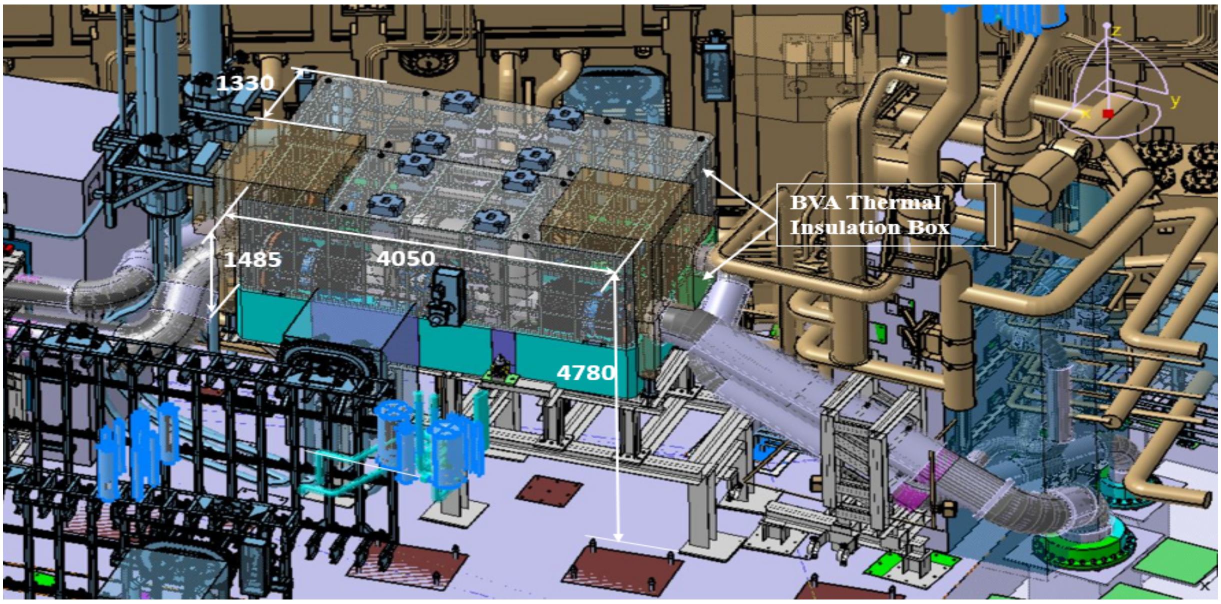

Figure 6– BVA and wider NBC Environment

In order to ensure integration with the RH system and the constraints of the NBC area, the maximum vertical height of the RDA and Thermal enclosure is 1800mm, as seen in the Figure 7 below.

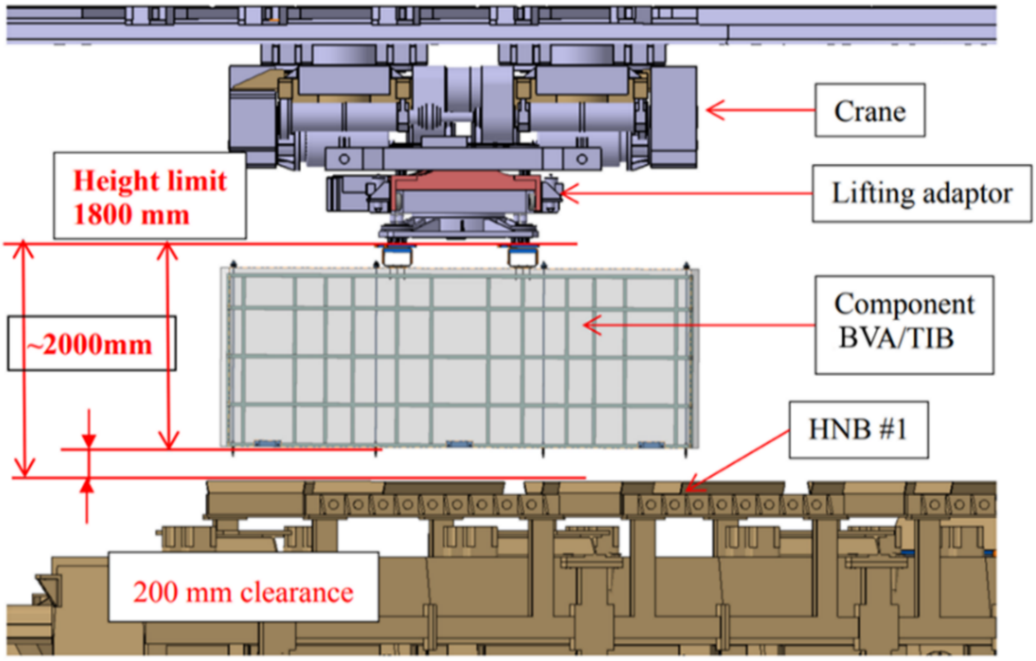

Figure 7– RH Lifting Arrangement & Constraints

9.6.1 Bleed Valve Integration

The Bleed Valves will be part of the larger Bleed Valve Assembly, which has constrained dimensions to enable Remote Maintenance. The BVs shall be capable of being installed into the BVA without increasing its dimensions. The BV dimensions are presented in Figure 5.

9.7 Design Life

All the components shall have a design life of at least 25 years.

The BV shall be operable (in-service) without need of maintenance for a period of at least 3 years in service. The above in-service period could be subject to a maximum of 60 baking and pressure cycles.

10 BVA Description and Specific Requirements

The BVA includes two parallel sets of Bleed Valves, each set formed of an upstream primary-vacuum facing valve and a secondary valve in series. The secondary valve provides a stable and controlled downstream pressure for the primary valve to ensure predictable vacuum rate.

To compensate for the interfacing piping displacements created by thermal expansion, seismic and other loads to the system, the BVA is equipped with a double bellows sub-assembly located on the upstream side of the primary BVs and downstream side of the secondary BVs. Bellows are identified as vulnerable components and as such shall be provided with double containment, hence the need for an inner (process facing) bellow and an outer (secondary confinement) bellow.

The interface between the BVA and the connecting DN300 pipework is a set of remotely handled high-vacuum flanges with double metal seals that enable the remote bolting and unbolting. One side of the flange includes two guide rails and a circular rack gear to enable installation and operation of the remote handling flange bolting tools.

The bellows sub-assemblies are equipped with interface features that enable a bellows compression mechanism to axially retract the vacuum flanges by 75-100mm. This retraction provides a gap between the flange faces to enable the insertion of remote handling closure plates and facilitate removal of the BVA by remote-operated overhead crane.

The BVA has a number of pumped interspaces to provide monitoring of the leak tightness of the BVA. These interspaces are connected to the ITER Service Vacuum System (SVS). All SVS monitoring capillaries are collected on the SVS connectors support frame attached to the BVA body. The connections to the SVS can be remotely connected and disconnected to enable remote removal of the BVA.

The design shall make possible replacement of the BVA in the relief line using remote handling tools. No in-situ disassembly of the BVA is foreseen. Information concerning remote handling maintenance and tools to apply will be provided by the IO at the contract's Kick-off meeting.

The BVA shall be equipped with a RH compatible lifting frame for lifting and transportation in both vertical and horizontal positions. The supports and lugs shall be designed and stress calculated in line with the requirements specified in the Load Case Specification VVPSS-RL[R27]. The BVA is covered by a RH compatible thermal insulation enclosure, which ensures a stable operating temperature and protects the component from fire. The BVA assembly shall be designed in compliance with the RH system requirements presented in the IS-23-24.VP-002 Interface between Bleed Line Valve Assembly and RH System[R56].

The maximum dimensions of the BVA are presented in Figure 2.

3D models and other design information developed for and by IO will be provided to the Contractor following contract award.

10.1 Bleed Valve Description

The Bleed Valves are procured by IO directly from the supplier and will be delivered on site during 2027. The Bleed Valve design is the ITER Type 6 All-Metal Gate Ultra-High Vacuum Valve (UHV) with extended pneumatic actuator and dust protection features. The UHV valve Type 6 has been developed, manufactured and tested by VAT.

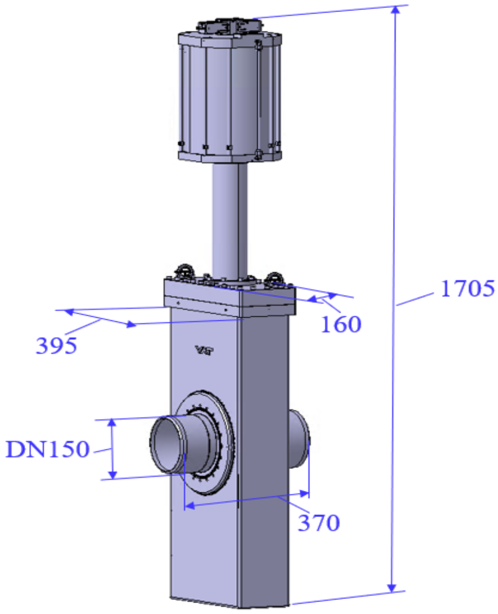

Figure 8- ITER Type 6 All-Metal Gate Ultra-High Vacuum Valve

The DN200 Type 6 valve, equipped with DN150 weld stubs of SCH40, is integrated in the preliminary design of the BVA, which has constrained dimensions to enable Remote Maintenance (see Figure 5). The dust protection features are designed to protect the valve seat seal and internals from dust contamination during LOCA event in the VV, when the dusty steam flow passes through the valve from the VV to the SLT tank.

The BV shall be capable of being installed into the BVA without increasing its dimensions.

The critical performance requirements for the BVA are the following:

Function	Criteria
Confinement of radioactivity	BVA tolerates the loads and displacements as defined in[R28], [R29]
Relief of pressure	The Bleed Valves shall enable a flow of 2 kg/s of steam @ 1.1 bar(a) & 250°C with a target pressure drop of 10 kPa or less
Vacuum sealing	Leak rate into the primary vacuum (volume upstream of the Primary BV) less than $1x10^{-10}$ Pa.m³/s @ 1 bar DP. Bleed Valves shall be periodically baked at 180°C.

The detail technical data of the ITER Type 6 All-Metal Gate Ultra-High Vacuum Valve are presented on the following link: https://www.vatgroup.com/series/uhv-all-metal-gate-valve-2/48146-RE24-ASG1.

The IO will procure the BVs and delivery to the IO site for assembly.

10.2 Vacuum Requirements

As a component that interfaces with the primary vacuum of the ITER Tokamak, the BVA shall comply with the ITER Vacuum Handbook[R4], Appendices[R32], [R33], [R34], [R35], [R36], and Attachment[R37].

VQC-1A components that are considered to be vulnerable shall be doubly vacuum contained with a monitored interspace connected to the Service Vacuum System (SVS).

10.3 Remote Handled Vacuum Flanges

The BVA assembly contains the specific ITER-style RH high vacuum flanges located on both sides of the BVA, as shown in Figure 2. The ITER style flanges have been qualified with the HELICOFLEX circular spring energised metallic double seals [R31] developed for the ITER UHV application. The vacuum flange connection contains fixed and rotated flanges, and metallic (silver) jacketed HELICOFLEX. The design of the vacuum flange connection is presented in Figure 9.

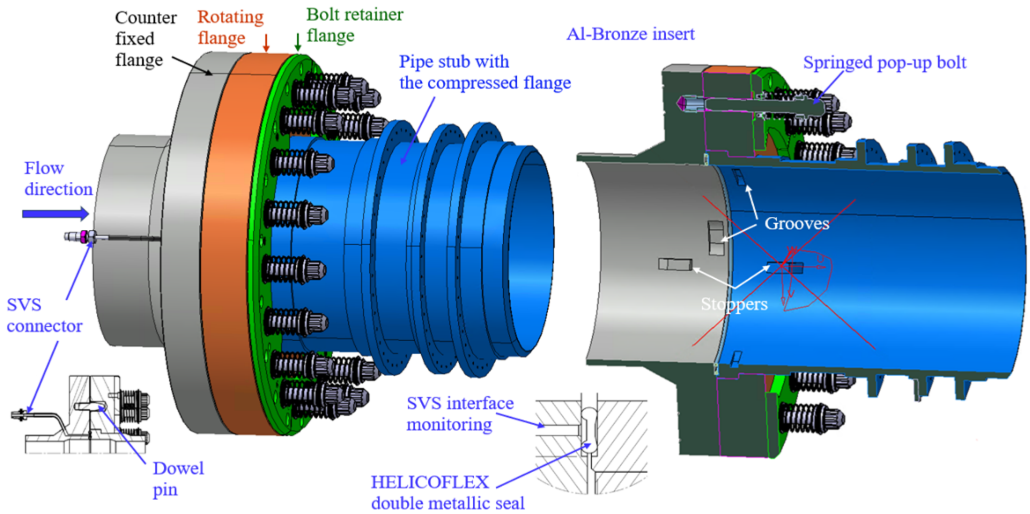

Figure 9. Design of the RH compatible flange connection.

The design of the vacuum flange connection was confirmed by FEM stress calculations.

The circular flanges of the BVA have the standard interfaces for the RH maintenance as defined in[R38]. The required bolt running torque of the metallic seal flange bolts is within the torque capacity of the flange bolt runner tools.

When installing the BVA, the BVA flange and the relief line can have angular misalignments. In case of misalignment, the dowel pin rotates the rotating flange to align the flange bolts to the threads in the fixed flange (see Figure 9). The rotating flange design makes the alignment easier and requires less demanding manufacturing and assembly tolerances.

On top of the rotating flange, there is a bolt retainer flange fixing the bolt retainer spring inside. When the bolt is fully released from the thread, the bolting tool socket grips the bolt and drags it until the bolt retaining groove meets the bolt retaining spring. The spring keeps the bolt at the released position.

The double metallic seal is placed close to the internal surface of the relief line in order to exclude any possible dust trapping area. The double metallic seal has interspace monitoring line between the metallic seals in the fixed flange, so that the disconnection of the SVS line is not required.

There is a sealing line at the circumferential surface of each flange where the confinement tool will contact to keep confinement during the flange disconnection operation.

The metallic seal is fixed to the flanges of the BVA remotely. The composite section of the seal is fixed to the flange with small screws. The metallic seal is removed and installed together with the BVA to be maintained. No handling operation is foreseen only for the metallic seal.

Tolerances of the flanges (flatness and surface roughness) as well as quantity and sizes of the bolts have been agreed with the seal manufacturer requirements to provide the specified leak tightness.

The opposite flange of the flange sub-assembly shall have a pipe extension of at least 200 mm closed with the welded counter blind flange and be equipped with SVS connector (see Figure 10).

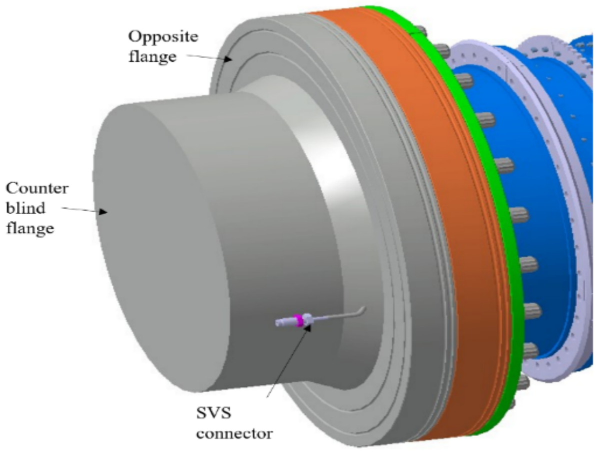

Figure 10. Flange sub-assembly with opposite flange

The helium leak tightness of the vacuum flange connections with double HELICOFLEX seals shall be:

- $1x10^{-9}$ Pa·m³/s from ambient to interspace between seals;
- $1x10^{-10}$ Pa·m³/s from interspace between seals to process.

The vacuum flange design, including the fasteners, is in compliance with the ITER Remote Handling Code of Practice[R38]. Bolting torque of the RH bolts is within the operating range of the RH bolting tools as defined in the ITER guideline; this value is 185 Nm for both DN300[R38].

Following unbolting of the vacuum flange and compression of the bellows, the open flange ends will be closed by insertion of confinement plugs by a remotely handled confinement tool (not part of the scope of supply). The vacuum flanges include features to enable the location of the confinement plugs. Three stoppers and three grooves are equally placed along circumference on the internal surface of the relief line (see Figure 9).

The prototype of the RH DN300 vacuum flange connection was designed, manufactured, tested and qualified in accordance with the ASME B31.3 process piping code [CS4] in line with the IO specifications. Detailed stress calculations to verify design were performed by the ITER Contractor for the combined loads specified in the Load Case Specification VVPSS-RL [R27] and the ITER Report on Stress Analysis of VVPSS Relief Lines [R28] and the technical note - update of the VVPSS Relief Line piping analysis[R29]. The stress calculations for the DN300 vacuum flanges were performed taking into account the compression forces applied to the flanges during the bellows compression and the thermal displacements[R39].

The 3D model and the drawing of the RH vacuum flange connection with the guide rails and pinion gears will be transferred to the Contractor after the Kick-Off meeting.

The Contractor shall purchase the RH flange connections, as shown in Figure 9 and Figure 10, from ***Fourvac Technologies***
Address: *Priyadarshni Industrial Premises, T - 165/03/08, M.I.D.C., Bhosari, Pune - 411026, India*
Contact: *sales@fourvac.com*

10.4 Guide Rails and Circular Rack Gear

The flange sub-assembly includes the mounting guide rails and circular rack gear for installation of the flange bolting tool (see Figure 11, Figure 12). The free wheels on the flange bolting tool will be engaged to the guide rails and a pinion gear mating to the circular rack gear will drive the flange bolting tool to move around.

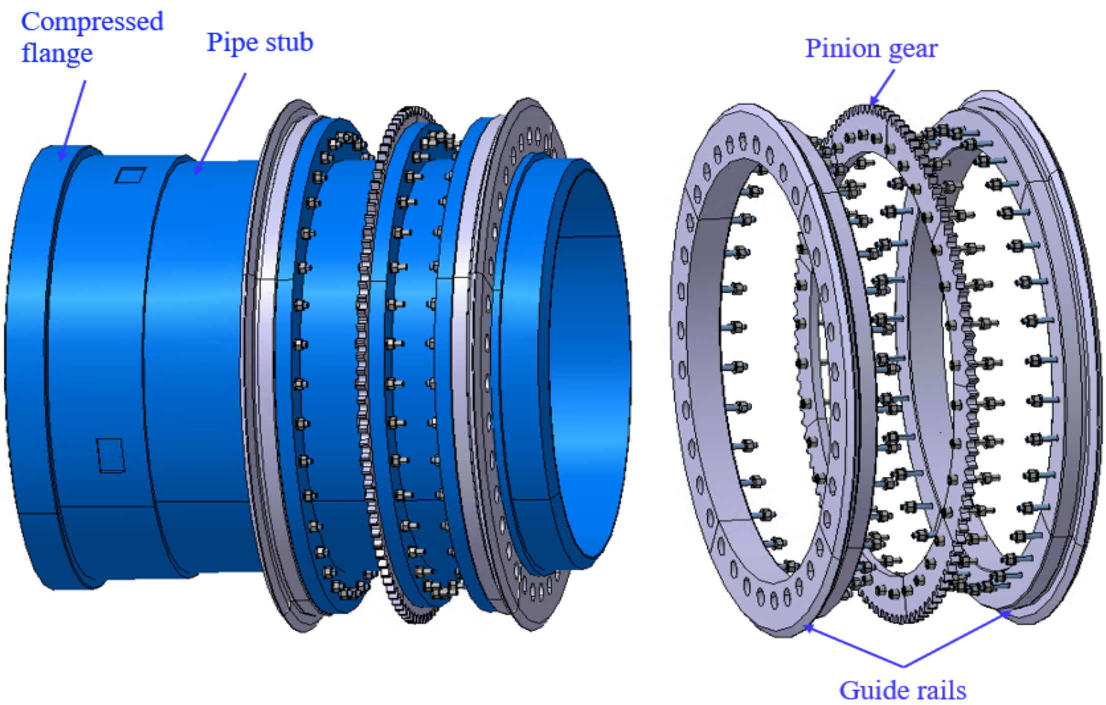

Figure 11. Guide rails and circular rack gear

The 3D model and manufacturing drawings of the guide rails and circular rack gear will be provided to the Contractor by the IO after the Kick-Off meeting.

10.5 Double Bellows Sub-Assembly

The bellows sub-assembly design allows for displacements of the DN300 relief line in response to thermal, pressure, seismic, and other accidental conditions. The displacements of the relief line and bellows are determined and can be found in the Report on Stress Analysis of VVPSS Relief Lines [R28] and the Technical note - update of the VVPSS Relief Line piping analysis[R29].

The bellows sub-assembly is of double-walled design with a continuously SVS monitored interspace, as shown in Figure 12.

The applicable type of bellows is a circular U convoluted-type bellows expansion joint with weld ends.

The bellows sub-assemblies located on each side of the BVA will be axially compressed by up to 100 mm each to provide adequate clearance during the RH maintenance at normal environmental conditions. The force required to operate the axial compression tool shall not exceed the capability of the remote handling tools[R56].

The steam, flowing through the BVA from the VV, contains the activated materials. To exclude the contamination of the bellows by the activated dust, the Contractor shall manufacture the double bellows assembly with an internal dust protection sleeve.

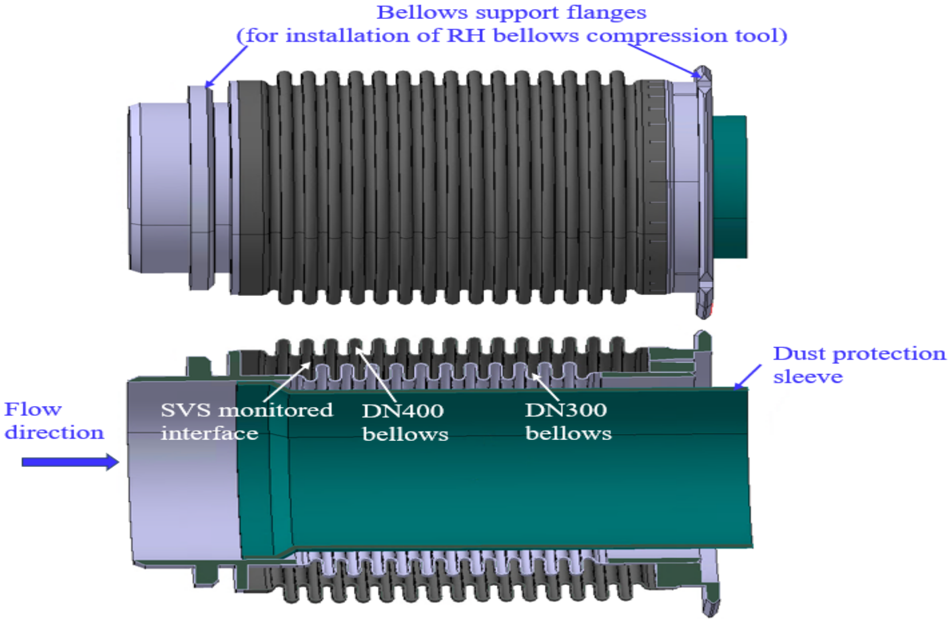

Figure 12. Double bellows sub-assembly

The prototype of the double bellows sub-assembly was designed, manufactured, tested and qualified in accordance with the ASME B31.3, Appendix X [CS4] and the EJMA standard [CS3] by the ITER Contractor in line with the IO specifications. Stress calculations to verify the design were performed in line with the combined loads specified in the Load Case Specification VVPSS-RL [R27] and the ITER Report on Stress Analysis of VVPSS Relief Lines[R28]. The stress calculations of the bellows assembly have been performed taking into account the compression forces applied to the flanges during the bellows compression and the thermal displacements[R39].

The 3D model and the drawing of the double bellows sub-assembly will be provided to the Contractor after the Kick-Off meeting.

The Contractor shall purchase the double bellows sub-assembly, as shown in Figure 12, from:

RATNAFLEX Engineering Private Limited (REPL)
Address: *Survey No. 803, B/h Gayatri Dairy, Ahmedabad - Mehsana Highway, P.O - Chhatral - 382729, Taluka: Kadi, Dist.: Mehsana, Gujarat, INDIA*
Contact: sales@ratnaflex.com

10.6 RH Lifting Frame

The Contractor shall design the RH lifting frame (see Figure 13) used for vertical lifting and horizontal transportation of the BVA in NB Cell.

The lifting frame shall have four twist lock interfaces for the Monorail Crane used in NB Cell for the equipment transportation.

The crane positioning marker on the BVA lifting frame shall be implemented on the Twist Lock Socket in line with the INT_DRW_CRANE_ALIGNMENT_MARKER drawing[R57].

The lifting frame shall be capable of lifting the BVA weight. The load capacity margin of the lifting frame shall be at least 6.75 times the total weight of the BVA, including the weight of the lifting frame. This margin is to ensure that the frame is capable of withstanding an SL2 earthquake during lifting without structural collapse.

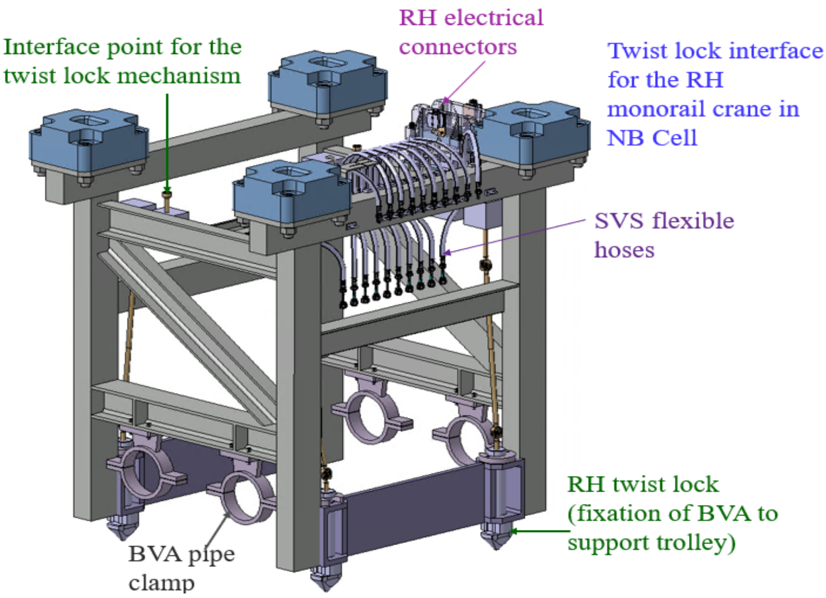

Figure 13. BVA lifting frame

10.7 RH Twist Lock Mechanism

The RH twist lock mechanism is used to fix the lifting frame to the support trolley frame (see Figure 14). The support trolley Frame is also included in the scope of supply by the Contractor. The RH twist lock has four independent locks that are attached to the vertical beams of the lifting frame. These locks are activated by the RH tool through the twist mechanism, which transmits the torques applied at the RH interface points (see Figure 14).

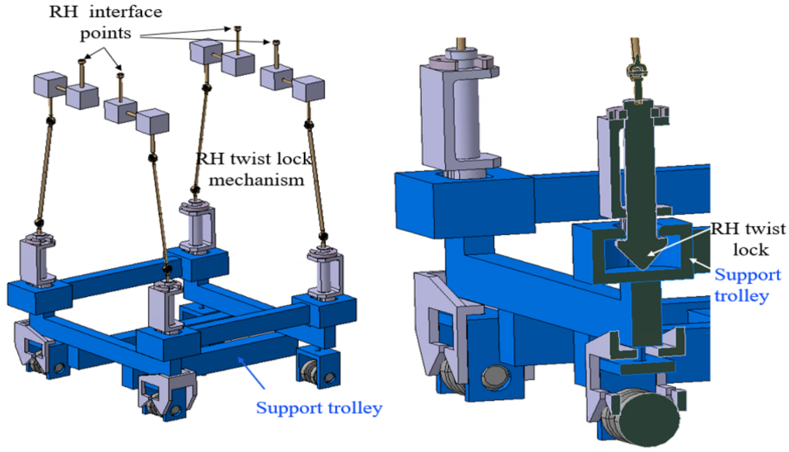

Figure 14. RH twist lock mechanism connected with the support trolley

The Contractor shall develop, design, manufacture, and test the RH twist lock mechanism using the IO 3D model as the base preliminary design in compliance with the requirements of the ITER Remote Handling Code of Practice[R38]. The design of the RH twist lock mechanism shall be reviewed and approved by the IO.

10.8 Pumped Interspaces and SVS Monitoring System

All pumped interspaces of the BVA shall have SVS connections for monitoring the interspace vacuum. The eight SVS connections in accordance with the lines shown on the VPRP P&ID are detailed below:

- One interspace for both the primary and secondary BVs
- Four intermediate pumping interfaces between two internal bellows located inside each BV
- One interface for the upstream double bellows of the BVA.
- Two interfaces for the two vacuum flanges, both upstream and downstream of BVs

Two interspaces of the Helicoflex double seals are pumped and monitored throughout the SVS connectors installed on the opposite flanges (see Figure 9 and Figure 10).

The SVS will create, maintain and monitor a pressure of 30-50 Pa(a) in the interspaces.

Helium leak rates for each pumped interspace separately shall be:

- From ambient into the interspace: 1E-9 Pa·m³/s
- From internal tube space on VST side into the interspace: 1E-9 Pa·m³/s
- From the interspace into VV space: 1E-10 Pa·m³/s
- From the interspace into the spool space between the primary and secondary BVs: 1E-9 Pa·m³/s.

For the SVS monitoring system, the dismountable connectors SWAGELOK VCR 1/4" are applicable.

All RH interface connectors shall be collected and installed on the support frame welded to the body of the BVA. The distance between the RH interface connectors shall be applicable for the RH bolting tool application. The interface connectors shall be connected with the connectors located at the SVS monitoring points of the BVA using the capillaries of 6x1 mm. The capillaries shall be fixed to the BVA body to be able to resist SL-3 event. The capillary fixations shall be designed taking into account the thermal expansion of the capillaries during the baking.

The design of the VCR interface connector shall have an alignment pin to help engage the connectors by the Manipulator. The details of the RH compatible VCR connectors shall be developed by the Contractor.

To prevent the dust penetration, the opened end of the connectors shall be closed during lifting, transportation and shipping to the IO site.

10.9 Baking System

The Relief Pipes will be equipped with trace heating capable of performing the baking process on the upstream side of the BVA. The heating system is out of the scope of supply of this spec, as the heating cables will be located on the upstream of relief pipes and terminated before the thermal enclosure, nevertheless the electrical heating components will be designed to periodically heat the assembly from the upstream flange to the first set of Bleed Valves up to 180°C. Therefore, there is no heating inside the thermal insulation boxes, both for RDA and BVA.

10.10 Compressed Air Supply System

Each BV is independently controlled using compressed air. Compressed air is supplied to the BVs through 1/8" ISO/NPT connectors. The contractor shall design a system to connect the compressed air supply to each valve. All supply pipes shall be securely fixed to the lifting frame to ensure stability. The design shall include removable connections to allow for RH disconnection of the air supply lines from the BVA to transport the assembly inside NB Cell.

Each valve must be individually controlled for opening and closing. Two CA lines will be connected to each valve, resulting in a total of eight separate CA lines that need to be routed inside the BVA thermal insulation box.

10.11 Electrical Position Indicators

Each valve is equipped with two position indicators using micro switches to indicate that the valve is closed or opened. The position indicators are connected to one 6-pin connector from the Glenair company (8070-2530-02Z16-6PA) installed on the valve. The mating connector 8070-3039-01Z16-6KA with pins compatible with AWG 20 wire is not part of the valve. The Contractor shall supply the mating connectors too.

All electrical supply lines shall be securely fixed to the lifting frame to ensure stability. The design shall include removable connections to allow for RH disconnection of the electrical supply lines from the BVA to transport the assembly inside NB Cell.

10.12 BVA Lifting Frame

The Contractor shall design and manufacture a special Lifting Frame to install, fix, lift, handle, and transport the BVA assembly. The design of the Lifting Frame shall provide the stable position of the BVA while it is being hung, lifted, and transported. The Lifting Frame design shall include an interface for the twist locks to test the twist lock mechanism, fixing the BVA to the frame. The final design of the Lifting Frame shall be agreed upon with the IO.

10.13 Fasteners

The BVA and RDA and the supporting structures use the fasteners for the following functions:

- RH vacuum flanges pop-up bolting (see Figure 9, Figure 15);

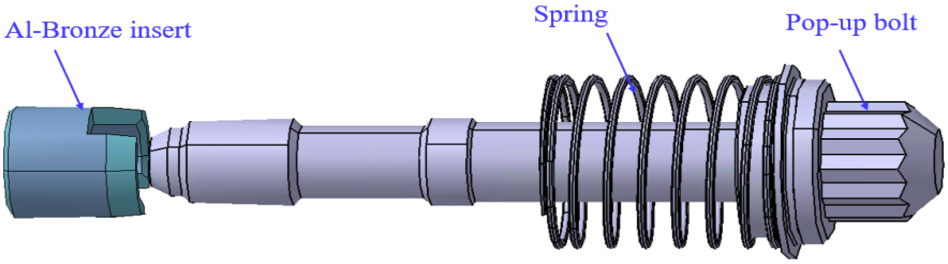

Figure 15. Flange pop-up bolting

- Bolting of the gears and guide rails;
- Bolting the pipe clamps;
- Bolting connections on/between TIB, Trolley Frame and Main Frame;
- Bolting connection for the support of tubing.

The sizes and number of the pop-up bolts are frozen. The stress calculations of the flange bolting have been performed by the IO Contractor for the flange prototype for the specified loads. The diameters and bolting torque of the RH fasteners are within the operating range of the RH bolting tools as defined in the ITER Remote Handling Code of Practice [R38] and the design code.

10.14 Bellows Assembly Clamps

The Contractor shall design and manufacture two bellows assembly clamps. These clamps shall secure the bellows assemblies and prevent them from sagging on both sides of the BVA due to the weight of the vacuum flanges during the lifting and handling of the BVA.

The bellows assembly clamps shall be capable of axially compressing the bellows by 50mm. Manual operation of the clamps is acceptable. Interface features provided for the nuclear phase remote handling bellows compression tool may be used to attach the bellows assembly clamps.

10.14.1 Remote Handling Bellows Compression Tool

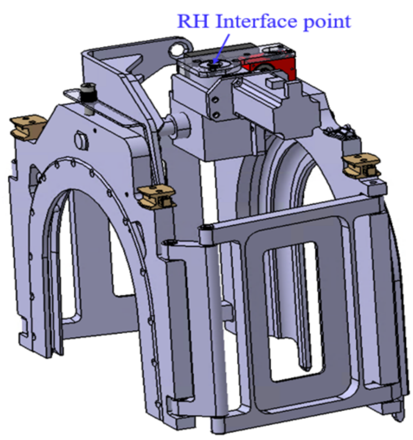

Figure 16. RH bellows compression tool

During the nuclear phase of operation of the ITER facility, an RH Bellows Compression Tool (BCT) will be available to compress the DN300 bellows assembly. The BCT has been designed, manufactured and tested by an IO Contractor. Design documentation and a single BCT prototype will be available to the contractor during the contract execution to assist in the development of the Bellows Assembly Clamps.

10.15 BVA&RDA Trolley Frame

The Trolley Frame is driven by PBS23 Remote Handling System. Its primary function is to facilitate the movement of the BVA&RDA along the piping axis when the vacuum flanges are disconnected from the pipes, and the double bellows are either compressed or extended, as illustrated in Figure 17.

The design of the Trolley Frame is consistent for both assemblies and consists of a sliding support (highlighted in blue) and a fixed support base (highlighted in green). The sliding support is equipped with four wheels that run on a rail and is connected to the driving shaft via two gearboxes, which are mounted on the support base. The gearboxes are situated outside the thermal insulation box to ensure easy access, with a driving socket available for remote handling.

The Trolley Frame is equipped with four lifting lugs that are designed to engage with the twist locks of the BVA&RDA when they are supported on the frame. It also features connections to the main frame of the BVA&RDA through pop-up bolts and a guided pin, which ensures proper alignment during installation.

The contractor shall design, manufacture and test the Trolley Frame using the IO 3D model as the base design and in compliance with the requirements of the ITER Remote Handling Code of Practice [R38] and the interface requirements between BVA&RDA and PBS23 Remote handling system[R56]. The analysis of the frame should take into account all loads presented in the VVPSS RP loads spec [R27] and the loads presented in the interface sheet with PBS23[R56]. The design and analysis shall be reviewed and approved by the IO.

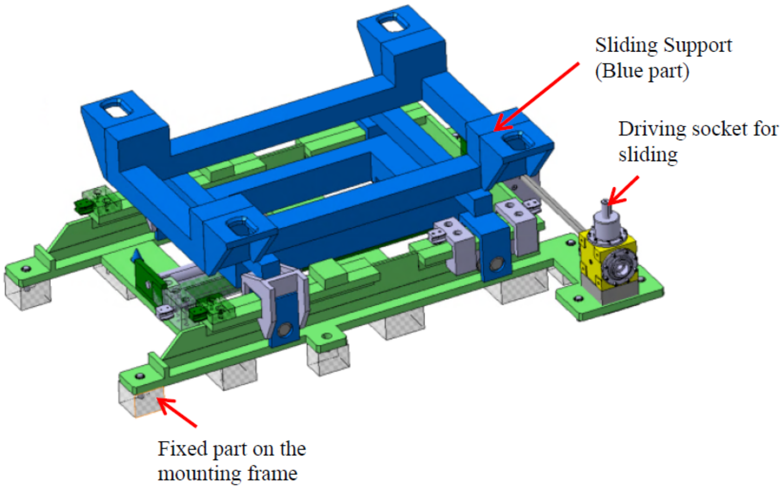

Figure 17. Trolley Frame for BVA&RDA

10.16 BVA&RDA Thermal Insulation Box

The general assembly of the BVA&RDA Thermal Insulation Box (TIB) is shown in Figure 18. The TIB serves two primary functions: 1- it acts as a thermal enclosure for the RDA and BVA components within the NBC. This function is crucial as it provides fire protection for the components against elevated thermal loads that could lead to failures in the event of a room fire. It also offers thermal insulation to maintain the temperature of the components during operational conditions, including backing and VV accidents when component temperatures rise. 2- The TIB serves as a support structure for piping. According to the piping analysis results, it acts as an axial limit stop for two relief pipes, enabling them to withstand the double bellows pressure thrust force during operational conditions.

The TIB is supported by the BVA&RDA mainframe and is designed with short legs and base plates that feature countersunk bolt connections. It consists of an upper box classified as RH Class 1 and a lower box classified as RH Class 3. The upper box is equipped with four lifting blocks that engage with the twist lock on RH tools. The upper and lower boxes are connected by lay shafts, which include remote handling features at the head. Additionally, alignment pins are designed to ensure proper positioning during installation and maintenance.

The axial stops are positioned upstream of the pipe, where the beam sections are reinforced to withstand the force. During assembly, the gaps between the flange surface and the TIB beams should be less than 1.5 mm to ensure proper support functionality.

A 50 mm layer of insulation material shall be added to the exterior of the box, and this insulation will be protected by stainless steel cladding. When designing the insulation and its attachment, it is important to ensure that they do not obstruct the features and accessibility required for the remote handling performance of the TIB.

On the TIB, there are supports designed for the SVS and CA lines. There are remote handling requirements to disconnect the service line during maintenance from the permanent connection of the lower TIB and the support frame.

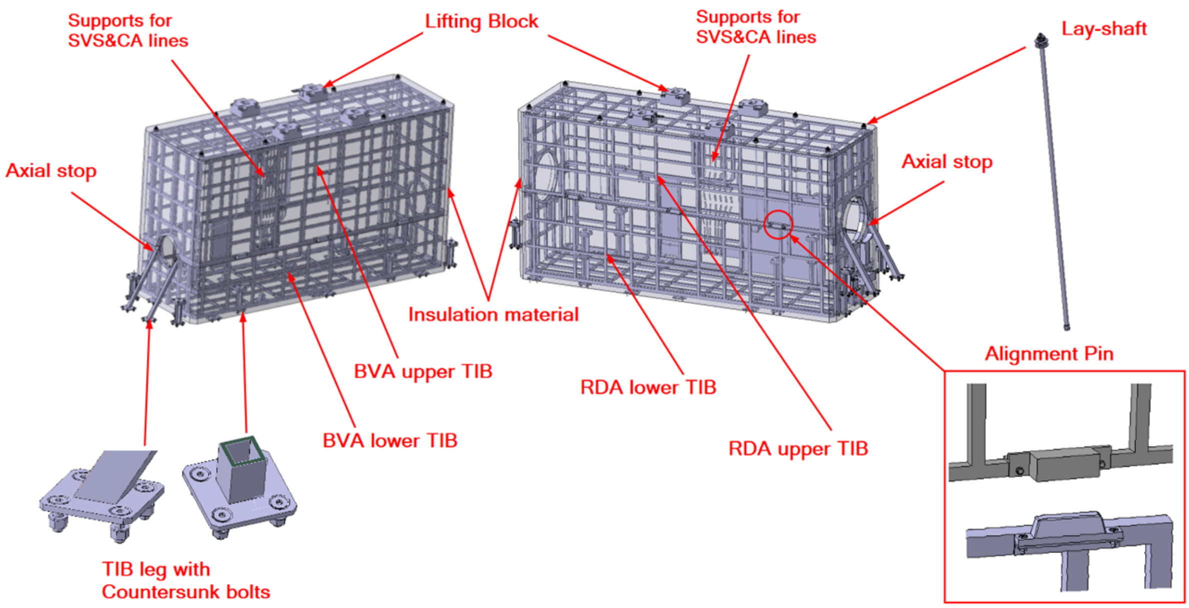

Figure 18. Thermal Insulation Box for BVA&RDA

According to the interface sheets [R56] between the PBS24 VVPSS and the PBS23 Remote Handling System, the insulation panels installed on the lower insulation boxes must be designed to comply with RH Class 3 standards. The contractor is responsible for finalising the engineering design for the connections (alignment and guidance) of these removable panels with the box structure. The panels should include the lifting features specified in the interface sheets.

Both the BVA and RDA Lower Thermal Insulation Boxes feature two small support structures that integrate all service lines, including compressed air and SVS tubing. Each line is equipped with a Swagelok VCR connector fixed to the supports. During maintenance, all lines must be disconnected from the supports to lift the assemblies. Additionally, these supports should be designed to rotate, allowing adequate space for lifting the BVA and RDA components. The contractor is responsible for finalising the connections of the two structures on the lower boxes and must verify the function and structural integrity of the supports during both operational and maintenance phases, considering all load case combinations specified in the load specifications.

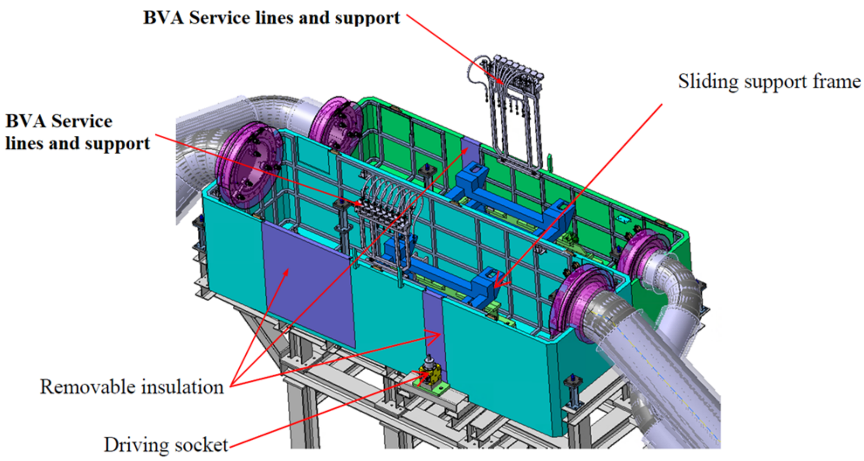

Figure 19. Removable panels and Service line with the supports on the Lower TIB

The contractor shall develop, design, analyse, manufacture, and assemble the two TIB using the IO 3D model as the base design in compliance with the requirements of the ITER Remote Handling Code of Practice [R38] and the interface sheets between BVA&RDA and PBS23 Remote handling system[R56].

10.17 BVA&RDA Main Frame

The function of BVA&RDA Main Frame is to support all the components mentioned above, including the Remote handling tools that are used during the maintenance and small tubing that have interface with other systems in NB Cell. The frame is designed with six legs, which are welded to the EP on the floor. The main frame model has been finalised by IO, based on the structural integrity analysis considering all the load combinations.

The frame is split into two main parts to be adapted to the installation plan on site, when doing the pre-assembly and disassembly of the frame on site the contractor should consider the lifting, alignment and temporary fix of the support frame to the ground of the assembly work area.

11 Structural Integrity Analysis

11.1 Structural Integrity

The contractor shall perform structural analysis of any components that are not fully designed when IO send the input for the scope of work, IO has performed the general structural analysis of the 6 assembly as shown in chapter 5, nevertheless few of the components or parts need to be selected and further developed by the contractor, for example the driving motor or switch box, the trolley wheel, the driving shafts, etc. the contractor shall also perform any assessment due to engineering changes or modifications during the contract phase that will impact the structural integrity analysis, all the analysis should be review and approved by IO.

The structural integrity of the components shall be assessed to verify that the design can withstand the critical load combinations.

The Contractor shall follow the ITER Procedure for Analyses and Calculations [R47] in order to identify the requirements and procedures that shall be followed by the Contractor for analyses and calculations to ensure an existing, modified, or proposed design of a structure, system, or component (SSC) will meet the ITER Technical Requirements (or a sub-set of them).

The structural analysis consists of verifying compliance with criteria based on the analysis method, considering the event category (I, II, III & IV) and the type of allowable damage as outlined in the Design Basis following the ITER Instruction for Structural Analyses[R48]. The maximum allowable mechanical loads, modal frequencies and valve stiffness factors shall be determined.

The detailed design assessment is based on the following four failure modes: plastic collapse, local failure, buckling and cyclic loading.

The thermal stresses in the different operational modes of the systems need to be investigated carefully to demonstrate that no structural damage occurs, and, for some components, the functioning needs to be demonstrated on a case-by-case basis.

The structural integrity analysis shall include the stress and deformation analyses. The structural integrity reports shall be performed in accordance with the ITER Guideline for Structural Integrity Report[R46]. The structural integrity reports shall follow the requirements of the ITER Template for Structural Integrity Report[R51].

All applicable loading conditions and the required service levels shall be addressed in accordance with the Loads Case Specification for VVPSS-RL [R27] and the interface piping loads described in Appendix 3. Additionally, support frame impacts shall comply with the ITER Report on Stress Analysis of VVPSS Relief Lines [R28] for the load combinations of dead weight, pressure, temperature, temperature gradients, bending, closing effort, seismic, fatigue, fire, lifting, transportation and installation loads. The structural analysis shall be performed for both normal and accidental environmental conditions, as defined in Section 15.3.

The analysis shall include the FEM stress calculations based on the ANSYS software. All files (input files, scripts, meshes, external functions) shall be submitted to IO. For each calculation referenced in the reports, the Contractor shall provide a set of files that clearly identifies the results corresponding to each calculation.

Geometry cleaning and simplification should be performed in order to obtain a 3D solid element mesh with a good size/precision ratio. If needed, sub-modelling may be used, where appropriate, to resolve small significant features in large components. Proposals for model simplifications with shells and beam elements, if properly justified, can be discussed and validated with IO.

Relevant failure modes to be checked in the analysis are gross plastic deformation and progressive plastic deformation.

The material properties used in the structural analysis are applicable in the references[CS6], [CS7] and[R26].

IO has performed the general structural integrity analysis for the components that are in the scope of this specification. The Contractor shall undertake all necessary analyses and calculations required to select standard part or items, such as the switch box, driving shaft, guide rails, motor, etc., used on the Trolley Frames, and the lay-shaft, lug supports, pin connection on the thermal enclosure box, if non-standard part and components are used by contractor for the manufacturing these should be also analyzed and justified to meet the structural criteria. The contractor shall perform the structural integrity analysis for the Bellow assembly Clamp. This includes operating and lifting conditions of the assembly, when the tools are engaged.

Some hand calculation is envisaged, but the demonstration shall be robust, and its use will be subject to the IO acceptance.

11.2 BVA Structural Integrity Analysis

The preliminary structural integrity analysis of the BVA has been performed as part of the BVA qualification process by IO, including the vacuum flange and the double bellows sub-assembly.

The layout of the BVA supports used in the stress analysis is shown in Figure 20:

11.3 Transportation Analysis

The Contractor shall design and analyse the transport packages used to deliver all the assemblies and the spare parts to the IO site.

The Contractor shall assume loads in all three axes of 4g for the analysis. No permanent deformation or stress ratio of greater than 80% shall be accepted.

A transportation analysis report shall be submitted to the IO for acceptance.

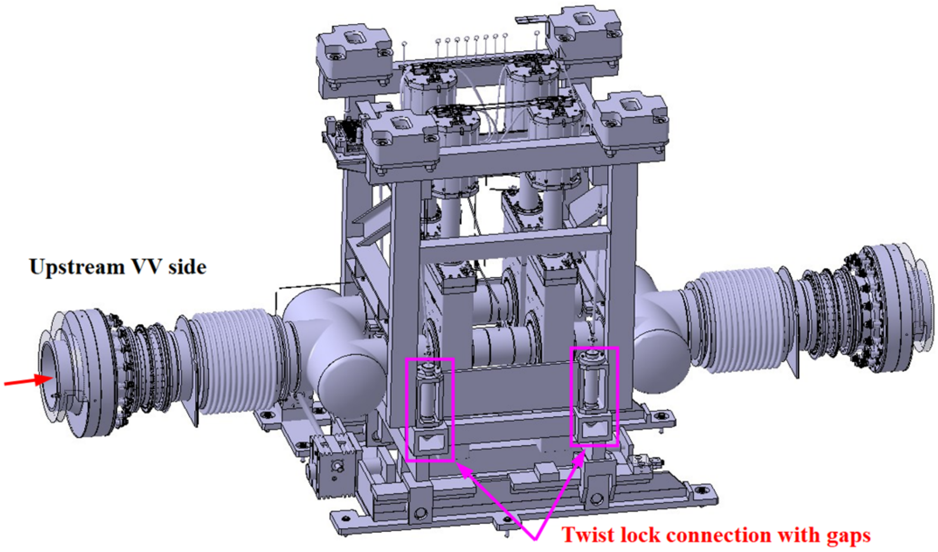

Figure 20- Layout of the BVA and supports

11.4 Structural Design Criteria

The structural design criteria applied to the structural integrity assessment of the components shall follow the acceptance criteria specified in the Loads Case Specification VVPSS-RL [R27] for the following ITER loading conditions based on the expectation of occurrence:

Category I: Operational Loading Conditions

Category II: Likely Loading Conditions Frequency f>10-2y-1

Category III: Unlikely Loading Conditions Frequency 10-2y-1>f>10-4y-1

Category IV: Extremely Unlikely Loading Conditions Frequency 10-4y-1>f>10-6y-1

Other events or event combinations that are beyond design basis may be classified in an additional category (category V) and represent extremely unlikely events.

11.5 Design Loads

The Contractor shall perform the structural analyses of the components design in accordance with the loads specified in Sections 2.4-2.6 of the Loads Case Specification VVPSS -RL[R27].

11.6 Analysis Documentation Requirements

All analyses performed on the components must have reports submitted to IO for review and approval before fabrication begins.

Analysis reports shall be produced in accordance with the Template for Structural Integrity Report [R51] The FEA models, as well as all calculation reports performed (including the ASME code calculations) for the BVA, shall be provided to IO.

12 Test Requirements

The contractor should deliver all the manufactured parts to IO site in the specified test area defined and agreed by IO, all the test and assembly of the components should be done on IO site. A final assembly of the whole scope should be completed together with RDA without any connection to the Relief pipes.

12.1 Site Acceptance Tests of the BVA

The Contractor shall perform the Site Acceptance Test (SAT) of the BVA after the assembly of the Bleed Valves with pipes, tee pieces, double bellows and vacuum flange sub-assemblies for the normal conditions of the VVPSS relief line, including as a minimum:

- Functional tests of each BV in the assembly. The functional test includes an operating cycle function. Each valve shall be opened/closed to verify any:
  - jamming;
  - un-commanded operation and
  - correct position/status indication.
- Behaviour in event of loss of pneumatic supply
- Helium leak testing to demonstrate required leak tightness at specified conditions
- Vacuum control of the SVS monitoring interspaces
- Functional testing of the twist lock transmissions
- Bellows compression tests on both sides of the BVA using the bellows assembly clamps
- Verification tests of the bellows assembly clamp to prevent the bellows from sagging

The Contractor shall prepare and submit the test procedures to IO for review and approval for all specified tests. The test program and test sequence shall also be submitted to IO for review and approval.

12.2 Helium Leak Testing

12.2.1 Helium Leak Test of the BVA

The BVA assembly shall be subjected to the specified conditions and then subsequently helium leak-tested.

Leak testing shall be performed using vacuum methods. Testing is anticipated to be performed by enveloping with a suitable bag filled with helium and determining the leak rate into the pumped interspaces, and then by injecting helium into the interspaces and determining the leak rate into the process.

Thermal insulation may be used around the equipment to protect the enveloping bag from high temperatures.

Helium leak testing shall be performed in compliance with Section 25 of the ITER Vacuum Handbook [R4] and the ITER Vacuum Handbook Appendix 12 Leak Testing[R35]. Personnel shall have applicable qualification for conducting the helium leak testing.

Note: The sensitivity of the Helium mass spectrometer detector shall be better than $1x10^{-11}$ $Pa{\cdot}m^3/s$.

Before each helium leak test, the BVA shall be properly out-gassed at elevated temperature and dried in accordance with the requirements of the ITER Vacuum Handbook, Section 5.4. The Contractor shall prepare and submit the helium leak test procedure for IO review and approval.

12.2.2 Acceptance Criteria

A leak test shall be performed after sealing of the pipework to demonstrate that the pipework is sufficiently leak tight. For a given sealed section of piping and for the entire network, the leak rate shall not be greater than presented in Table 3.

The leak tests will be performed initially at ambient temperature, before increasing to baking temperature, and after.

The allowable leak rates for the different scenarios are defined below:

- The maximum allowable helium leak rate across the valve seat shall be 1x10-10 $Pa.m^3/s$ (0.1MPa $\Delta P_{helium)}$) measured at the operating temperature.
- The maximum allowable helium leak rate across the air to vacuum boundary shall be 1x10-10 $Pa.m^3/s$ measured at the operating temperature.

Acceptance Criteria	**VQC-1A** Maximum Leak Rate ($Pa \cdot m^3/s$ air equivalent)	**VQC-3A** Maximum Leak Rate ($Pa \cdot m^3/s$ air equivalent)	**TC2A**
Prefabricated component (Global Test)	$1x10^{-10}$	$1x10^{-9}$	$1x10^{-9}$
Individual Weld	$1x10^{-10}$	$1x10^{-10}$	$1x10^{-10}$
Condition	Ambient temperature, ΔP=0.1 MPa (in either direction), Concentration He > 50% over area under test.		

Table 3. Helium Leak Test acceptance criteria

12.3 Thermal Test

The Contractor shall perform one thermal baking test heating up to 180°C.

To exclude undue stress on the vacuum components being heated, the temperature shall be controlled to ensure that it remains uniform to within ±20°C at all points on the surface of the vacuum component, unless otherwise agreed by the IO. The rate of temperature increase or decrease during heating and cooling shall be maintained within specified limits and shall not exceed 10°C per hour[R36], unless otherwise agreed upon by the IO.

The temperature limit of the Bleed Valve actuators, which is below 180°C shall be respected during the baking process.

Acceptance criteria: After the thermal test, the helium leakage rate of the BVA shall not exceed the maximum allowable limit specified in Section 12.2.2.

12.4 Verification Tests of the Twist Lock Mechanism

The Contractor shall verify the operability of the twist lock transmission. All twist lock transmissions shall be tested.

The functional testing of the twist lock transmissions shall include a demonstration of the unlocking, lifting, lowering and re-locking of the BVA&RDA onto the maim support Frame.

Acceptance criteria: All twist lock transmissions shall provide both locking and unlocking of the RH twist locks to the support trolley or support frame.

12.5 Testing of Bellows Assembly Clamps

The Contractor shall verify the operability of the bellows clamps that prevent the bellows from sagging during handling and transportation.

Acceptance criteria: No bellows sagging during handling and transportation.

12.6 Lifting Test

The BVA shall be subject to a load test of the hanging/lifting lugs.

Hanging and lifting lugs of the assemblies shall be load tested to 150% of the complete assembly weight without the lifting frame. The test load shall have a hold time of 20 minutes.

The bellows assemblies shall be clamped to prevent sagging during the lifting test.

The lifting frame of the assembly shall be load tested to 150 % of the complete assembly weight, including the weight of the lifting frame. The test load shall have a hold time of 20 minutes.

Acceptance criteria: no deformations of the lifting lugs as detectable by visual inspection.

12.7 Functional Test of the Trolley Frames

The contractor shall perform a functional test of the Trolley Frames with the BVA&RDA supported and connected. Both frames should be mounted on the pre-assembled main frame. The test shall demonstrate that during the bellows compression/extension, the sliding support can slide smoothly and properly on the fixed support by driving the remote handling socket. The sliding support should accommodate the target displacements and the space needed for the insertion/removal of the flange closure plates.

The test of the trolley and actuation system shall meet:

- Displacement range of at least 150 mm;
- Ability to apply force to compress bellows;
- Ability to lock in place when under bellows tension or preloading due to BCT.

The lateral movement of the assembly, deviating from the axial direction of the BVA&RDA, should be avoided and minimised.

12.8 Pre-assembly/Disassembly of all the Components

The contractor shall perform the complete pre-assembly/disassembly of all the components on the main support frame, according to IO installation planning[R59]. This activity consists of following the installation sequence and EWP Planning for PBS24 VVPSS Components in NB-Cell to simulate the final installation process, which should include:

- The connections between the components (twist locks);
- The alignment and lay-shaft locking connections between upper TIB and lower TIB;
- Bolting and unbolting of the trolley Frame and TIB on the support Frame;
- Connection/disconnection of the electrical connector.

13 Material Properties

The materials shall be 300-series austenitic stainless steel in accordance with code requirements of the ASME B&PVC Section II Part D (Metric) [CS7] and for the piping components of the BVA in compliance with the ASME B31.3 process piping code [CS5], Category M fluid Service.

The valve body is made of 316L stainless steel as specified in the VAT manufacturer's catalogue. Some parts of the actuator are made from Aluminium 6061-T6.

The base piping and fitting material shall be 304L stainless steel (seamless).

Stainless steel F304L forged material shall be used for the BVA flanges.

The flange fasteners shall be from the stainless steel Grade 660 and possible hardening may be required.

The flange thread inserts shall be from Aluminium Bronze grade CA104.

The double bellows assembly shall be from SA 240 Type 304 stainless steel.

The material selected for the BVA Lifting Frame, primary clamps & twist locks, TIB structure and Trolley Frames is S355J2H according to EN10210-2019 - hot formed welded structural hollow sections, tolerances, dimensions and sectional properties.

13.1 Low Activation Requirements

In addition to the composition requirements of Section 5.2.4, "lower-activation" materials shall be selected for the BVA with the following maximum chemical component concentrations presented on Table 4:

Element	Co	Nb	Ta
Maximum concentration (%)	0.05	0.1	0.01

Table 4. Tensile and Yield strength for metal temperature

13.2 Carbon Steel Contamination

The Contractor shall properly segregate carbon and stainless steel work areas to fully exclude carbon steel contamination. Protection provisions shall be taken in order to exclude any contamination from carbon steel dust during the manufacturing processes, cleaning, handling, marking, storage, transportation and other activities with the BVA as well as the BVA components. The Contractor shall prepare the Clean Work Plan that details the measures taken to ensure the absence of contamination of the BVA and BVA components and submit to the IO for review and approval.

13.3 Material Certification

The Contractor shall provide certification declaring the material used in the VVPSS BVA in compliance with the requirements detailed in this Specification, and those specified by the material grade.

The Contractor shall provide the Inspection certificates Type 3.1 or Type 3.2, in accordance with EN 10204 [CS21]. The certificate shall include the information defined by the EN 10168 [CS22], including:

- Identification of the specific pipework component and Ident Code;
- Reference to the Customer Technical Specification;
- Identification of the Contract number and a description of the items as ordered, provided and certified as meeting the requirements of the Contract, together with all agreed on changes;
- Identification of any procurement requirements that have not been satisfied with reference to any relevant non-conformances of deviation requests;
- Identification of the heat number of the components;
- All test results and references to the test reports.

Where chemical or mechanical properties information additional to that required by the EN 10168-2004 [CS22] is required for the relevant ASTM specifications, additional tests shall be performed on samples taken off the original materials to obtain the additional information and a new material certificate shall be created by the material manufacturer. All tests shall be witnessed and approved by a notified body unless tests are carried out by an ISO 17025 [CS18] accredited laboratory.

Inspection Certificate Type 3.2 must be provided by the Contractor that does not have a Quality Assurance System in line with requirements of ISO 9001-2015 [CS19]. The certificates can be provided by the Contractor provided there is justification from the Agreed Notified Body following material testing.

Each flange, elbow, piece of pipe and other component materials shall be clearly marked, so that they are readily identifiable with their test certificates and reports at all times. Marking shall be transferred to all pieces when a part is cut to make more than one component. Material without identification shall not be used in the manufacture of the BVA. The method of marking and marking procedures are subject to IO acceptance.

The hydrogenous materials (e.g. polymers, hydrocarbons) shall be excluded to the maximum extent possible for components in direct contact with the VVPSS system fluids containing radioactive materials including tritium due to hydrogen exchange leading to degradation of the components. Halogenated materials, sulphur and phosphorus, and processes involving the use of these materials, shall be excluded, when possible, for all components having a Tritium Classification.

Only materials listed in the Vacuum Handbook Appendix 3 [R32] of the ITER Vacuum Handbook are approved for use.

Materials not in the list can be added if demonstrated to meet the ITER requirements and approved by the IO.

All materials shall be new.

13.4 Counterfeit Materials

The Contractor shall include a section in the Quality Plan that defines the measures put in place to avoid the procurement of counterfeit materials. The full supply chain for all materials that are to be presented at the Manufacturing Readiness Review.

In addition to the material testing required in Section 13.3, confirmatory material composition and tensile strength testing shall be undertaken on samples taken directly from each batch of pressure boundary raw materials following their delivery to the Contractor's works.

14 Manufacturing Requirements

The detailed Quality Plan[R9], the Manufacturing and Inspection Plan[R10], work plans and procedures shall be developed by the Contractor. Work plans and procedures shall be developed by the Contractor for each step of manufacture. They shall be submitted to the IO for review and approval/acceptance. Manufacturing activities shall be carried out in accordance with the Manufacturing and Inspection Plan.

14.1.1 Welding Requirements

The welding procedures and welder's examinations for the BVA components shall be qualified in accordance with the code requirements of the project.

The BVA welds shall be executed under the Contractor's responsibility and in line with his experience. The Contractor shall demonstrate the required quality of the BVA welds to be in compliance with the specified leak tightness.

Each welding procedure that is to be followed in fabrication shall be included or cross-referenced in the MIP and weld map. Additionally, the procedures shall be included in the Weld Data Package.

All weld metal mechanical testing and prior welding procedure tests shall be performed on the weld test coupons.

During the welding process for the stainless steel piping, the inside of the root shall be protected by purging with a suitable inert gas to prevent oxidation. Oxygen concentration shall be monitored during welding.

During manufacturing, particular attention shall be given to cleanliness, especially the removal of weld spatter, debris and other foreign matter, particularly from the coolant passages. All surface treatment, cleaning, mounting, and vacuum acceptance testing of the RD assemblies shall be considered and accounted for in the design.

All burrs and rough edges shall be removed. For safe operation, the opened threaded holes shall be always closed by the removable plugs.

The hanging, lifting and RH lugs as well as the supports shall be attached prior to final NDE. The BVA shall not be lifted utilizing a single hanging/lifting lug. The material requirements for the lugs and supports shall be equivalent to the requirements of the pressure boundary materials.

All repairs, re-work, or scrapping shall be documented and records maintained for each specific item. The records shall relate repairs with the procedure used. A maximum of one weld repair cycle shall be permitted on austenitic stainless steel. The IO shall be notified in the event the weld repair is unsuccessful.

Grinding, surfacing equipment, tools and abrasives for use on corrosion resistant materials shall be new or not previously used on carbon steel or other metal(s)/alloy(s), such that contamination of the finished surfaces is completely excluded.

14.1.1.1 Welding Materials

The filler shall be qualified according to the approved weld procedure specification (WPS) and approved by the IO Welding Quality Control engineer. Filler metals and auxiliary materials shall comply with Section 328.3 of the ASME B31.3 [CS5] and be approved by IO.

The storage of the filler material shall be in a controlled environment (ventilated and dry). It is not allowed to place different types of filler materials in direct contact with each other. Contractor shall prepare a procedure or work instruction for filler material storage to be accepted by the IO.

Welding materials shall be identified and controlled so that they can be traced to each welding operation performed on the captive piping. The Contractor shall agree on a procedure for material traceability with the IO prior to commencement of the work.

14.1.1.2 Preparation for Welding

Preparation of piping welding shall comply with Section 328.4 of the ASME B31.3[CS5].

Parts to be joined by the fillet & groove welding shall be brought into as close contact with the base metal as is practical and aligned correctly in position with clamps, bolts or other suitable devices.

Arc ignition and arc quenching are prohibited beyond the welding area. Voltage, current level and shielding gas purging speed shall be recorded and meet the requirements of the approved WPS by the Contractor.

All welding processes may be single-pass or multiple-pass according to the welding size and length.

This entails cleaning of internal and external surfaces (Subsection 328.4.1), end preparation (Subsection 328.4.2), and alignment (Subsection 328.4.3). The surface within 50mm areas of the weld is to be deposited shall be smooth, free from cracks, fins, tears and other discontinuities which will affect the quality of the welding.

14.1.1.3 Full Penetration Welds

The welding processes for use on vacuum sealing welds shall be compliant for VQC-1A with the ITER Vacuum Handbook [R4] and the Vacuum Handbook Attachment 1 – Welding[R37]. For VQC-1A, the boundary to air full penetration welds is required in accordance with Section 7 of the ITER Vacuum Handbook[R4].

14.1.1.4 Weld Identification

Each weld shall be identified with a unique weld identification number on the weld control record or equivalent. Weld numbers shall be specified on the Contractor's drawings. The location of all welds shall be shown on the Contractor's drawings. All the joints shall be fabricated in accordance with the issued drawing, including the exact position, weld effective size and length.

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).

14.1.1.5 WPS and WPQR

In order for a WPS to be qualified, conformance with all of the applicable requirements of the relevant part of the ASME Section IX [CS8] is required for each type of joint, including the welding type, base metal type, filler material type, main WPS parameter, the fillet weld size and distance, etc. The WPS and WPQR shall be provided to IO engineer to review and approve by the IO one month before the welding erection.

14.1.1.6 Welding Repairs

Repairs shall be made using qualified personnel and qualified procedures prepared by the Contractor.

Welding repairs shall be in compliance with the following general requirements:

- All repaired welds shall be documented in compliance with the relevant code;
- NCRs shall be issued in case of welding repairs;
- Weld defects to be repaired shall be removed to sound metal;
- Preheating and heat treatments shall be as required for the original welding. Thermal processes dedicated to either the pipe or the weld shall not adversely affect each other;
- Repair welds shall be non-destructively tested to the same requirements as the original weld.

All repairs, rework, or scrapping must be documented, and records shall be maintained for the specific items involved. The location, depth and size of the area of all base metal weld repairs, regardless of depth of repair, shall be documented and provided to the IO.

The records shall relate repairs to the procedure used. A maximum of one weld repair shall be permitted on austenitic stainless steel without prior approval of the IO. Repairs that are performed due to the conditions determined from informational or inadvertent NDE but prior to final NDE shall be included in the repair cycle limit.

The IO shall be immediately notified in the event the second weld repair is unsuccessful, or any repair results in greater than 25% of the welds being removed.

Non-conforming conditions shall be promptly reported to the IO, upon identification of the Nonconforming condition. No further work shall be performed until the IO have approved the proposed disposition of the non-conforming condition.

Weld control records for all welds shall be available for review by the ANB and the IO.

14.1.2 Material Test Requirements

All tests shall be witnessed and approved by a notified body unless tests are carried out by an ISO 17025 [CS20] accredited laboratory. Where this is not possible, all tests shall be witnessed and approved by a notified body to be approved by the IO.

Non-destructive examination is defined as a Special Process.

All testing required by the ASTM standards for stainless steel material shall be performed. The Contractor shall perform the following tests and inspections:

- Cast analysis (if applicable);
- Magnetic permeability;
- Tensile;
- Tensile test at design temperature 250°C;
- Impact;
- Non-destructive electric;
- Visual examination;
- Dimensional inspection;
- Intergranular corrosion.

Test program and test procedures shall be submitted to the IO for review and approval. The test reports shall include certification that all requirements of this Specification have been met. The test required by this Specification shall be presented in the appropriate EN 10204 [CS21] certificate and also the Certificate of Compliance.

14.1.3 Surface Condition

The assessment of the surface roughness is defined as a Special Process.

Inner and outer surfaces of the welds shall be free of any injurious defects and free of any oxidation.

All wetted surfaces of the BVA(internal surfaces of the assembly) and sub-assembly shall be polished to a surface roughness (Ra) of less than 1.6µm.

The roughness of the metallic components for different VQC shall not exceed the maximum average surface roughness listed in Table 8-1, Section 8 of the ITER Vacuum Handbook[R4].

All other external surfaces of the vessels, including the external weld seams, shall have a mill finish.

The measurement of the surface roughness shall be performed in accordance with the ASME B46.1 [CS25]. The roughness cut-off value used in measurement shall be included in a roughness report that shall be included in the final documentation package

14.1.4 Repair by Welding

Repair of the BVA by welding is not permitted.

14.1.5 Dimensions and Tolerances

The dimensions, shape and tolerances of the manufactured BVA shall comply with the ISO 2768-mK standard [CS26][CS27]. The ISO 286-1 standard [CS28] shall be followed for limits and fits. For welded parts, dimensions and tolerances shall be in compliance with the ISO 13920 [CS29].

When dimensions, sizes, or other parameters are not specified with tolerances, the values of these parameters are considered nominal and allowable tolerances or local variances may be considered acceptable when based on engineering judgment and standard practices as determined by the designer. Resolution of design tolerances not specifically covered by this specification shall require review and approval by the IO.

All repairs, rework, or scrapping shall be documented and records maintained for the repairs, rework, or scrapping performed on specific items. The records shall relate repairs with the procedure used. All repairs shall be submitted to the IO for review and approval.

14.2 NDE Examination

The Contractor shall perform the examinations for the work scope described in this Specification, in accordance with the specific NDE requirements for the BVA and in compliance with the ASME Sections V Nondestructive Examination [CS8] and the ASME B31.3 Process Piping, Section X302.2.2 [CS5].

All full penetration welds shall be subjected to 100% volumetric and 100% visual examination. Liquid penetrant testing (LPT) and magnetic particle techniques are not applicable for the NDE examination of the RDA piping components.

Volumetric examination shall be performed using radiographic testing (RT). Ultrasonic testing may be used where RT is not possible and by specific IO approval of the procedures to be used.

For all VQC-1A vacuum boundary welds of the BVA which become inaccessible, 100% volumetric examination of production welds shall be performed. All welds shall permit the volumetric examinations to be performed in accordance with the applicable codes and standards.

All vacuum sealing welds in each VQC shall be subject to helium leak testing, in accordance with the Section 25 of the Vacuum Handbook [CS5]. Welds shall be made in such a way that they can be leak tested at the time of completion.

Welds that cannot be inspected are not permitted for use on VQC-1A.

In addition to the ASME B31.3 [CS5] requirements for Category M piping for NDE, the requirements for the piping components listed in Table 5 apply:

Component	Required NDE
Full penetration weld	Visual examination: 100% Volumetric examination: 100%

Table 5. NDE requirements for piping components

14.2.1 Examination Personnel

Examination personnel shall be qualified and certified at least Level 2 in accordance with the requirements of the ISO 9712 - Non-destructive Testing - Qualification and Certification of NDT Personnel [CS23] or Section 342 of ASME B31.3 [CS5].

The Contractor shall provide to IO the NDT/NDE qualification certificate of the personnel.

14.2.2 NDE Qualification and Responsibility

Any examination shall be performed in accordance with a written procedure that conforms to one of the methods specified in the Section 343 and 344 of ASME B31.3 [CS5] and/or the ISO 9712 - Non-destructive Testing - Qualification and Certification of NDT Personnel [CS23].

Welded joints shall comply with the requirements specified by the design and manufacturing codes.

14.2.3 Visual Examination

Visual examination shall be in accordance with the ASME B&VP Code Section V Article 9 [CS8].

14.2.4 Radiography Examination

Radiographic examination shall be in accordance with the ASME BVP Code Section V Article 2 [CS8]. Radiography shall be performed after final post weld heat treatment.

14.2.5 Ultrasonic Examination

Ultrasonic examination shall be in accordance with the ASME BVP Code Section V Article 4 [CS8].

14.2.6 In-Process Examination

In-process examination shall be as required by the Section 344.7 of ASME B31.3 [CS5]. Dimensional and layout check is included as part of the in-process examination. The dimensional, geometry and layout check of all the manufactured/installed pre-assembly piping components run shall be carried out as per approved fabrication drawings.

14.2.7 Dimensional Inspection

The Contractor shall perform a dimensional inspection on the BVA. The dimensions shall meet the dimensional requirements as specified in the engineering drawings of the approved design of the BVA. The Contractor shall provide a dimensional compliance certificate/dimensional inspection report for the manufactured BVA to the IO for approval.

14.2.8 Surface Finish Check

The Contractor shall perform the required surface roughness measurements on the BVA piping. The Contractor shall provide the surface roughness measurement reports to the IO for approval.

14.2.9 Acceptance Criteria

The acceptance criteria shall meet the requirements stated in Table 341.3.2 of Section 341.3.2 of ASME B31.3 [CS5].

14.2.10 Progressive Sampling for Examination

An examined item with one or more defects shall be repaired or replaced; the repair shall be reexamined using the same methods, extent and acceptance criteria as the original work.

14.2.11 NDE Records

The IO reserves the right to inspect all NDE reports for auditing purposes. NDE reports shall be catalogued according to the weld maps.

15 Service Conditions

All service conditions are presented for the BVA.

15.1 Normal Environmental Conditions

Normal environmental conditions (external to the BVA) in the NB Cell during normal operation of the ITER machine:

- Temperature (maximum excursion range in the room): between 18°C and 35°C
- Humidity: up to 60%
- Pressure 99.86-101 kPa
- Magnetic field: up to 173 mT
- Total integrated dose at 1.5 m above the floor: 1.6E+5 Gy (gamma equivalent)
- Neutron Fluence: 4.5E+14 n/cm^2 @ 1Mev silicon based
- Neutron Flux: 1.1E+10 n/cm^2/s

15.2 Accidental Environmental Conditions

Accidental conditions (external to the BVA) in the NB Cell are:

• Accidental event NB Cell Internal Explosion following hydrogen-dust explosion in the VV:

- Temperature (up to 345°C)

- Pressure (peak, up 200 kPa)

- Humidity (peak): 100%.

Note: The BVA is housed within a thermal insulation box, which is covered by the PFP insulation to protect from overheating in the event of a fire. The insulation has a thickness of 50mm.

15.3 Seismic Events

The BVA&RDA and their supports are the Hardened Safety Core Component and as such shall be capable of withstanding the accelerations associated with an SL3 seismic event without loss of structural integrity.

16 Qualification Requirements

16.1 Qualification Process

The BVA shall be qualified as PIC components in accordance with the equipment qualification requirements presented in the RCC-M Volume Q [R4] and the ITER Qualification of Protection Important Components (PIC) [R43]using applicable documentation, methods, tests and procedures for the BVA qualification to meet with the qualification requirements specified in this Specification.

Qualification shall provide documented evidence that the equipment is able to fulfil its safety functions in all postulated normal and operating conditions in which it is required and during the required operating period.

The BVA is an active mechanical equipment.

The qualification process might consider the following methods of qualification applicable for nuclear installations:

- Qualification by analysis
- Qualification by testing
- Combined method

The methods above might be used in combination, as necessary.

IO is responsible for all Bleed Valve qualification and the BVA qualification by analysis, as part of the overall qualification of the BVA assembly. The contractor is responsible for the BVA qualification by testing. The qualification by analysis is considered only a part of the overall qualification process. The qualification documents prepared by the Contractor will be included in the BVA Qualification Synthesis Report, which is compiled by the IO.

Note: the Contractor is invited to provide information regarding its qualification experience and capabilities during the bidding process.

The BVA qualification process can be illustrated in a flowchart, as shown in Figure 21:

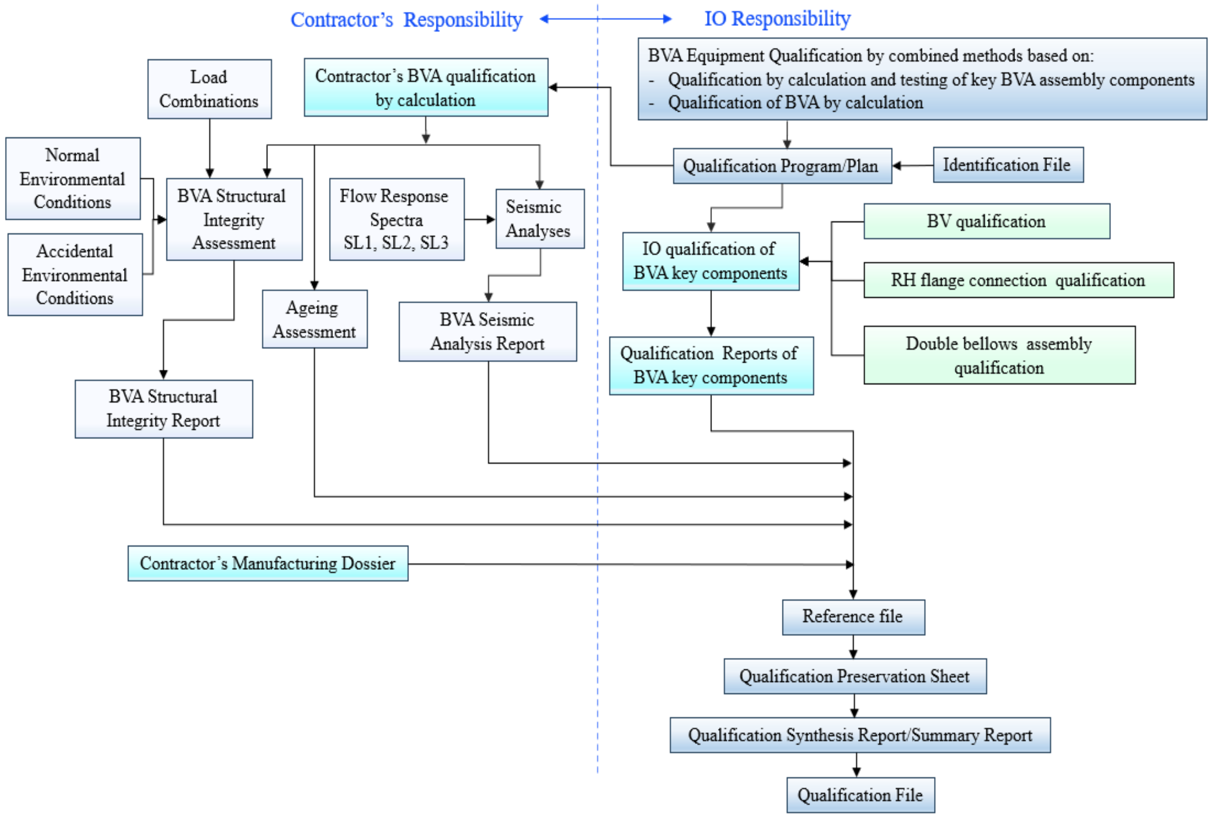

Figure 21. Flowchart of the overall BVA qualification process

The contractor should perform the following scope of qualification activities: Overall assembly qualification of the BVA in accordance with the overall Qualification Plan, including assessments under normal and accidental conditions, ageing effects, and functional performance in static magnetic fields.

- BVA Qualification Documentation:
  - Identification File
  - Qualification Synthesis Report

Includes:

- Contractor's qualification documents
- Qualification documentation for the key BVA components
- IO additional qualification documents (if need)

- Qualification Preservation Sheet
- Reference file
- Qualification File.

The Contractor shall prepare and submit to the IO for review and approval a Qualification Plan for the qualification by calculation following the RCC-M Volume Q [CS4] or a Qualification Plan as named in the ITER Qualification of Protection Important Components (PIC)[R43]. The Qualification Program/Plan defines the procedures and the methods to demonstrate the qualification of PIC equipment. It shall be established at the beginning of the qualification process.

The Contractor shall propose the Qualification Plan [R43] covering the qualification of the BVA by the calculation in accordance with the IO Qualification Plan and the Template for Qualification Plan [50]. The Qualification Plan shall address the strategy for qualification adopted, the targets of the qualification, the methods, the tools and the expected results. The Contractor shall demonstrate, through calculations in accordance with the BVA Qualification Plan, that the assembly can perform its safety functions. The BVA calculation is Protection Important Activity (PIA). The Contractor's Qualification Plan shall be submitted to the IO for review and approval.

The Contractor can follow the ITER Guidelines for Qualification of Mechanical Equipment [R44] to perform the BVA qualification process and the qualification documentation.

16.2 Lifetime

The BVA shall be designed for an operating lifetime no less than 20 years, PR895-R[R53].

From an equipment qualification, the equipment lifetime is considered to begin at the end of manufacturing. Therefore, time spent in storage (e.g., in the warehouse) and during installation is included in the total lifetime. In this context, the qualified lifetime of the equipment shall be no less than 25 years.

16.3 Acceptance Criteria

Characteristics that are verified during the qualification procedure shall be explained in the Qualification Plan together with target values or limits that enable the declaration that qualification has been achieved.

16.4 Contractor's Qualification Documentation

The Contractor shall prepare and submit to the IO the Qualification Documentation for the BVA by calculation. It includes, but is not limited, the following detailed list of deliverables:

- Identification File
- Qualification Plan for qualification by calculation
- Structural Integrity Report
- Seismic Analysis Report
- Ageing Assessment Report.

The Contractor shall produce the qualification documentation in format adopted by the IO and with quality sufficient for communication it to the ASNR.

17 Cleaning, Pickling and Passivation

The BVA shall meet the cleanliness requirements of the ASME NQA-1 (Subpart 2.1) Cleanness Class B for internal surfaces and Cleanness Class C for external surfaces [CS12].

All BVA components shall be thoroughly cleaned of mill scale, heat treating scale, heavy oxide, slag, flux, oil, grease, organic matter, dirt, oxide stains, or any other foreign materials.

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. Only clean stainless steel brushes, chipping hammers, and grinding wheels, surfacing equipment, tools and abrasives for use on corrosion resistant materials shall be new or not previously used on carbon steel or other metal(s)/alloy(s), such that contamination of the finished surfaces is completely excluded.

The stainless steel components shall be passivated as the final stage in cleaning prior to shipment. The passivation shall be performed with a chemical treatment of the stainless steel with a mild oxidant, such as a nitric acid solution, to enhance the spontaneous formation of the protective passive film.

The pipes, piping fittings and flanges shall be pickled and passivated in accordance with the ASTM A380/A380M [CS15].

High-quality water shall be used to clean pipe products. The minimum requirements for the high-quality water are given by the Table 304.1 of ASME NQA-1 (Subpart 2.1) [CS12].

Cleaning procedures, including pickling and passivation procedures, shall be submitted to the IO for review and acceptance prior to the start of production.

18 Marking & Labelling

To comply with the requirements of nuclear and other regulations and realize the full traceability and item control process throughout the project lifecycle the procedures for identification and item control shall be executed in line with .

All components and the main subcomponents shall be clearly marked in a permanent way and in a visible place with the IO official numbering system according to the Procedure for Labelling on Physical Items[R17].

18.1 Identification

The BVA shall provided with a permanently attached nameplate made of the same material as the assembly, in a location where it is readable. The nameplate shall include at least the following information:

- Assembly name and number
- Safety class
- Quality Class
- Name and address of the manufacturer and, where appropriate, of the authorized representative established within the Community
- Year of manufacture
- Maximum allowable internal pressure(PS, bar-g)
- Minimum internal pressure(Pmin,int, bar-g)
- External working pressure(Pext, bar-g)
- Maximum external pressure(Pmax,ext, bar-g)
- Volume V of the pressure equipment in L
- Maximum allowable temperature associated with PS (TS Max in °C)
- Minimum allowable temperature (TS min in °C)
- Test pressure PT applied in bar-g and date
- Intended use

- Tare mass in kg
- Fluid type and group.
- INB number.

Final nameplate information shall be approved by the IO.

The nameplate and attachment shall be such that removal shall require wilful destruction of the nameplate or its attachment system. The attachment weld to the pipe shall not adversely affect the integrity of the pipe. The nameplate area shall be identified as a low stress area. A qualified welding procedure shall be used to attach the nameplate to the pipe. The nameplate and its bracket shall be of the same material as the pipe.

Evidence shall be provided (i.e. pictures or inspection reports) to the IO that the markings and labelling requirements are fully respected prior to sending the goods.

In addition to the requirements for marking specified in the ASTM A312/A312M [CS14] the following requirements shall be satisfied:

- Each piece of pipe and bellows shall be clearly marked in a permanent way and in a visible place. The BVA shall be marked in line with the IO numbering system. The PNI identification marks will be provided to the Contractor following initiation of the contract;
- A detailed 'IO component identification standard' together with printed label templates and RFID tagging standards will be provided by the IO;
- Marking shall utilize marking paint or ink;
- Marking paint or ink shall only be applied to the external surfaces
- 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. Marking paint or ink shall have a halogen content <200 ppm.
- Fluids used for marking shall be approved by the IO;
- Readily identifiable with their test certificates and reports at all times.

18.2 Paint

No Marking paint on the BVA shall be allowed.

The Carbon steel Support Frame and plates shall be painted. The paint shall be a 3-layer epoxy coating that meets the requirements for Zone II coatings as defined in IO Technical specification for Coating and Tagging [R60]. The finish coat colour shall be RAL 7035 (grey).

19 Documentation

All documentation shall be in English language with the International System of Units.

All drawings shall be clean and legible white prints with uniform background density suitable for electronic scanning and subsequent reproduction. Electronic formats of all documents shall be agreed and approved by the IO. All documents shall be submitted in PDF files and native format, or another electronic format if mutually agreed upon.

The drawings shall contain at least component identification, materials, equipment design characteristics, fabrication inspection, finish treatment, dimensions with allowable tolerances and miscellaneous where appropriate.

The quality of reproductions shall be of such clarity as to produce a third generation copy which will meet the legibility requirements stated above.

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.

Supplier shall submit documents/data through electronic transmission (e-mail or FTP site) as PDF files and native format. Hard copies may be submitted in addition to electronic transmission. Hard copies shall be submitted rolled but shall not be folded.

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.

19.1 Manufacturing Dossier

A Manufacturing Dossier shall be provided and organized in the manner below. Note that the identified documents shall be provided but are not limited to those identified.

Section 1 – Table of Contents

Section 2 – Contract Documentation

- Final Technical Specification
- Quality Plan
- Manufacturer Declaration of Conformity
- Certificates of Conformance

Section 3 – Design Documentation

- As-Built Drawings
- Bill of Material
- Deviation Requests
- Clarification Requests
- Manufacturing Readiness Review Report

Section 4 – Material Documentation

- Material Test Reports / Type 3.1 or 3.2 Certificates
- Material Supplier's Quality System Certificate
- Full Supplier List
- Consumables List

Section 5 – Fabrication Documentation

- Completed / Signed off Manufacturing and Inspection Plan
- Clean Work Plan
- Heat Treatment Reports including Temperature Measurement Data
- NDE Reports
- Surface Roughness Measurement Report
- Visual Inspection Report
- Inspection Reports with complete dimensional and tolerance evaluation
- Certificate of Cleanliness
- Contractor Deviation Request (CDRs) if any
- Non-conformance Reports and Deviation Notices if any
- Drawing Showing Identification Markings Locations and RT Station Marker Origins

Section 6 – Procedure Documentation:

- Manufacturing Procedures (Special Processes)
- Permanent Marking and Labelling Procedures
- Qualifications of the Personnel for Manufacturing Special Processes
- NDE/Inspection Personnel Certifications
- Calibration Certificates for Measurement and Test Equipment
- Test Procedures of tests performed on the BVA

Section 7 – Delivery Documentation

- Packing and Shipping Procedures
- Photographs of Packaged BVA
- Contractors Release Note
- Delivery Report

19.2 List of Minimum scope of supply

The Contractor shall provide paper copies of the original manufacturing drawings, Final Report as described above ranged in folders, NDE records and X-ray films.

The scope of supply under this Specification shall include as a minimum:

a) Quality Plan

b) Manufacture and Inspection Plan

c) Schedule of supply

d) Clean Work Plan

e) Material certificates

f) Material test reports

g) Component design including all specified systems and connections

h) Structural integrity analysis and seismic assessment reports

i) Pressure loss assessment report

j) Manufacturer's specifications

k) Manufacturing, inspection, examination, and test procedures

l) Certificates of personal qualification

m) Inspection, examination, and test reports

n) Cleaning, preservation and packaging reports

o) Transportation and delivery of the component, fully equipped with all specified systems and connections, to the IO site

p) Delivery to the IO site the following:

- Two bellows assembly clamps
- Six spare metallic (silver) jacketed HELICOFLEX seals for the DN300 flanges

q) Assembly of all the components with RDA on support Main Frame

r) Final Documentation Package (Manufacturing Dossier)

s) Equipment Qualification Documentation

t) Other documents specified in this Specification

20 Packaging and Handling

The Contractor shall make provision for storage of the BVA at the manufacturing site for up to 3 months.

The packaging for the BVA shall provide protection from physical and mechanical damage and shall meet the minimum requirements of Level B for overseas shipment in accordance with the ASME NQA-1 [CS12].

The requirements associated the VQC-1A classified components shall be respected during packaging, handling and storage.

The BVA shall be capped, plugged, and sealed. Weld end preparations shall be protected from corrosion and physical damage.

The Contractor shall design and supply appropriate packaging, adequate to prevent damage during shipping lifting and handling operations.

The BVA and its components shall be moved during handling only by halogens free fabric belts or similar. Use of PMUC certified materials or equipment shall be acceptable.

The Contractor shall avoid contact with any fluorides, Cu, Pb, Zn, sulphur, chlorides or mercury compound.

The Contractor shall submit the preservation procedures to the IO for review and approval.

Accelerometers shall be fitted to the packaging and shall be capable of recording the acceleration along three perpendicular directions.

After packaging, a “Declaration of Integrity” document ensuring the integrity of the items and the packages shall be created. This “Declaration of Integrity” shall be included within or referenced within the Delivery Report.

Each shipment shall be accompanied by a Delivery Report prepared by the Contractor in accordance with the requirements of the Quality Requirements for IO Performers [R9] in line with the Delivery Report Template[R18].

The Packing List shall be visible at all time.

The Delivery Report shall be signed by a representative of the IO and its Contractor.

21 Deliverables and Schedule Milestones

21.1 Schedule for Delivery

The estimated duration of this contract is 24 months from the Kick-off meeting. The contract schedule is presented in Table 6:

No	Deliverable	Descriptions	Estimated Date for Deliverable
D1	Minutes	Kick-off meeting minutes	T0
D2	Quality Plan	Quality Plan	T0 +0.5 months
D3	Progress report	Monthly progress report	Monthly since T0+1

D4	Documentation for Manufacturing Readiness Review	The following documentation shall be submitted to the IO, reviewed and approved: - Final 3D model - Manufacturing and Inspection Plan - Material test certificates 3.1 or 3.2 of all materials - Manufacturing drawings of the components - General assembly drawings - Bill of materials - Procedures of all Special Processes - Technical specification for procurement	T0 +6.0 months
	Hold Point 1	Manufacturing Readiness Review (MRR). IO provides approval to start manufacturing activities.	T0+6.5 months
D5	FAT of components	Completion of manufacturing of the components in the contractor's factory, and their acceptance by testing or inspection.	T0+15 months
D6	Delivery	Deliver the components to IO site	T0+17 months
D7	Site Acceptance Testing	SAT testing of the BVA and other components	T0+ 23 months
D8	Documentation delivery	All documentation required under the contract	T0 + 24 months
D9	Receiving Inspection	Formal acceptance of the completed assembly by IO	T0 + 24 months

Table 6. *List of deliverables and due dates*

T0 is the date of the Kick-off meeting to be held by both Parties within 5 working days from the contract signature.
If necessary, the IO TRO may request the additional meeting on the IO site to review the Contractor's data.
The items shall be delivered to the following address:
ITER Organization,
Route de Vinon-sur-Verdon
CS 90 046
13067 St Paul Lez Durance
France

21.2 List of Deliverable Documentation

The Contractor shall deliver the components to the IO site.

Before the shipment, a Release Note shall be prepared in accordance with the requirements of the Quality Requirements for the IO Performers [R9] in line with the Release Note Template [R25] and approved by the IO.

The following documents will be submitted to IO to logistics.data@iter.org at least 15 working days prior to the planned shipment date:

- Release Note [R25]
- Delivery Report [R18]
- Packing List [R23]
- Equipment Storage & Preservation Requirements Form[R22].

Notification of the shipping shall be also sent to: logistics-planning@iter.org

Upon receipt of the package, the IO shall open the package and make a visual inspection of its content to check:

- The integrity of the package, including identifying visible damage;
- The number and type of components contained in the shipment;
- The enclosed documentation;
- The reading of the accelerometers or other sensors;
- The integrity of the components.

In the case of anomalies the IO shall make any additional relevant remark on the inspection.

The IO will inspect the accelerometers or other sensors mounted on the boxes. If these accelerometers record shocks above 4g, a thorough inspection of the components shall be performed. A decision on acceptance of the delivery of the components will be made by the IO.

If the components are in an acceptable condition, the IO will sign the Delivery Report. The signature of the Delivery Reports is an IO Hold Point.

The original of the Delivery Report shall be kept by the IO and a copy of it shall be kept by the Contractor.

Declaration of conformity to be signed by the Contractor and enclosed with Packing List.

22 Appendix 1: Reference Nodes Location

There is one Global Coordinate System for the ITER site (see Figure 22). This system is referred to as the Tokamak Global Coordinate System (TGCS). The origin of the TGCS is the nominal centre of the Tokamak machine. ITER project uses the metric system (SI).

This coordinate system is selected is to make the referenced locations of the BVA assembly relative to the Tokamak machine to which it is connected. Due to the size and location of the BVA it cannot be defined well with other local coordinate Systems. The location and coordinates of this system are clearly defined by the ITER Design Office. They are defined by a translation (in the X, Y and Z Directions) and a plane rotation (measured in degrees, clockwise direction) with respect to the TGCS.

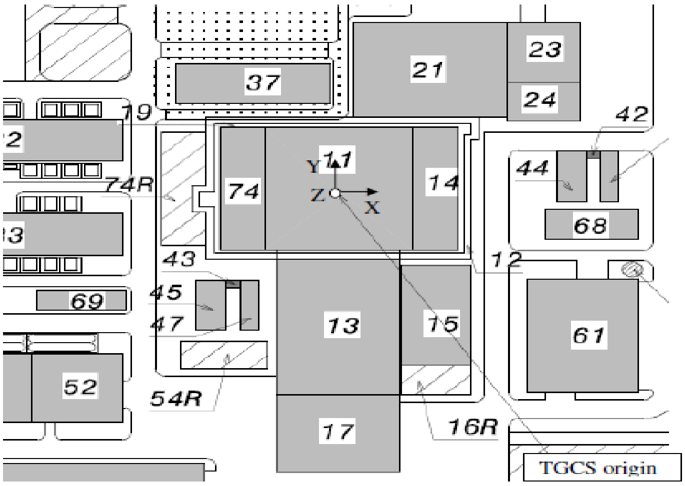

Figure 22. Definitions of Tokamak Global Coordinate System

The TGCS origin coordinates can be described with the French Lambert III and NGF-IGN69 systems, as described above and as follows in Table 7.

ITER TGCS (Tokamak Global Coordinate System) (m)	Lambert III and NGF-IGN69 (m)
X = 0.000	X = 877220.160
Y = 0.000	Y = 162276.390
Z = 0.000	Z = 316.680

Table 7. TGCS origin coordinates in the French System

The TGCS is rotated on the Z axis in counterclockwise direction precisely by 37.0 degrees relative to the Geographic North (see Figure 23).

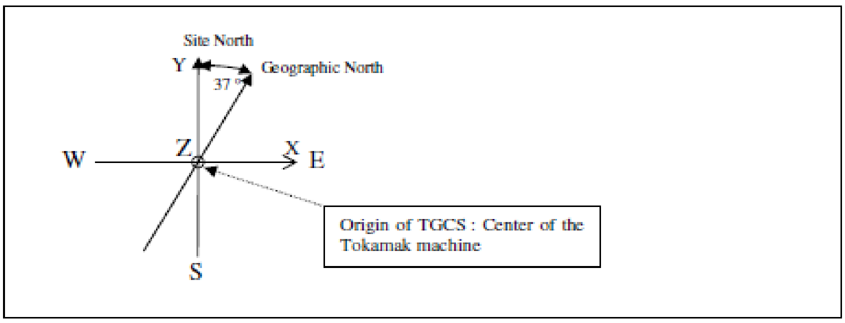

Figure 23. Rotation of the TGCS with respect to the Geographic North

In the TGCS, the X axis direction indicates the "East" of the site, and the Y axis direction indicates the "North" of the site, called "Site North".

The BVA assembly is placed in NB Cell on level L1 (yellow mark, see Figure 24).

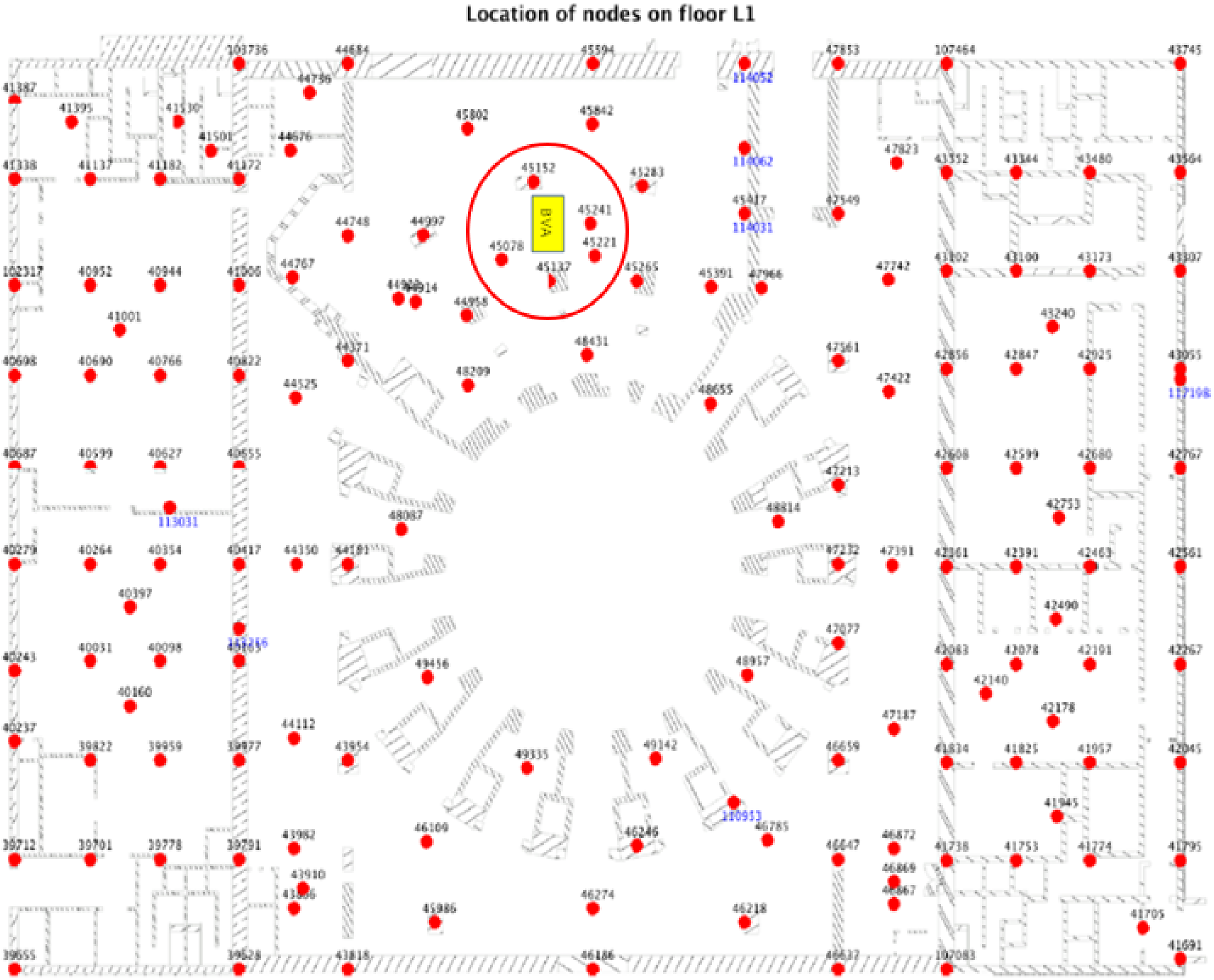

Figure 24. Node's location on floor L1

FRS at nodes 45078, 45137, 45152, 45221, and 45241 have been enveloped to determine the applicable FRS for the BVA in each direction, as shown in Figure 25 - Figure 33.

Coordinates of the reference's nodes are presented in Table 8:

Reference node	Floor	X	Y	Z
45078	L1	-9.16	26.87	-0.25
45137	L1	-4.41	24.98	-0.25
45152	L1	-5.95	33.80	-0.25
45221	L1	0.18	27.22	-.025
45241	L1	0.21	30.08	-0.25

Table 8. Coordinates of the reference nodes

23 Appendix 2 - Seismic Event Floor Response Spectra

23.1 Damping Factors

The BVA is part of the VVPSS Relief Piping system and shall have the damping factors defined by[R27]:

System	Description	SL-1	SMHV and SL-2	SL-3
Piping	Piping system	3%	4%	5%

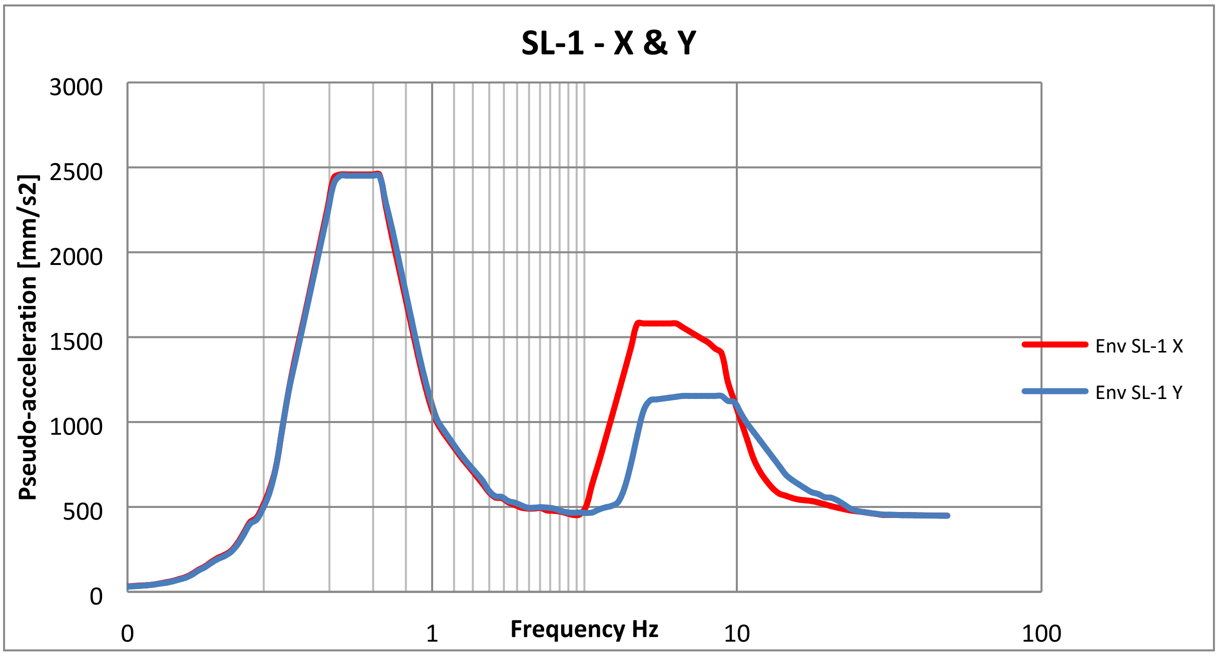

Figure 25. FRS - SL-1 - Horizontal (X&Y direction)

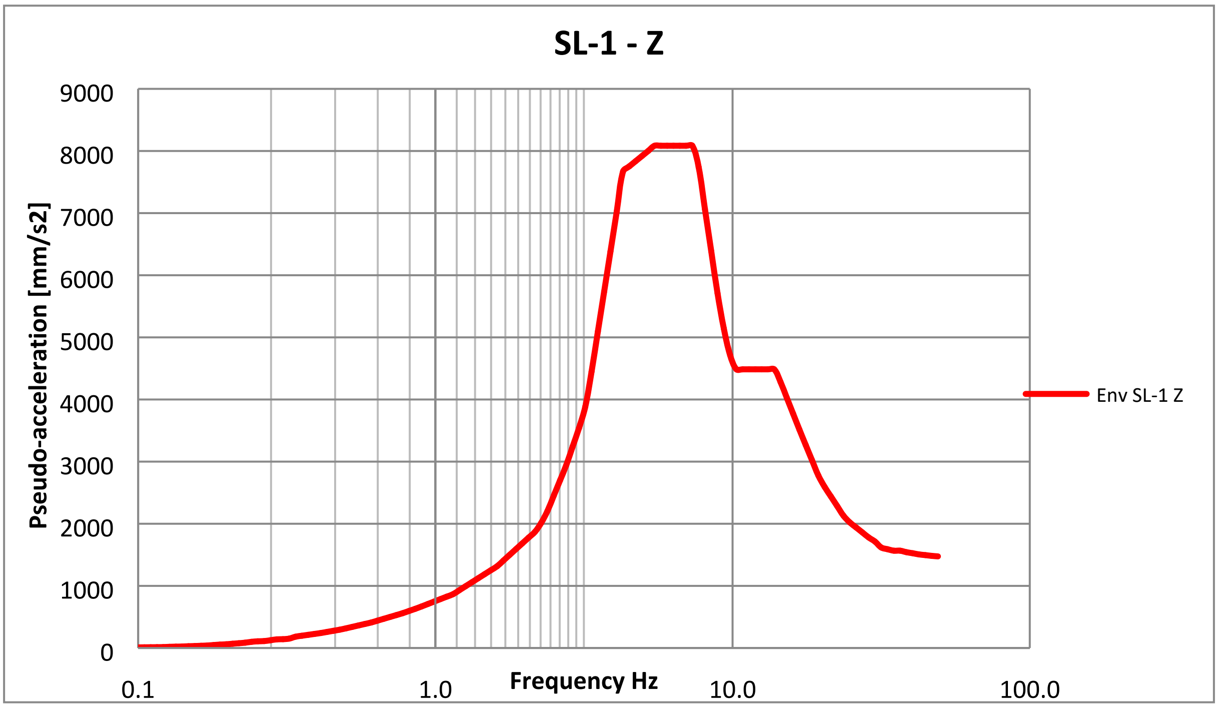

Figure 26. FRS - SL-1 - Vertical (Z direction)

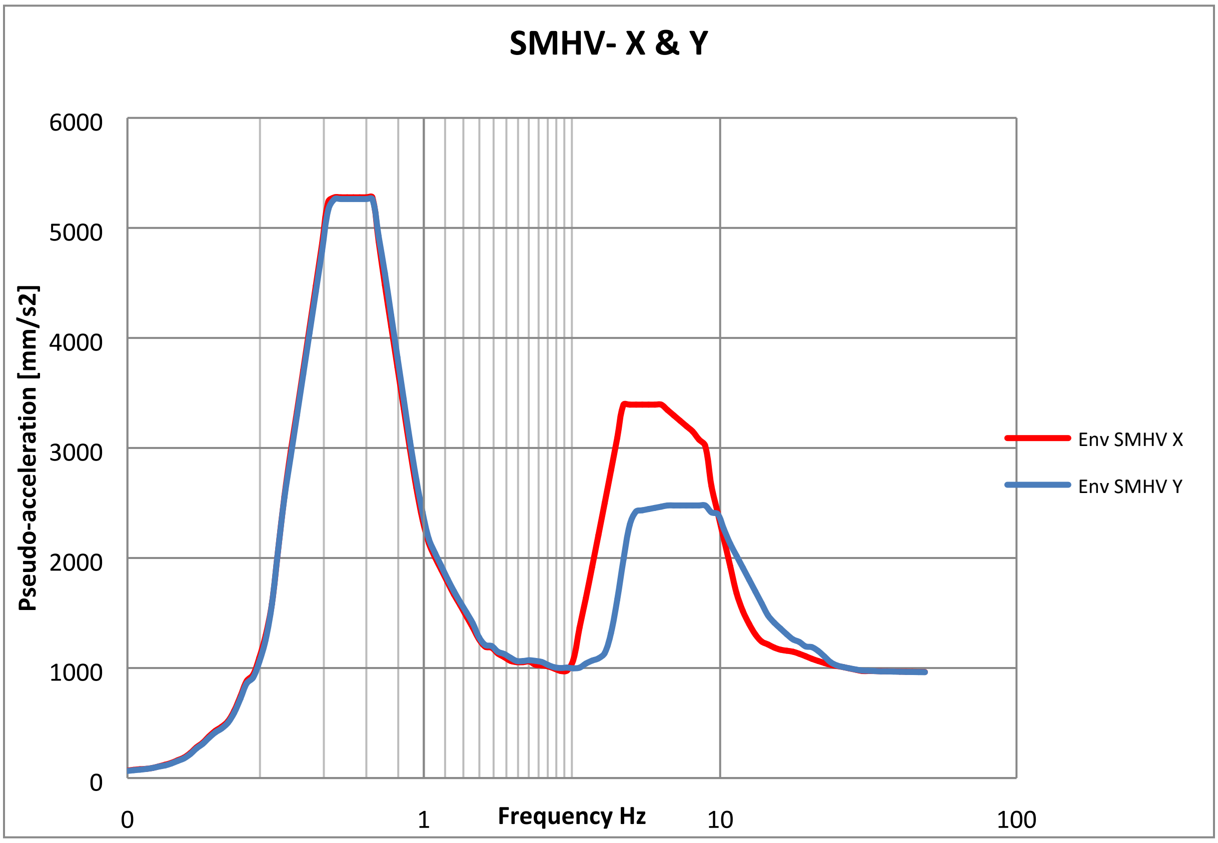

Figure 27. FRS - SMHV - Horizontal (X&Y direction)

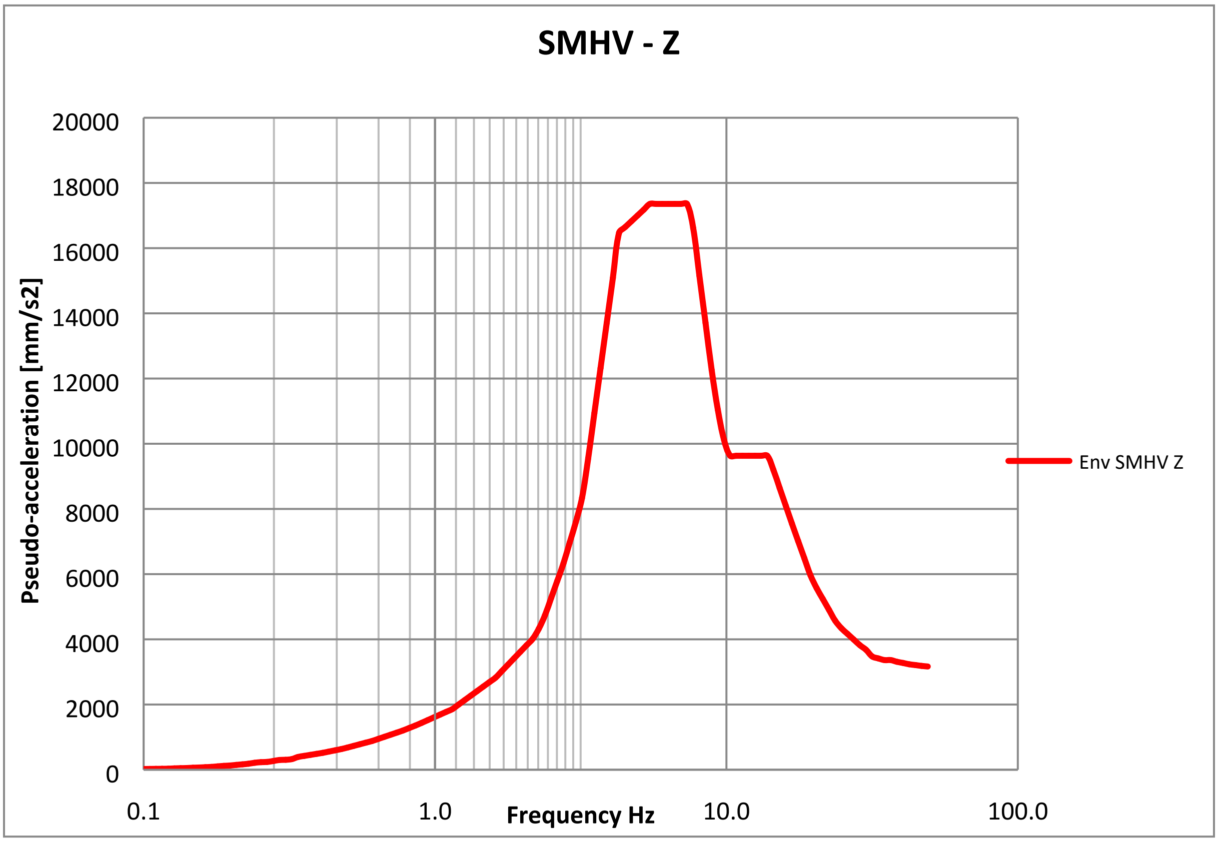

Figure 28. FRS – SMHV - Vertical (Z direction)

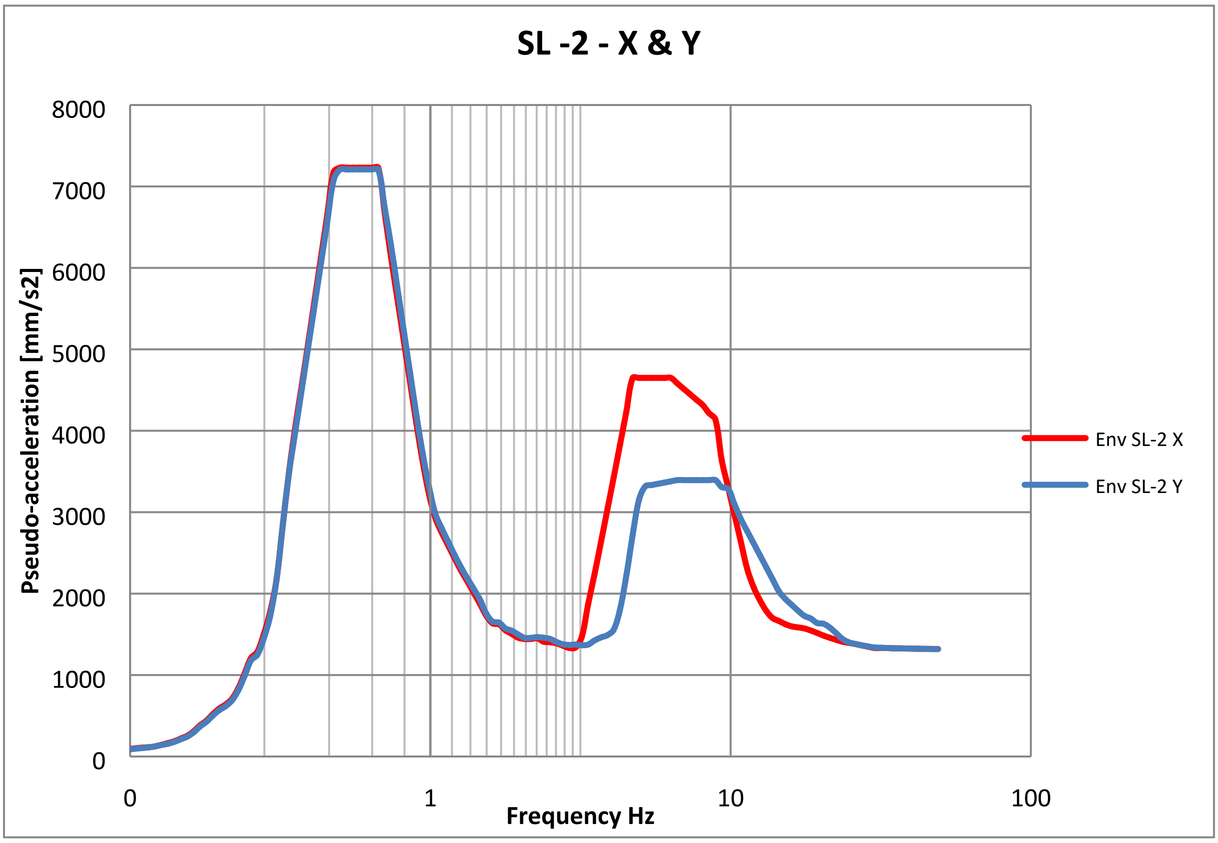

Figure 29. FRS - SL-2 - Horizontal (X&Y direction)

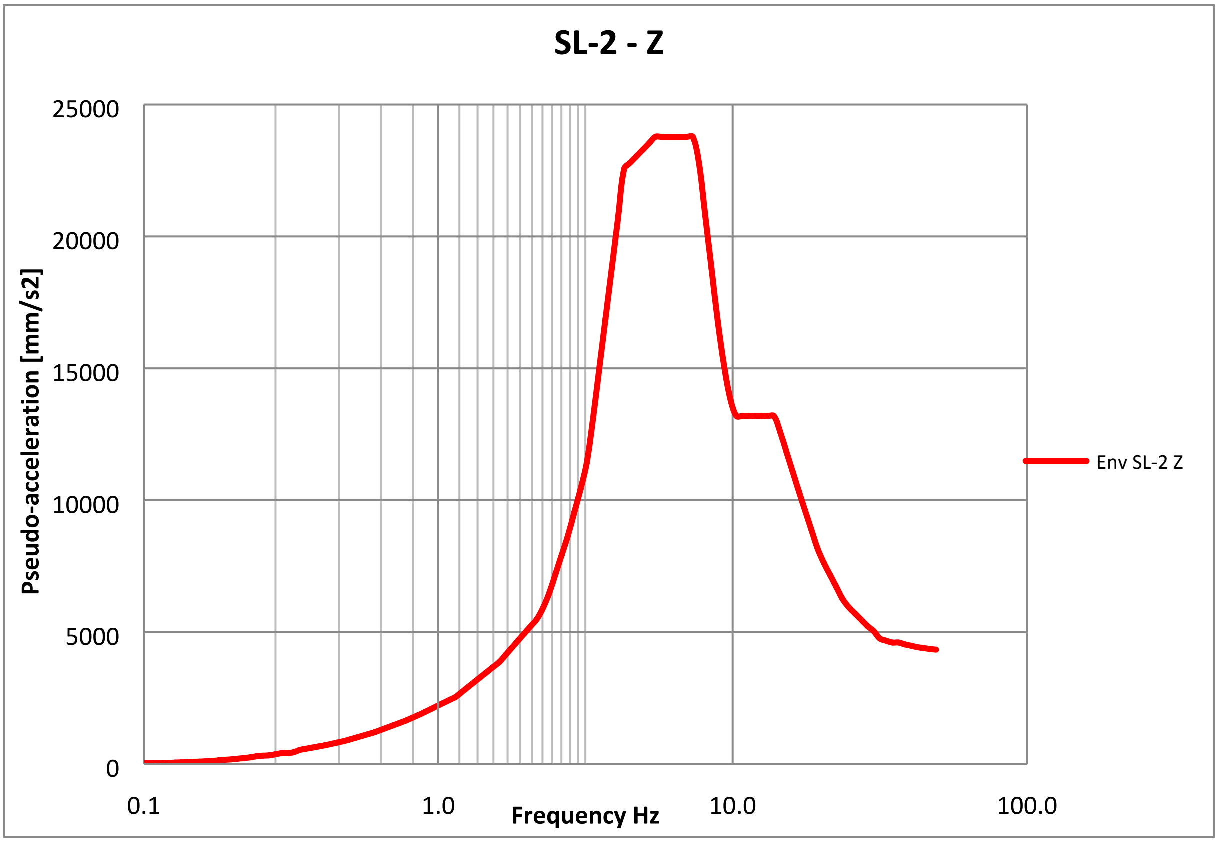

Figure 30. FRS - SL-2 - Vertical (Z direction)

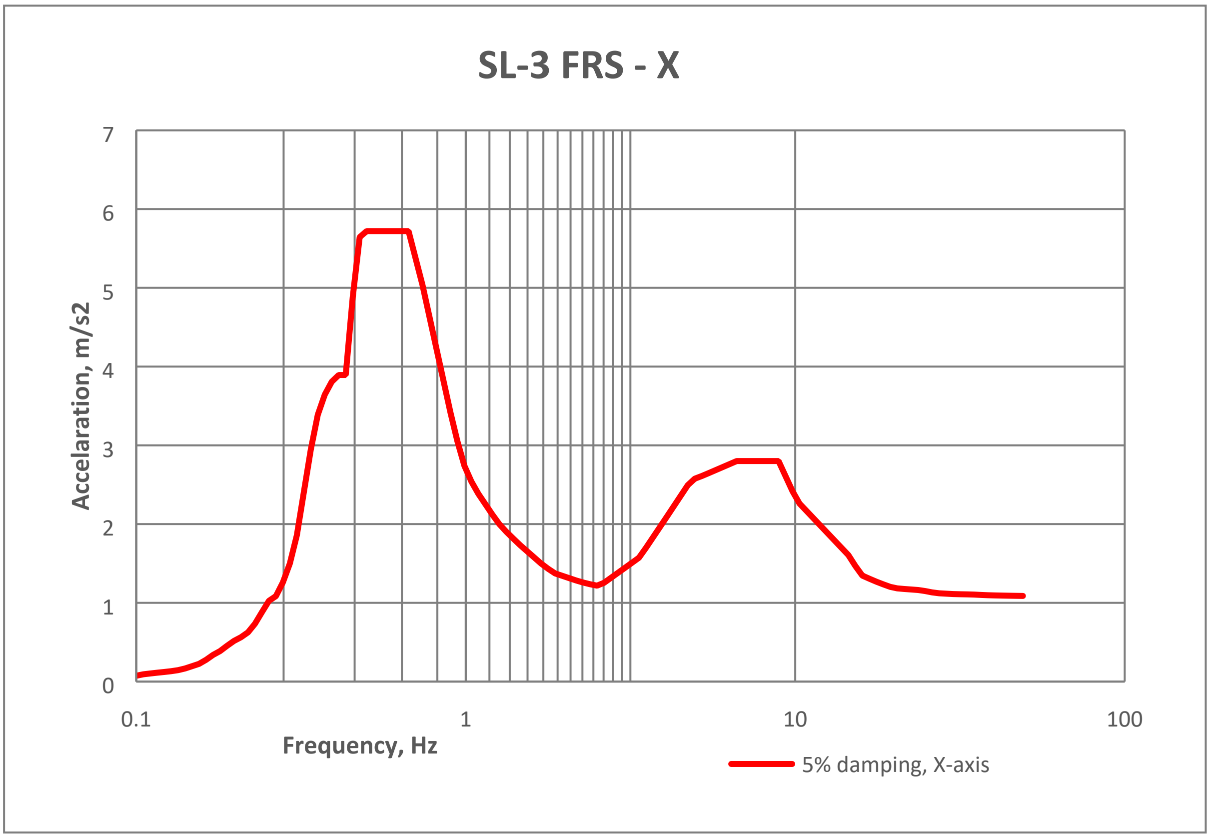

Figure 31. FRS – Envelop SL-3 - Horizontal (X direction)

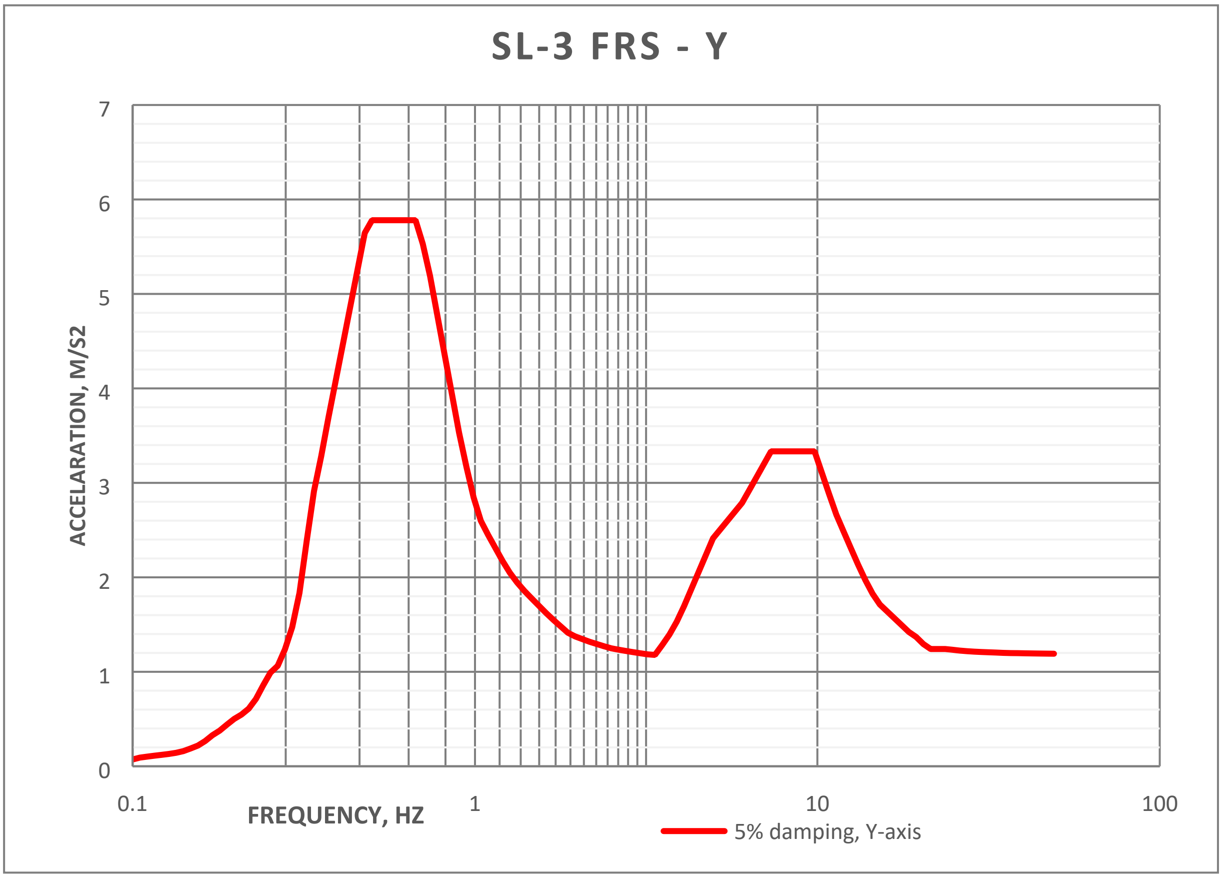

Figure 32. FRS – Envelop SL-3 - Horizontal (Y direction)

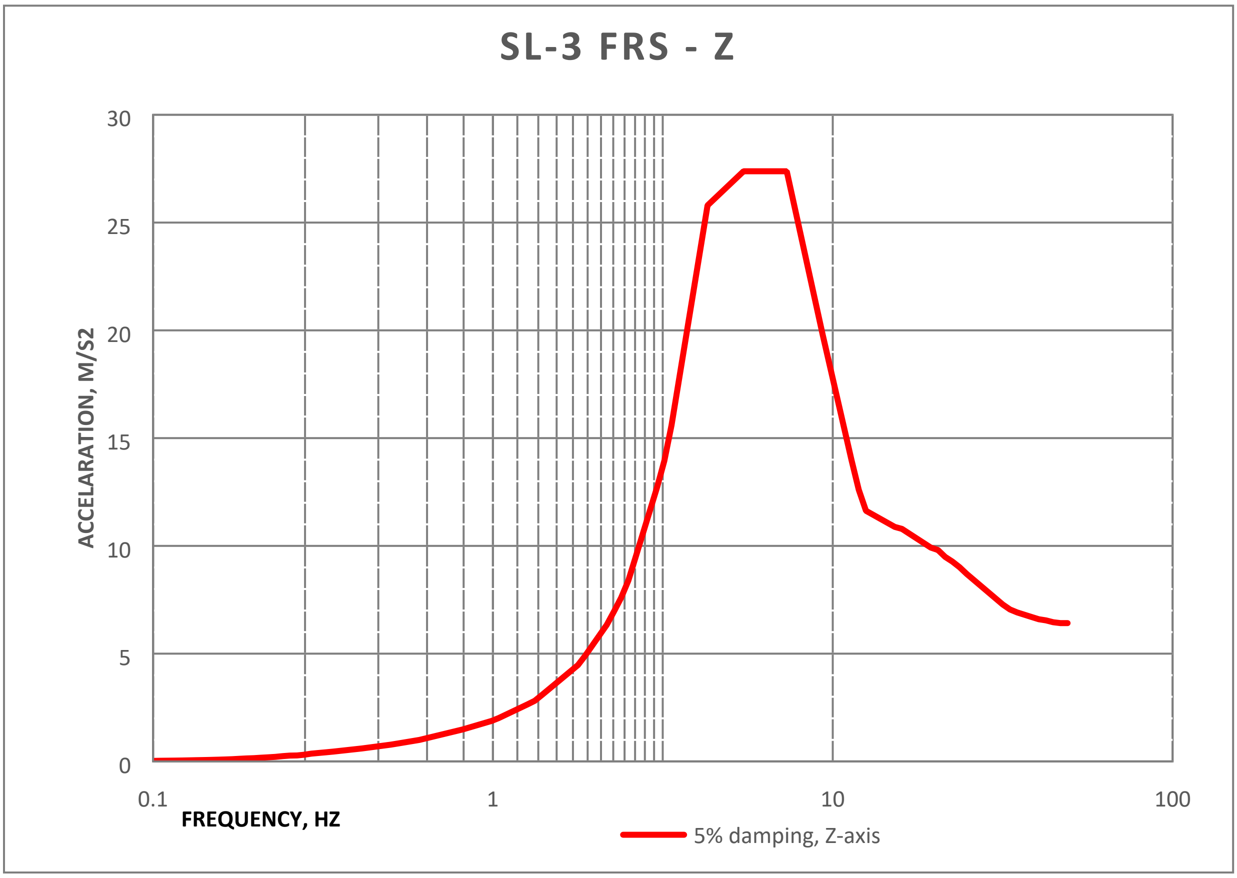

Figure 33. FRS – Envelop SL-3 - Vertical (Z direction)

23.2 FRS – SL-1 and SMHV spectrum

Frequency	SL-1 Design FRS			Frequency	SMHV Design FRS		
Hz	X[mm/s2]	Y[mm/s2]	Z[mm/s2]	Hz	X[mm/s2]	Y[mm/s2]	Z[mm/s2]
0.10000	31.662	30.038	9.989	0.10000	67.979	64.492	21.447
0.10500	34.796	33.074	11.187	0.10500	74.709	71.012	24.020
0.11025	37.345	35.425	12.292	0.11025	80.181	76.059	26.392
0.11576	38.905	38.546	13.341	0.11576	83.531	82.761	28.643
0.12155	42.785	42.546	14.907	0.12155	91.863	91.349	32.006
0.12763	49.338	48.579	19.179	0.12763	105.932	104.301	41.179
0.13401	56.379	53.412	21.888	0.13401	121.049	114.680	46.996
0.14071	64.168	61.759	24.197	0.14071	137.772	132.601	51.952
0.14775	75.355	72.346	28.670	0.14775	161.791	155.331	61.556
0.15513	86.629	83.037	31.579	0.15513	185.999	178.286	67.803
0.16289	105.362	101.132	35.941	0.16289	226.219	217.137	77.167
0.17103	130.095	125.561	40.395	0.17103	279.322	269.587	86.731
0.17959	149.619	145.005	47.924	0.17959	321.240	311.335	102.896
0.18857	176.576	170.683	54.991	0.18857	379.118	366.466	118.069
0.19799	199.840	193.228	60.179	0.19799	429.067	414.871	129.208
0.20789	216.926	209.810	68.835	0.20789	465.752	450.475	147.793
0.21829	240.128	233.892	76.807	0.21829	515.568	502.179	164.910

Frequency	SL-1 Design FRS			Frequency	SMHV Design FRS		
Hz	X[mm/s2]	Y[mm/s2]	Z[mm/s2]	Hz	X[mm/s2]	Y[mm/s2]	Z[mm/s2]
0.22920	284.566	276.250	85.927	0.22920	610.980	593.124	184.491
0.24066	346.343	336.544	99.645	0.24066	743.619	722.580	213.943
0.25270	411.147	401.086	107.923	0.25270	882.757	861.155	231.718
0.26533	436.806	425.017	111.389	0.26533	937.848	912.536	239.159
0.27860	509.262	492.272	124.638	0.27860	1093.414	1056.938	267.605
0.29253	602.217	584.306	139.344	0.29253	1292.995	1254.540	299.179
0.30715	736.680	734.543	141.901	0.30715	1581.696	1577.107	304.671
0.32251	966.649	966.607	151.664	0.32251	2075.452	2075.362	325.631
0.33864	1192.487	1186.992	182.163	0.33864	2560.339	2548.542	391.116
0.35557	1382.334	1361.332	197.542	0.35557	2967.952	2922.860	424.134
0.37335	1552.285	1535.672	212.092	0.37335	3332.847	3297.178	455.373
0.39201	1727.401	1710.012	226.641	0.39201	3708.831	3671.496	486.612
0.41161	1905.705	1884.352	241.191	0.41161	4091.661	4045.814	517.851
0.43219	2084.010	2058.692	259.066	0.43219	4474.491	4420.132	556.231
0.45380	2262.314	2233.032	276.942	0.45380	4857.322	4794.450	594.611
0.47649	2440.619	2407.371	294.818	0.47649	5240.152	5168.768	632.991
0.50032	2458.293	2451.055	316.553	0.50032	5278.099	5262.559	679.659
0.52534	2458.293	2451.055	340.026	0.52534	5278.099	5262.559	730.057
0.55160	2458.293	2451.055	363.499	0.55160	5278.099	5262.559	780.455
0.57918	2458.293	2451.055	386.972	0.57918	5278.099	5262.559	830.853
0.60814	2458.293	2451.055	410.445	0.60814	5278.099	5262.559	881.250
0.63855	2458.293	2451.055	440.310	0.63855	5278.099	5262.559	945.371
0.67048	2458.293	2451.055	470.174	0.67048	5278.099	5262.559	1009.492
0.70400	2272.421	2293.637	500.039	0.70400	4879.021	4924.574	1073.613
0.73920	2086.548	2136.220	529.903	0.73920	4479.942	4586.589	1137.734
0.77616	1912.540	1958.575	560.488	0.77616	4106.337	4205.175	1203.401
0.81497	1738.532	1780.930	595.631	0.81497	3732.731	3823.761	1278.855
0.85572	1564.525	1603.285	630.774	0.85572	3359.126	3442.347	1354.309
0.89850	1390.517	1425.640	668.623	0.89850	2985.521	3060.933	1435.573
0.94343	1229.546	1263.861	708.119	0.94343	2639.908	2713.584	1520.372
0.99060	1093.084	1124.093	747.614	0.99060	2346.915	2413.494	1605.171
1.04013	994.213	1011.524	787.109	1.04013	2134.634	2171.802	1689.970
1.09213	933.451	951.263	826.605	1.09213	2004.175	2042.417	1774.769
1.14674	880.865	896.352	866.100	1.14674	1891.270	1924.522	1859.569
1.20408	828.279	841.442	930.323	1.20408	1778.365	1806.626	1997.459
1.26428	776.912	790.554	994.546	1.26428	1668.076	1697.365	2135.349
1.32749	731.767	744.288	1058.769	1.32749	1571.146	1598.030	2273.240
1.39387	683.855	700.473	1122.992	1.39387	1468.277	1503.956	2411.130
1.46356	636.837	654.686	1187.215	1.46356	1367.326	1405.650	2549.021
1.53674	587.183	595.405	1251.438	1.53674	1260.715	1278.369	2686.911
1.61358	555.665	562.882	1315.661	1.61358	1193.045	1208.541	2824.802
1.69426	551.833	558.720	1407.824	1.69426	1184.817	1199.604	3022.682
1.77897	527.026	534.538	1499.988	1.77897	1131.556	1147.684	3220.562

Frequency	SL-1 Design FRS			Frequency	SMHV Design FRS		
Hz	X[mm/s2]	Y[mm/s2]	Z[mm/s2]	Hz	X[mm/s2]	Y[mm/s2]	Z[mm/s2]
1.86792	511.835	525.009	1592.151	1.86792	1098.941	1127.224	3418.442
1.96131	496.092	509.270	1684.315	1.96131	1065.139	1093.432	3616.323
2.05938	490.588	495.439	1776.478	2.05938	1053.321	1063.737	3814.203
2.16235	490.588	495.439	1868.642	2.16235	1053.321	1063.737	4012.083
2.27047	493.561	498.442	2014.223	2.27047	1059.705	1070.184	4324.655
2.38399	479.192	495.792	2207.081	2.38399	1028.854	1064.494	4738.732
2.50319	477.249	491.014	2453.356	2.50319	1024.682	1054.235	5267.500
2.62835	472.557	478.389	2699.632	2.62835	1014.608	1027.128	5796.269
2.75977	463.076	468.834	2949.476	2.75977	994.252	1006.614	6332.699
2.89775	453.266	465.687	3244.567	2.89775	973.188	999.857	6966.276
3.04264	454.963	467.420	3539.658	3.04264	976.832	1003.578	7599.853
3.19477	450.986	464.584	3883.666	3.19477	968.293	997.489	8338.460
3.35451	462.222	467.269	4449.347	3.35451	992.419	1003.255	9553.010
3.52224	507.080	469.955	5093.731	3.52224	1088.731	1009.021	10936.540
3.69835	558.667	485.349	5738.115	3.69835	1199.491	1042.073	12320.071
3.88327	612.678	490.936	6382.499	3.88327	1315.455	1054.070	13703.601
4.07743	667.263	504.969	7026.883	4.07743	1432.653	1084.198	15087.131
4.28130	722.422	583.548	7671.267	4.28130	1551.084	1252.911	16470.661
4.49537	778.156	700.541	7753.842	4.49537	1670.748	1504.102	16647.954
4.72014	829.855	821.784	7836.416	4.72014	1781.747	1764.419	16825.246
4.95614	836.835	950.737	7918.991	4.95614	1796.734	2041.287	17002.539
5.20395	843.816	987.935	8001.565	5.20395	1811.722	2121.154	17179.831
5.46415	850.796	1007.487	8084.139	5.46415	1826.710	2163.134	17357.123
5.73736	860.541	1027.039	8084.139	5.73736	1847.632	2205.114	17357.123
6.02422	872.333	1046.592	8084.139	6.02422	1872.950	2247.094	17357.123
6.32544	884.125	1066.144	8084.139	6.32544	1898.268	2289.074	17357.123
6.64171	895.917	1085.696	8084.139	6.64171	1923.587	2331.054	17357.123
6.97379	895.917	1105.249	8084.139	6.97379	1923.587	2373.034	17357.123
7.32248	895.917	1117.649	8084.139	7.32248	1923.587	2399.658	17357.123
7.68861	895.917	1117.649	7740.842	7.68861	1923.587	2399.658	16620.043
8.07304	895.917	1117.649	7063.745	8.07304	1923.587	2399.658	15166.275
8.47669	895.917	1117.649	6386.647	8.47669	1923.587	2399.658	13712.507
8.90052	895.917	1117.649	5709.550	8.90052	1923.587	2399.658	12258.739
9.34555	842.319	1117.649	5142.188	9.34555	1808.509	2399.658	11040.580
9.81283	788.722	1117.649	4713.132	9.81283	1693.432	2399.658	10119.371
10.30350	735.124	1052.321	4485.660	10.30350	1578.355	2259.394	9630.976
10.81860	681.527	991.013	4485.660	10.81860	1463.278	2127.764	9630.976
11.35960	630.982	940.633	4485.660	11.35960	1354.755	2019.594	9630.976
11.92760	598.515	890.252	4485.660	11.92760	1285.046	1911.424	9630.976
12.52390	566.048	839.872	4485.660	12.52390	1215.337	1803.254	9630.976
13.15010	536.390	789.491	4485.660	13.15010	1151.662	1695.085	9630.976
13.80760	523.485	739.111	4485.660	13.80760	1123.953	1586.915	9630.976
14.49800	517.674	688.730	4282.448	14.49800	1111.477	1478.745	9194.667

Frequency	SL-1 Design FRS			Frequency	SMHV Design FRS		
Hz	X[mm/s2]	Y[mm/s2]	Z[mm/s2]	Hz	X[mm/s2]	Y[mm/s2]	Z[mm/s2]
15.22290	512.183	657.642	4026.930	15.22290	1099.687	1411.996	8646.055
15.98410	507.915	632.916	3771.412	15.98410	1090.523	1358.907	8097.444
16.78330	503.663	608.426	3515.895	16.78330	1081.394	1306.327	7548.833
17.62240	499.426	584.173	3267.754	17.62240	1072.298	1254.254	7016.060
18.50350	485.135	560.157	3023.002	18.50350	1041.614	1202.689	6490.564
19.42870	462.242	536.377	2778.251	19.42870	992.461	1151.633	5965.068
20.40020	453.211	512.833	2594.188	20.40020	973.072	1101.084	5569.875
21.42020	434.760	500.031	2439.246	21.42020	933.454	1073.597	5237.205
22.49120	426.539	497.124	2284.305	22.49120	915.803	1067.355	4904.536
23.61570	418.238	486.040	2129.363	23.61570	897.981	1043.556	4571.867
24.79650	414.298	476.629	2021.734	24.79650	889.522	1023.351	4340.783
26.03630	410.865	469.759	1940.986	26.03630	882.152	1008.600	4167.411
27.33820	407.455	464.431	1860.238	27.33820	874.829	997.160	3994.040
28.70510	404.174	459.503	1779.489	28.70510	867.786	986.579	3820.668
30.14030	401.740	455.325	1713.428	30.14030	862.559	977.609	3678.830
31.64730	401.740	454.362	1617.992	31.64730	862.559	975.543	3473.925
33.22970	400.913	452.992	1589.964	33.22970	860.785	972.601	3413.747
34.89120	400.573	451.435	1566.468	34.89120	860.053	969.257	3363.299
36.63580	400.421	451.435	1566.468	36.63580	859.728	969.257	3363.299
38.46750	400.096	450.567	1542.312	38.46750	859.029	967.394	3311.436
40.39090	399.911	449.973	1525.321	40.39090	858.633	966.120	3274.954
42.41050	399.752	449.295	1506.322	42.41050	858.291	964.662	3234.161
44.53100	399.584	448.936	1495.306	44.53100	857.931	963.891	3210.510
46.75750	399.505	448.421	1483.287	46.75750	857.761	962.785	3184.704
49.09540	399.396	448.118	1474.835	49.09540	857.526	962.136	3166.558

23.3 FRS – SL-2 and SL-3 spectrum

Frequency	SL-2 Design FRS			Frequency	SL-3 Design FRS		
Hz	X[mm/s2]	Y[mm/s2]	Z[mm/s2]	Hz	X[m/s2]	Y[m/s2]	Z[m/s2]
0.10000	93.122	88.346	29.380	0.10000	0.083	0.081	0.028
0.10500	102.341	97.276	32.904	0.10500	0.092	0.092	0.031
0.11025	109.837	104.190	36.153	0.11025	0.103	0.102	0.035
0.11576	114.426	113.371	39.237	0.11576	0.113	0.112	0.039
0.12155	125.839	125.136	43.844	0.12155	0.122	0.121	0.043
0.12763	145.113	142.879	56.409	0.12763	0.132	0.131	0.050
0.13401	165.820	157.095	64.378	0.13401	0.145	0.143	0.058
0.14071	188.729	181.645	71.168	0.14071	0.167	0.160	0.064
0.14775	221.631	212.782	84.323	0.14775	0.196	0.189	0.072
0.15513	254.793	244.228	92.881	0.15513	0.225	0.219	0.081
0.16289	309.889	297.448	105.709	0.16289	0.277	0.267	0.091
0.17103	382.633	369.297	118.810	0.17103	0.339	0.329	0.103
0.17959	440.055	426.486	140.954	0.17959	0.387	0.377	0.122
0.18857	519.340	502.008	161.738	0.18857	0.454	0.441	0.140
0.19799	587.764	568.317	176.998	0.19799	0.517	0.501	0.151
0.20789	638.017	617.088	202.456	0.20789	0.563	0.547	0.173
0.21829	706.258	687.917	225.904	0.21829	0.625	0.610	0.191
0.22920	836.959	812.499	252.727	0.22920	0.734	0.713	0.212
0.24066	1018.656	989.836	293.073	0.24066	0.882	0.857	0.246
0.25270	1209.256	1179.665	317.422	0.25270	1.025	0.992	0.271
0.26533	1284.724	1250.049	327.615	0.26533	1.085	1.063	0.278
0.27860	1497.828	1447.860	366.582	0.27860	1.260	1.238	0.312
0.29253	1771.226	1718.548	409.834	0.29253	1.500	1.473	0.362
0.30715	2166.707	2160.420	417.357	0.30715	1.858	1.835	0.393
0.32251	2843.085	2842.961	446.071	0.32251	2.404	2.387	0.423
0.33864	3507.314	3491.153	535.775	0.33864	2.947	2.913	0.455
0.35557	4065.688	4003.918	581.006	0.35557	3.388	3.283	0.492
0.37335	4565.544	4516.682	623.799	0.37335	3.643	3.693	0.528
0.39201	5080.590	5029.447	666.592	0.39201	3.808	4.084	0.565
0.41161	5605.015	5542.211	709.384	0.41161	3.893	4.474	0.602
0.43219	6129.440	6054.975	761.960	0.43219	3.893	4.865	0.646
0.45380	6653.866	6567.740	814.536	0.45380	4.876	5.255	0.690
0.47649	7178.291	7080.504	867.111	0.47649	5.644	5.645	0.734
0.50032	7230.273	7208.985	931.039	0.50032	5.720	5.780	0.778
0.52534	7230.273	7208.985	1000.078	0.52534	5.720	5.780	0.832
0.55160	7230.273	7208.985	1069.116	0.55160	5.720	5.780	0.888
0.57918	7230.273	7208.985	1138.154	0.57918	5.720	5.780	0.943
0.60814	7230.273	7208.985	1207.192	0.60814	5.720	5.780	0.999

Frequency	SL-2 Design FRS			Frequency	SL-3 Design FRS		
Hz	X[mm/s2]	Y[mm/s2]	Z[mm/s2]	Hz	X[m/s2]	Y[m/s2]	Z[m/s2]
0.63855	7230.273	7208.985	1295.029	0.63855	5.720	5.780	1.080
0.67048	7230.273	7208.985	1382.866	0.67048	5.720	5.780	1.161
0.70400	6683.590	6745.992	1470.702	0.70400	5.377	5.529	1.241
0.73920	6136.906	6282.999	1558.539	0.73920	5.034	5.189	1.322
0.77616	5625.119	5760.514	1648.494	0.77616	4.630	4.775	1.403
0.81497	5113.331	5238.029	1751.856	0.81497	4.226	4.360	1.484
0.85572	4601.543	4715.544	1855.217	0.85572	3.822	3.945	1.582
0.89850	4089.755	4193.059	1966.539	0.89850	3.417	3.531	1.681
0.94343	3616.313	3717.239	2082.702	0.94343	3.051	3.174	1.780
0.99060	3214.952	3306.156	2198.865	0.99060	2.740	2.847	1.878
1.04013	2924.157	2975.071	2315.028	1.04013	2.540	2.598	2.012
1.09213	2745.445	2797.832	2431.191	1.09213	2.384	2.449	2.170
1.14674	2590.781	2636.331	2547.354	1.14674	2.253	2.311	2.329
1.20408	2436.116	2474.830	2736.245	1.20408	2.121	2.172	2.488
1.26428	2285.035	2325.158	2925.136	1.26428	2.000	2.048	2.647
1.32749	2152.255	2189.082	3114.027	1.32750	1.903	1.945	2.813
1.39387	2011.338	2060.214	3302.918	1.39387	1.816	1.857	3.083
1.46356	1873.049	1925.547	3491.809	1.46356	1.731	1.777	3.360
1.53674	1727.007	1751.191	3680.700	1.53674	1.654	1.699	3.637
1.61358	1634.308	1655.536	3869.591	1.61358	1.576	1.622	3.914
1.69426	1623.037	1643.293	4140.660	1.69426	1.498	1.549	4.192
1.77897	1550.077	1572.169	4411.729	1.77897	1.432	1.481	4.469
1.86792	1505.398	1544.143	4682.798	1.86792	1.373	1.413	4.902
1.96131	1459.095	1497.852	4953.867	1.96132	1.344	1.374	5.380
2.05938	1442.906	1457.174	5224.936	2.05938	1.314	1.346	5.858
2.16235	1442.906	1457.174	5496.004	2.16235	1.284	1.318	6.335
2.27047	1451.650	1466.005	5924.185	2.27047	1.258	1.294	6.952
2.38399	1409.389	1458.211	6491.414	2.38399	1.236	1.270	7.595
2.50319	1403.674	1444.158	7215.754	2.50319	1.218	1.248	8.389
2.62835	1389.874	1407.025	7940.094	2.62835	1.254	1.234	9.466
2.75977	1361.989	1378.923	8674.930	2.75977	1.318	1.221	10.553
2.89775	1333.135	1369.667	9542.844	2.89776	1.381	1.208	11.641
3.04264	1338.127	1374.765	10410.758	3.04264	1.445	1.196	12.728
3.19477	1326.429	1366.423	11422.549	3.19478	1.509	1.185	13.948
3.35451	1359.477	1374.322	13086.315	3.35451	1.573	1.179	15.600
3.52224	1491.412	1382.220	14981.562	3.52224	1.697	1.284	17.639
3.69835	1643.138	1427.497	16876.809	3.69835	1.829	1.395	19.679
3.88327	1801.993	1443.931	18772.057	3.88327	1.961	1.530	21.718
4.07743	1962.538	1485.203	20667.303	4.07743	2.094	1.693	23.757

Frequency	SL-2 Design FRS			Frequency	SL-3 Design FRS		
Hz	X[mm/s2]	Y[mm/s2]	Z[mm/s2]	Hz	X[m/s2]	Y[m/s2]	Z[m/s2]
4.28130	2124.772	1716.317	22562.550	4.28130	2.227	1.873	25.797
4.49537	2288.696	2060.414	22805.417	4.49537	2.361	2.053	26.114
4.72014	2440.749	2417.012	23048.282	4.72014	2.495	2.233	26.430
4.95614	2461.280	2796.284	23291.149	4.95614	2.576	2.413	26.747
5.20395	2481.811	2905.691	23534.015	5.20395	2.610	2.506	27.064
5.46415	2502.342	2963.198	23776.881	5.46415	2.647	2.600	27.381
5.73736	2531.003	3020.704	23776.881	5.73736	2.686	2.693	27.381
6.02422	2565.685	3078.211	23776.881	6.02422	2.724	2.787	27.381
6.32544	2600.368	3135.718	23776.881	6.32544	2.762	2.923	27.381
6.64171	2635.050	3193.224	23776.881	6.64171	2.800	3.060	27.381
6.97379	2635.050	3250.731	23776.881	6.97379	2.800	3.197	27.381
7.32248	2635.050	3287.203	23776.881	7.32248	2.800	3.334	27.381
7.68861	2635.050	3287.203	22767.182	7.68861	2.800	3.334	25.860
8.07304	2635.050	3287.203	20775.720	8.07304	2.800	3.334	24.340
8.47669	2635.050	3287.203	18784.257	8.47669	2.800	3.334	22.820
8.90052	2635.050	3287.203	16792.794	8.90052	2.800	3.334	21.299
9.34555	2477.410	3287.203	15124.083	9.34555	2.609	3.334	19.779
9.81283	2319.770	3287.203	13862.153	9.81283	2.417	3.334	18.327
10.30350	2162.130	3095.061	13193.117	10.30347	2.261	3.108	16.875
10.81860	2004.490	2914.745	13193.117	10.81864	2.167	2.883	15.423
11.35960	1855.828	2766.567	13193.117	11.35957	2.074	2.663	13.971
11.92760	1760.337	2618.389	13193.117	11.92755	1.980	2.485	12.604
12.52390	1664.846	2470.212	13193.117	12.52393	1.887	2.309	11.629
13.15010	1577.619	2322.034	13193.117	13.15013	1.793	2.134	11.442
13.80760	1539.662	2173.856	13193.117	13.80763	1.700	1.971	11.255
14.49800	1522.571	2025.678	12595.435	14.49801	1.606	1.826	11.068
15.22290	1506.420	1934.240	11843.911	15.22291	1.468	1.713	10.881
15.98410	1493.867	1861.517	11092.389	15.98406	1.346	1.640	10.788
16.78330	1481.361	1789.489	10340.866	16.78326	1.307	1.567	10.572
17.62240	1468.901	1718.156	9611.042	17.62243	1.269	1.494	10.355
18.50350	1426.868	1647.520	8891.184	18.50355	1.235	1.422	10.139
19.42870	1359.536	1577.579	8171.326	19.42873	1.203	1.369	9.922
20.40020	1332.975	1508.334	7629.965	20.40016	1.184	1.294	9.808
21.42020	1278.705	1470.680	7174.254	21.42017	1.176	1.241	9.489
22.49120	1254.525	1462.130	6718.543	22.49118	1.169	1.241	9.272
23.61570	1230.110	1429.529	6262.832	23.61574	1.163	1.241	9.011
24.79650	1218.523	1401.850	5946.278	24.79652	1.150	1.234	8.696
26.03630	1208.427	1381.644	5708.783	26.03635	1.133	1.225	8.413
27.33820	1198.396	1365.972	5471.287	27.33817	1.121	1.218	8.129

Frequency	SL-2 Design FRS			Frequency	SL-3 Design FRS		
Hz	X[mm/s2]	Y[mm/s2]	Z[mm/s2]	Hz	X[m/s2]	Y[m/s2]	Z[m/s2]
28.70510	1188.748	1351.478	5233.792	28.70508	1.116	1.213	7.846
30.14030	1181.587	1339.191	5039.493	30.14033	1.112	1.210	7.563
31.64730	1181.587	1336.360	4758.801	31.64735	1.109	1.207	7.280
33.22970	1179.157	1332.331	4676.366	33.22971	1.107	1.204	7.050
34.89120	1178.154	1327.749	4607.258	34.89120	1.105	1.200	6.912
36.63580	1177.709	1327.749	4607.258	36.63576	1.100	1.198	6.807
38.46750	1176.753	1325.197	4536.213	38.46755	1.097	1.197	6.701
40.39090	1176.209	1323.451	4486.238	40.39092	1.094	1.196	6.597
42.41050	1175.741	1321.455	4430.358	42.41047	1.092	1.195	6.544
44.53100	1175.248	1320.399	4397.959	44.53099	1.090	1.193	6.458
46.75750	1175.015	1318.884	4362.609	46.75754	1.089	1.192	6.417
49.09540	1174.693	1317.994	4337.750	49.09540	1.088	1.191	6.417

24 APPENDIX 4 – Simple Template of Monthly Progress Report

Contract No	
Reported Month	
Contractor Responsible	
Title of the Contract	

1) Main activities for the reported month	- - - - - - -
2)Main results, achievements or issues during the reported month	- - - - - - -
3) Main activities for the next month	- - - - - - -
4) Outstanding issues or risks identified for future implementations	- - - - - - -