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Technical Specifications (In-Cash Procurement)

Technical specification of the preliminary design of the VVPSS relief line cleaning tool

This technical specification of for Preliminary Design of the VVPSS relief line cleaning tool.

Table of Contents

1 Purpose

The purpose of this task is to perform preliminary design of the VVPSS relief line cleaning tool, including production of all necessary design report and justification documents. Nuclear safety related design and verification such as the confinement function of the enclosure are not foreseen to be carried out within this contract.

2 Scope

The Vacuum Vessel Pressure Suppression System (VVPSS) is to protect the ITER Vacuum Vessel (VV) and attached components from over pressure conditions in the case of an incident or accident. The VVPSS shall be available at any time there is a possibility of overpressure to the VV. There are project requirements on the VVPSS saying

"The Vacuum Vessel Pressure Suppression System (VVPSS) limits over pressurization of the vacuum vessel to a maximum of 0.15 MPa absolute. [PR143-I]"

Figure 1 shows the layout of the VVPSS. The system includes four Vapour Suppression Tanks (VSTs) containing enough water at room temperature to condense the steam resulting from the design basis coolant leaks into the VV, thus limiting over-pressurization to 0.15 MPa absolute.

The VSTs are connected through two vapour relief lines to the VV plasma chamber. The large relief pipe (DN500) incorporates two redundant Rupture Disk Assemblies (RDA) in parallel with two rupture disks in series for each. This system is designed to rupture/burst when a severe Ingress of Coolant Event (ICE) or other postulated over pressure incident or accident occurs. The main function of the VVPSS is a passive function provided by the rupture disks. When ruptured, this disk assembly allows direct connection of the VV to three VSTs. It is envisaged to occur in only the most severe of event categories.

The system design also includes a bleed line parallel to the main relief line. This smaller relief line (DN300) is equipped with two redundant Bleed Line Valves Assemblies (BLVA) in parallel with two bleed valves in series for each. When opened, this bleed valve assembly allows direct communication of the VV to the 4th VST. This small relief line and the VST connected to it, is designed to be able to manage the less significant events (Category II), thus limiting the amount of contaminated water to be processed after the accident. The small relief line is the first to be activated by opening the bleed valves in any category event. If the opening of the bleed valves and the steam discharge capacity of the associated small relief line is not sufficient to cope with the amount of steam entering the VV, then also the rupture disks will open.

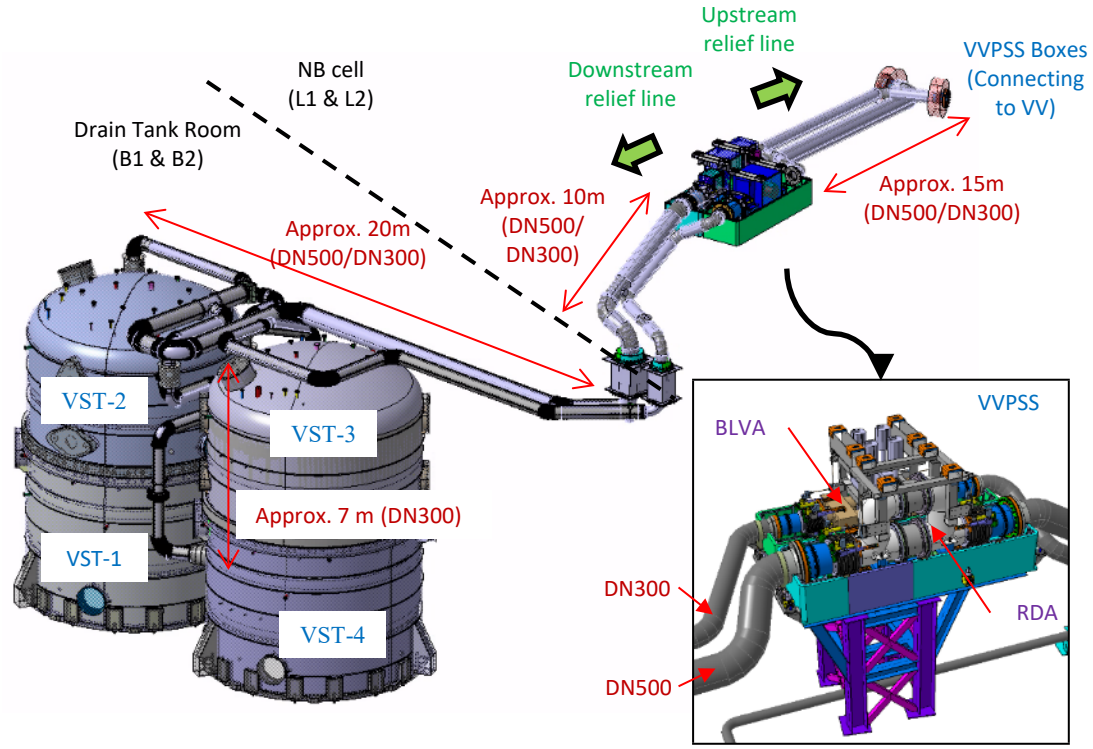


Figure 1: Layout of the VVPSS and Relief lines

After an incident or accident, inside the RDA, BLVA, upstream and downstream relief lines can be contaminated by the radioactive dust. This contamination needs to be cleaned as much as possible in order to control the radiation level in the NB cell and the Drain Tank Room (DTR) where human worker access is required for hands-on maintenance operations. The cleaning method for the upstream relief lines that are connected to the VV is vacuum cleaning. It is to avoid water flow into the VV. The cleaning method for the downstream relief lines that are routed toward the VSTs are either vacuuming cleaning or water jet cleaning depending on the contamination levels. Water flow into the VST does not cause a problem since the VSTs is filled with water.

Figure 2 shows a concept of the VVPSS cleaning tool. It has a similar size as the RDA and the BLVA. It will be transported by the Monorail Crane System (MCS) in the NB cell, and deployed to the same location where the RDA and BLVA are located on the lower Thermal Insulation Box (TIB). The Beam Line Transporter (BLT) manipulator connects the power and water supply, and the Flange Bolting Tool (FBT), Flange Closure Tool (FCT) and Bellows Compression Tool (BCT) will connect the VVPSS cleaning tool to the VVPSS relief line flanges in the same way as the RDA and the BLVA.

The VVPSS cleaning tool has an envelope to provide a enclosure that contains the waterjet cleaning system and vacuum cleaning system in order to limit spreading of contamination in the NB cell, and the tool storage pipe that stores a crawler inside and connects with VVPSS relief line flanges. The crawler with waterjet nozzle or vacuum suction nozzle travels and cleans the inside of the VVPSS relief lines. The enclosure and bellows are common systems that can be used for both DN300 and DN500 pipes by reconfiguring to the corresponding Tool Storage Pipe. It is recommended to use the same enclosure design for both the vacuum cleaning and water jet cleaning tool with minimum modification to reduce the storage space in the Hot Cell Facility.

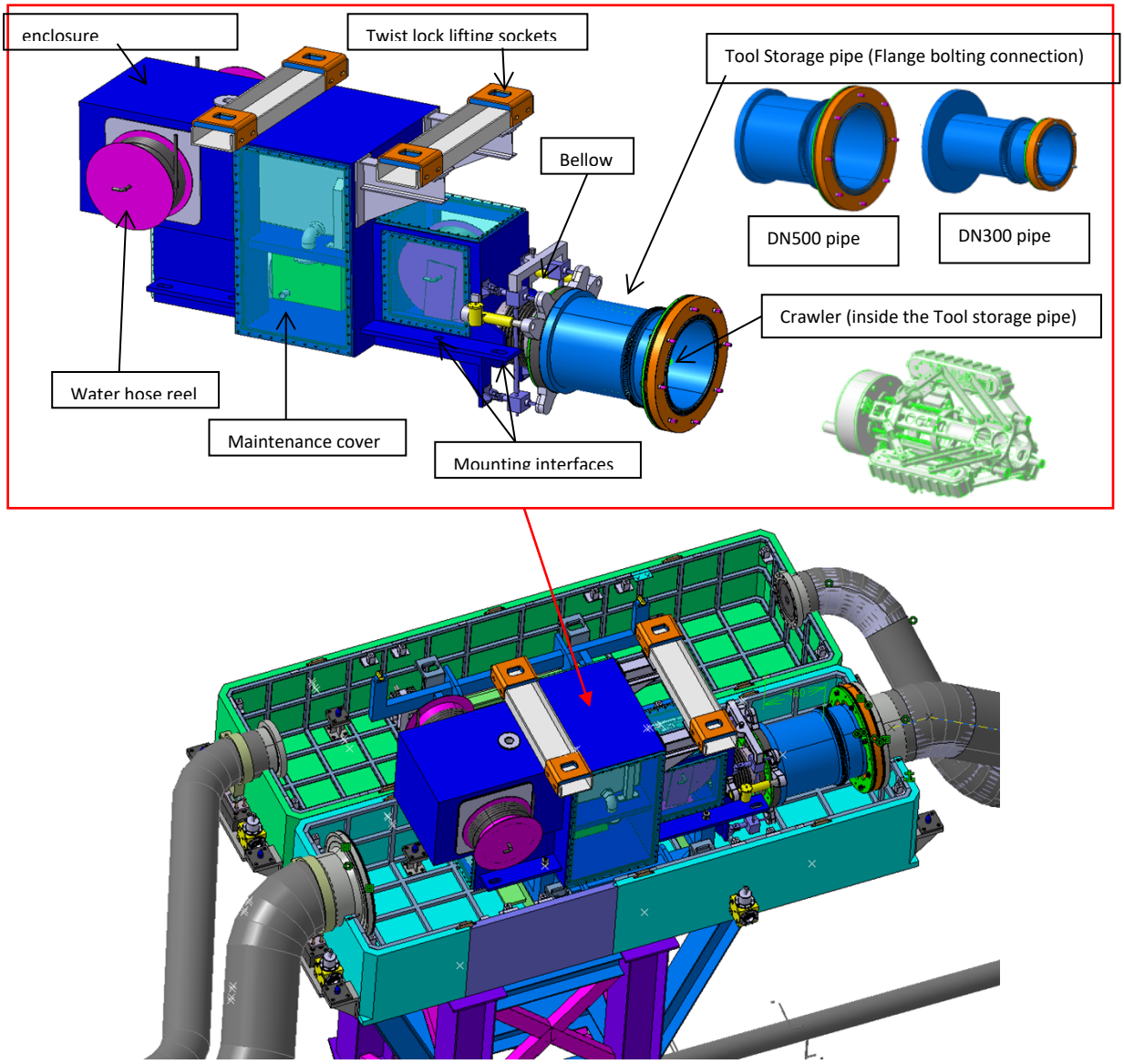


Figure 2: VVPSS cleaning tool (for illustration purpose only. The crawler can be any type once it satisfies the requirements

Remote deployment sequence of the VVPSS cleaning tool is as follows:

1) Start condition: The RDA or the BLVA is removed, only one of them. The bellows of the VVPSS cleaning tool is compressed by 80mm.
2) The monorail crane delivers the VVPSS cleaning tool on the lower TIB.
3) The BLT drives the RDA/BLVA support trolley backward by 80mm, which increases the distance between the flanges to 160mm.
4) The monorail crane deploys the flange closure tool.
5) The flange closure tool encloses of the flanges of the VVPSS cleaning tool and the relief line.
6) The flange closure tool removes the closure plates from the flanges of the VVPSS cleaning tool and the relief line.

7) The BLT drives the RDA/BLVA support trolley forward by 80mm, which reduces the distance between the flanges to 80mm.
8) The BLT extends the bellows until the rubber seal is in contact with the flange and provides sealing.
9) The monorail crane deploys the flange bolting tool.
10) The flange bolting tool bolts the VVPSS cleaning tool to the relief line.

Refer to details of the VVPSS tool design in the reports below.

- VVPSSRHE CDR - Operation of the VVPSS RH Equipment (VPZGV3 v1.1).
- Final Design Report - DN300 Prototype Confinement Tool *(ITER_D_Y6WREY v1.0)*
- Final Design Report - DN300 Prototype Flange Bolting Tool *(ITER_D_Y6WA86 v1.0)*
- Final Design Report - DN300 Prototype Mock-Up Environment *(ITER_D_YBXP6N v1.0)*

Detailed mock-up testing has been done for a number of VVPSS tools. The final 3D design is available in a CATIA V5 model, which will be provided. The Tool Storage Pipes need to be designed using this detail model and adapted to the cleaning tool.

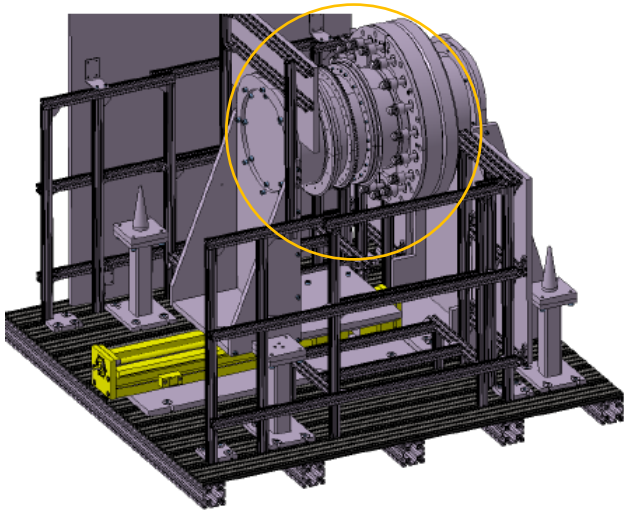


Figure 3: Detail design of the flange interfaces that can be integrated in the VVPSS cleaning tool.

Figure 4 show the arrangement of stoppers inside the VVPSS relief line flanges. They are to align the closure plate with respect to the flange and to prevent the closure plate is being sucked into the relief line by the VV negative pressure. Stoppers will be integrated in both VVPSS relief line and cleaning tool side.

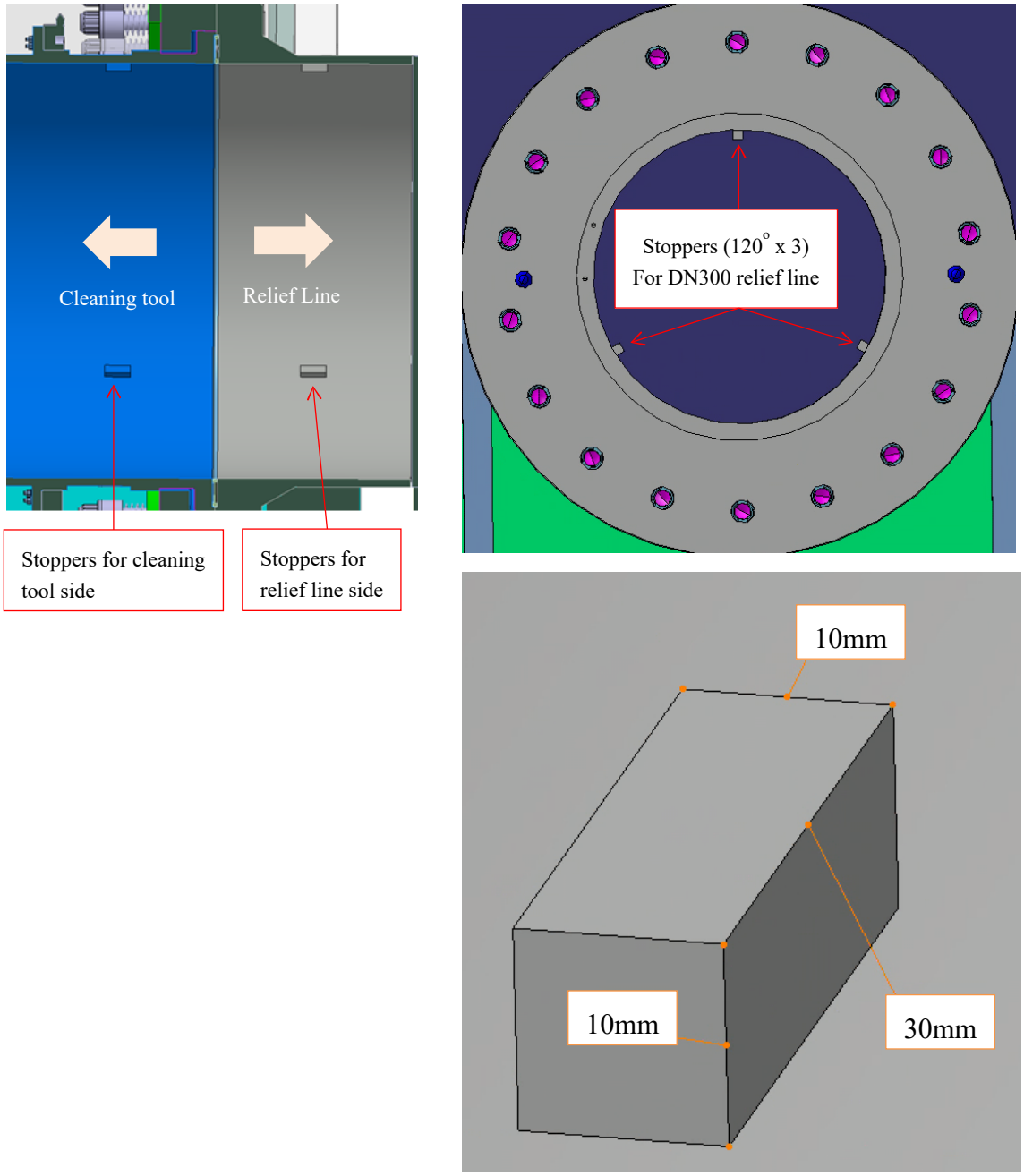


Figure 4: Stoppers arrangement in the VVPSS relief line flanges.

Figure 5 through Figure 8 show the detailed routing of the VVPSS relief line. The relief lines DN300 and DN500 are fully independent. The upstream lines are made by two parallel pipes, and connected to HNB1 with DN500 and HNB2 with DN300 via corresponding VVPSS box. The downstream lines are made by two parallel pipes, and connected to VST-1 with DN300 and connected to the remaining three VSTs with DN500 (& DN300). The horizontal pipes in the pipe routing have minimum 1 degree slope to ensure the flow water towards the VSTs by gravity.

In order to perform the complete vacuum or waterjet cleaning inside the VVPSS relief lines, a crawler vehicle is to be utilized to accommodate pipe branches as well as steep slopes and bends (Max. 90°) with horizontal and vertical translation.

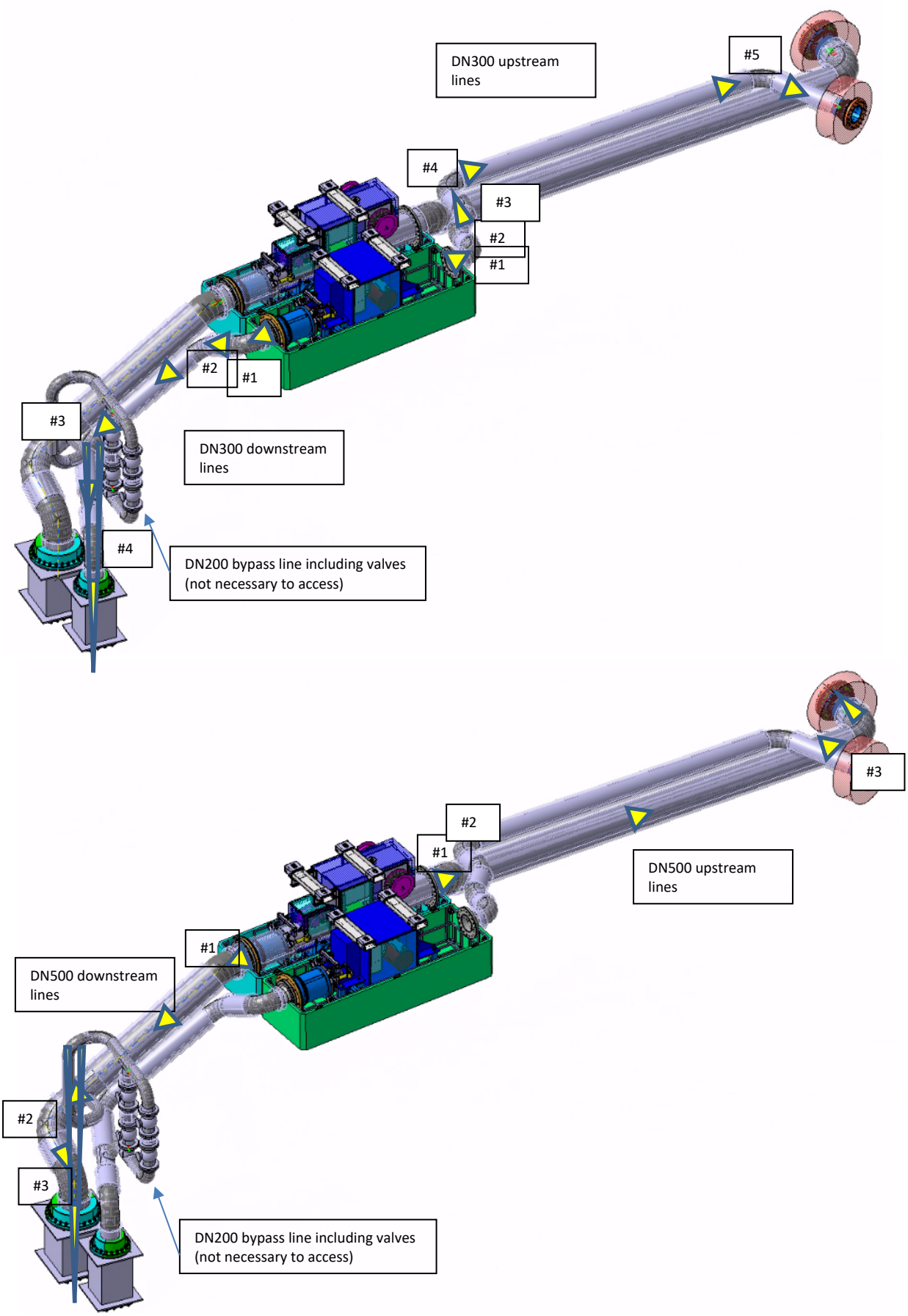
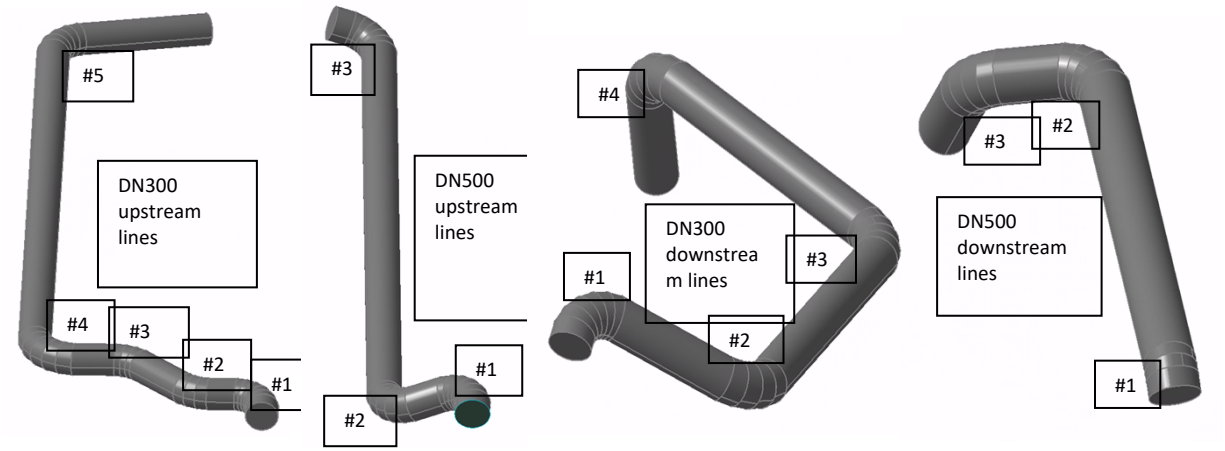

DN300 upstream lines
#5
#4
#3
#2
#1
#2
#1
#3
DN300 downstream lines
#4
DN200 bypass line including valves (not necessary to access)
#3
#2
#1
DN500 upstream lines
#1
DN500 downstream lines
#2
#3
DN200 bypass line including valves (not necessary to access)

Figure 5: Detail routing of VVPSS relief line in the NB cell (1/2)



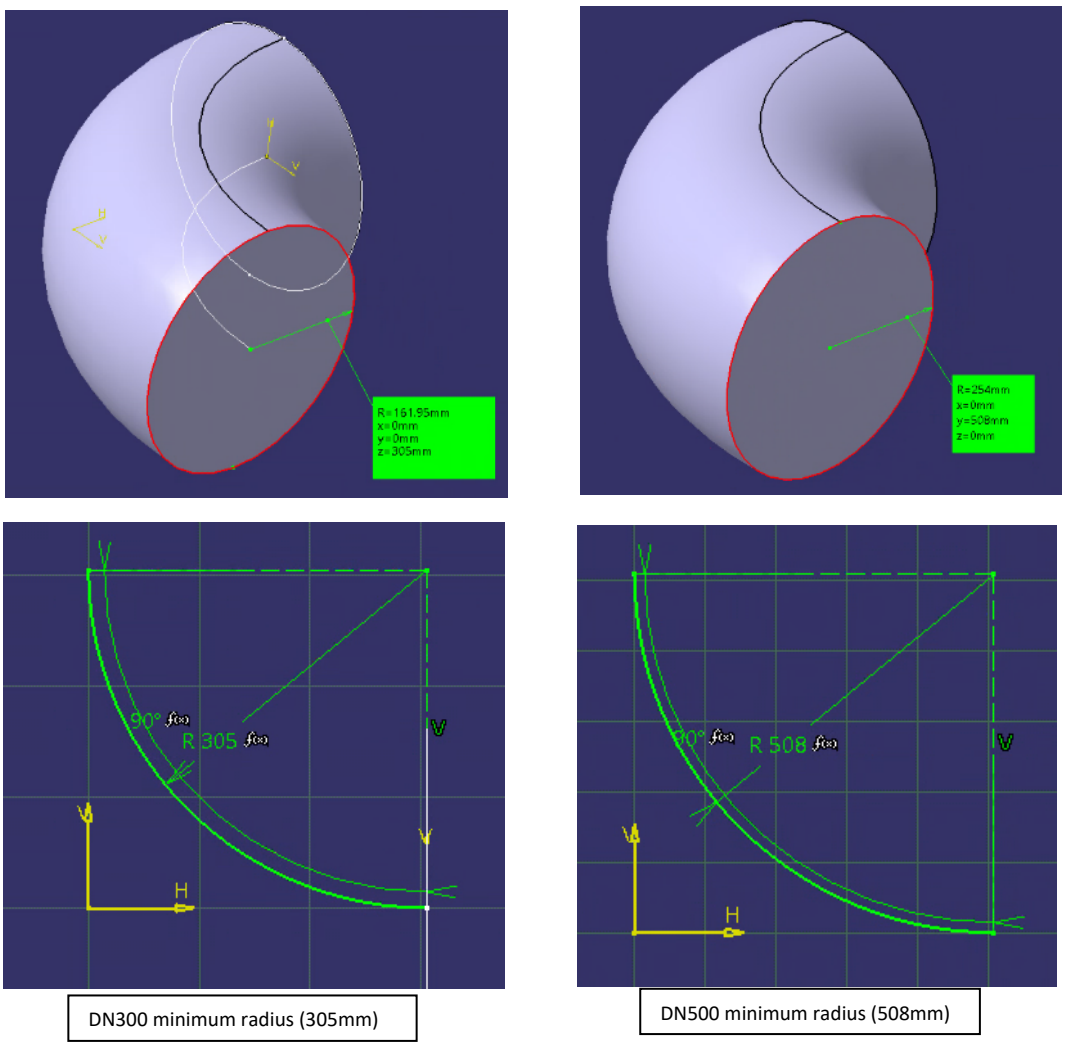


Figure 6: Detail routing of VVPSS relief line in the NB cell (2/2)

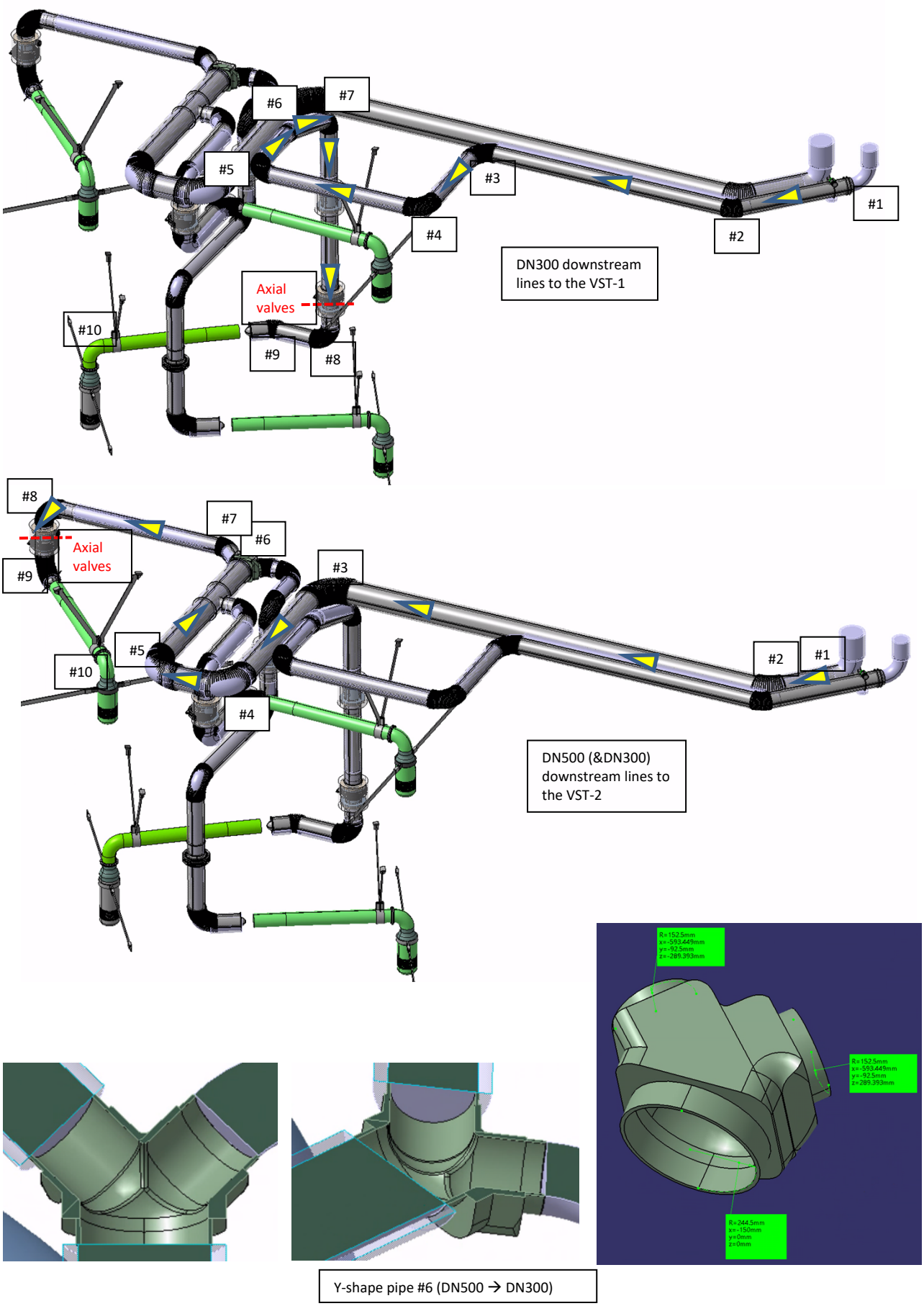


Figure 7: Detail routing of VVPSS relief line in the DTR (1/2)

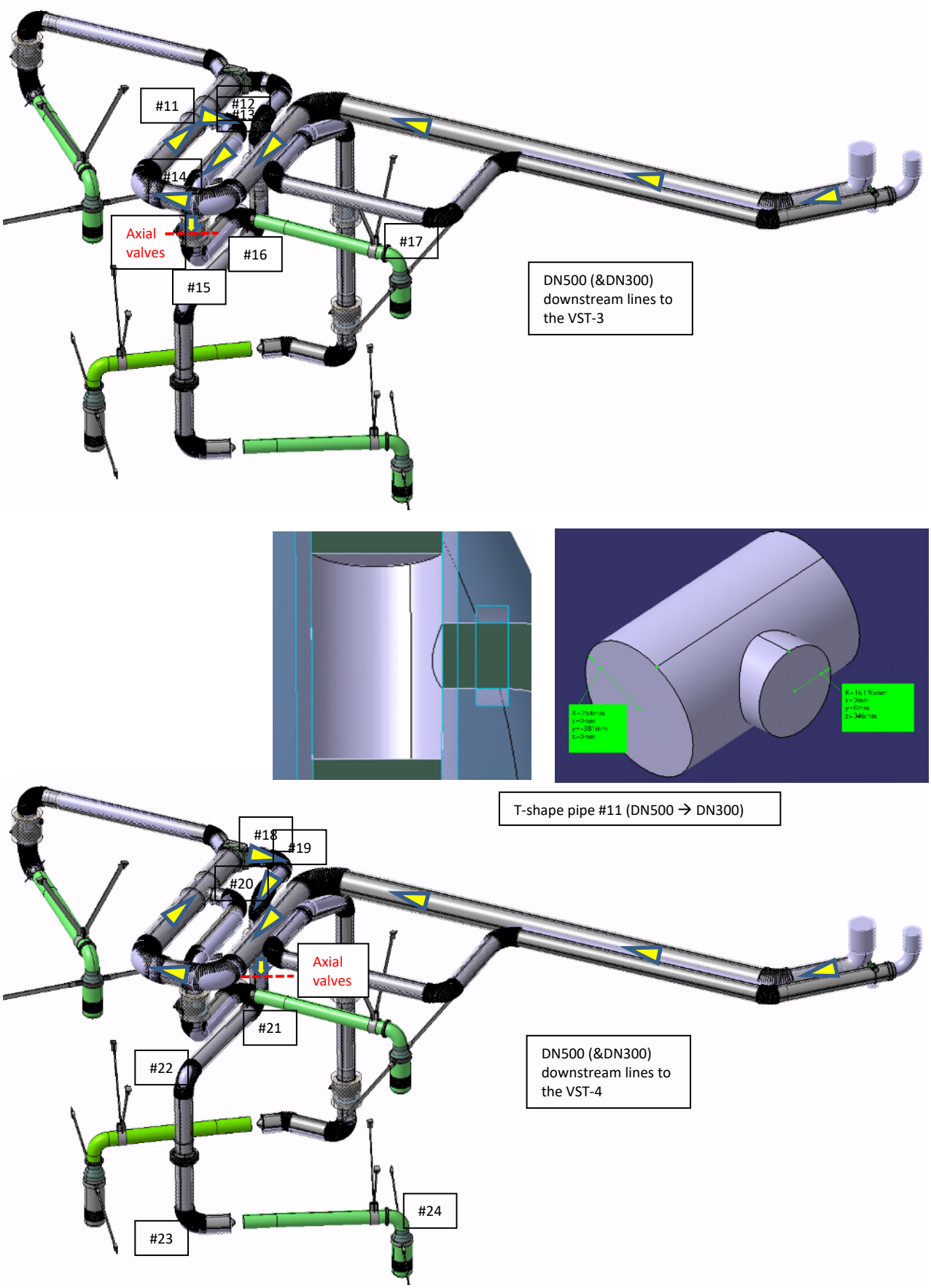


Figure 8: Detail routing of VVPSS relief line in the DTR (2/2)

Table 1 and Table 2 list the length and bending radius of each relief line measured in the CATIA. 10% uncertainty margin is considered.

Table 1: Length of the VVPSS relief lines

Relief lines	Area	Section of the relief lines	Length
DN300	NB Cell	Length of the upstream pipe	11.0 m
		Length of the downstream pipe	8.2 m
	DTR	Length of the downstream to the VST-1	33.8 m
DN500 (&DN300)	NB Cell	Length of the upstream pipe	11.4 m
		Length of the downstream pipe	6.7 m
	DTR	Length of the downstream to the VST-2	34.0 m
		Length of the downstream to the VST-3	32.4 m
		Length of the downstream to the VST-4	39.0 m

Table 2: Bending radius of the VVPSS relief lines

Relief lines	Area	Section of the relief lines	Angle	Bending Radius
DN300	NB Cell	Bending of the upstream pipe#1	90	305 mm
		Bending of the upstream pipe#2,3	45	457 mm
		Bending of the upstream pipe#4	45	457 mm
		Bending of the upstream pipe#5	70	457 mm
		Bending of the downstream pipe#1	90	305 mm
		Bending of the downstream pipe#2	70	457 mm
		Bending of the downstream pipe#3	66	457 mm
		Bending of the downstream pipe#4	83	457 mm
	DTR	Bending of the downstream to the VST-1#1	90	305 mm
		Bending of the downstream to the VST-1#2	45	457 mm
		Bending of the downstream to the VST-1#3	90	457 mm
		Bending of the downstream to the VST-1#4	90	457 mm
		Bending of the downstream to the VST-1#5	90	457 mm
		Bending of the downstream to the VST-1#6	23	457 mm
		Bending of the downstream to the VST-1#7	67	457 mm
		Bending of the downstream to the VST-1#8	90	457 mm
		Bending of the downstream to the VST-1#9	35	457 mm
		Bending of the downstream to the VST-1#10	90	457 mm
DN500 (&DN300)	NB Cell	Bending of the upstream pipe#1,3	90	508 mm
		Bending of the upstream pipe#2	90	508 mm
		Bending of the downstream pipe#1	30	762 mm
		Bending of the downstream pipe#2	77	508 mm
		Bending of the downstream pipe#3	67	508 mm

	DTR	Bending of the downstream to the VST-2/3/4#1	90	508 mm
		Bending of the downstream to the VST-2/3/4#2	45	762 mm
		Bending of the downstream to the VST-2/3/4#3	90	508 mm
		Bending of the downstream to the VST-2/3/4#4	90	508 mm
		Bending of the downstream to the VST-2/3/4#5	90	508 mm
		Y-shape of the downstream to the VST-2/4#6	45	-
		Bending of the downstream to the VST-2#7 (DN300)	45	457 mm
		Bending of the downstream to the VST-2#8 (DN300)	90	537 mm
		Bending of the downstream to the VST-2#9 (DN300)	90	305 mm
		Bending of the downstream to the VST-2#10 (DN300)	90	305 mm
		T-shape of the downstream to the VST-3#11	45	-
		Bending of the downstream to the VST-3#12 (DN300)	45	457 mm
		Bending of the downstream to the VST-3#13 (DN300)	45	457mm
		Bending of the downstream to the VST-3#14 (DN300)	90	305 mm
		Bending of the downstream to the VST-3#15 (DN300)	90	305 mm
		T-shape of the downstream to the VST-3#16 (DN300)	90	-
		Bending of the downstream to the VST-3#17 (DN300)	90	305 mm
		Bending of the downstream to the VST-4#18 (DN300)	45	457 mm
		Bending of the downstream to the VST-4#19 (DN300)	90	305 mm
		Bending of the downstream to the VST-4#20 (DN300)	90	457 mm
		Bending of the downstream to the VST-4#21 (DN300)	90	305 mm
		Bending of the downstream to the VST-4#22 (DN300)	90	305 mm
		Bending of the downstream to the VST-4#23 (DN300)	90	305 mm
		Bending of the downstream to the VST-4#24 (DN300)	90	305 mm

The scope of this task is to perform preliminary design of the VVPSS cleaning tool in order to demonstrate the complete sequence of the VVPSS relief line cleaning.

The task is composed of following subtasks.

- **Subtask-1: Preliminary design of the Vacuum cleaning system for DN300**
- **Subtask-2: Preliminary design of the Waterjet cleaning system for DN300**
- **Subtask-3: Preliminary design of the DN500 VVPSS cleaning tools by upgrading DN300 tools**

3 Definitions

For a complete list of ITER abbreviations see: ITER Abbreviations (ITER_D_2MU6W5).

- BLVA - Bleed Line Valve Assembly
- BCT - Bellows Compression Tool
- BLT - Beam Line Transporter
- BLVA - Bleed Line Valve Assembly
- CD - Concept Design
- COTS - Commercial Off-The-Shelf
- DET - Data Exchange Task (IO's means to CAD model transfer)
- DTR - Drain Tank Room
- FBT - Flange Bolting Tool
- FCT - Flange closure Tool
- FD - Final Design
- ICE - Ingress of Coolant Event
- IO - ITER ORGANIZATION
- LOCA - Loss of Coolant Accident
- LOVA - Loss-of-Vacuum Accident
- LTM - Long Term Maintenance
- MCS - Monorail Crane System
- NBRHS - Neutral Beam Remote Handling System
- PD - Preliminary Design
- PIC - Protection Important Component
- RDA - Rupture Disk Assembly
- RHE - Remote Handling Equipment
- SIC - Safety Important Component
- SVS - Service Vacuum System
- TIB - Thermal Insulation Box
- TRO - Technical Responsible Officer
- VST - Vapour Suppression Tank
- VV - Vacuum Vessel
- VVPSS - Vacuum Vessel Pressure Suppression System

4 References

Applicable documents

[AD-01] Load Specification of the Neutral Beam RH System, ITER_D_7JJVLK, v4.8.
[AD-02] Appendix 1 - Seismic loads on the Neutral Beam RH System, ITER_D_RZAMEM, v2.3
[AD-03] Appendix 2 - Nuclear loads on the Neutral Beam RH System, ITER_D_TVKQAT, v2.1.
[AD-04] ITER Remote Handling Code of Practice, ITER_D_2E7BC5, v1.2.
[AD-05] IS-23.05-23.03 NBRHS and CPRHS, ITER_D_9QBB9Q, v4.3.
[AD-06] IS-23.05-53-0021 NBRHS and Tool Interfaces, ITER_D_DSNBYF, v3.4.
[AD-07] IS-23-24.VP-001 NBRHS and Rupture Disk Assembly, ITER_D_LZNFH5, v2.4.
[AD-08] IS-23-24.VP-002 NBRHS and Bleed Line Valve Assembly, ITER_D_LZU7Q6, v2.4.
[AD-09] IS-23.24.VP-003 NBRHS and Relief Lines, ITER_D_LZYKNJ, v2.2.

[AD-10] Interface drawing for the MCS standard twist lock lifting features (SMDD 026618), ITER_D_2MFPEY, v--D.
[AD-11] Interface drawing for Torque Multiplier Bolt Runner for NBRHS (SMDD 026411), ITER_D_62JC7D, v--A.
[AD-12] Interface drawing for standard stillage (SMDD 054103), ITER_D_57PDTY, v--A.
[AD-13] Interface drawing for M12-M24 Power Torque Tools (SMDD 026409), ITER_D_56M2NN, v--B.
[AD-14] Final Design Report - DN300 Prototype Confinement Tool *(ITER_D_Y6WREY v1.0)*
[AD-15] Final Design Report - DN300 Prototype Flange Bolting Tool *(ITER_D_Y6WA86 v1.0)*
[AD-16] Final Design Report - DN300 Prototype Mock-Up Environment *(ITER_D_YBXP6N v1.0)*
[AD-17] Expected content of System Design deliverables, ITER_D_43S7GL, v2.2.
[AD-18] Procedure for the preparation, review and approval of the DDDs, ITER_D_2M24AM, v1.2.
[AD-19] Remote Handling Compatibility Procedure, ITER_D_2NRTWR, v2.7.
[AD-20] Template for RH Operations Sequence Description, ITER_D_9B9G3C, v1.0.

Reference documents – RH level

[RR-01] DDD 23.05 APPENDIX P - Design of the VVPSS RH Equipment, ITER_D_VEWT5H, v1.0.
[RR-02] Final Report of the Concept Design of the RH System for VVPSS Maintenance, ITER_D_TWYWUK, v1.0.
[RR-03] Design Description Document of Neutral Beam RH System, ITER_D_2N4GUZ, v2.1.
[RR-04] Final Design Report - DN300 Prototype Confinement Tool, ITER_D_Y6WREY, v1.0
[RR-05] D6 Controls Design Report, ITER_D_YGTB6F, v1.1
[RR-06] D7 VVPSS Manufacturing and Assembly Report, ITER_D_29D287, v1.0.
[RR-07] Report on Stress Analysis of VVPSS Relief Lines, ITER_D_YWLH59, v1.2.
[RR-08] DN300_FF_RF_ASSEMBLY (SMDD), ITER_D_ 2JU26F, v--C.
[RR-09] 05_VVPSSRHE CDR - Introduction to VVPSS RH Equipment, ITER_D_VQ7UAJ, v1.1.
[RR-10] 08_VVPSSRHE CDR - Design Description of the VVPSS RH Equipment, ITER_D_VPYTSB, v1.2.
[RR-11] 12_VVPSSRHE CDR - Operation of the VVPSS RH Equipment, ITER_D_VPZGV3, v1.1.
[RR-12] Radiation doses calculation in Drain Tank Rooms, ITER_D_T9B45M, v4.0.

References – VVPSS level

[RR-13] SRD-24-VP (VVPSS), ITER_D_28B2U6, v5.2.
[RR-14] Load Specification for the VVPSS, ITER_D_34Q3WT, v1.6.
[RR-15] DDD - Modified VVPSS, ITER_D_TK2TAJ, v1.1.
[RR-16] HMS Process Basis Document, ITER_D_WZ83SZ, v2.0.

5 Estimated Duration

It is estimated that this contract will take 7 months to complete.

6 Work Description

6.1 Common Applicable Technical Requirements

Requirement

<< Main function >>

[REQ_0.01] The VVPSS cleaning tool shall provide means to clean the DN300/DN500 VVPSS relief lines.

<< Working environment >>

[REQ_0.02] The VVPSS cleaning tool shall be operated in the following working environment inside the VVPSS relief line:

- Temperature: 18 ~ 50 ℃
- Humidity: 5% ~ 70%
- Nominal pressure (gauge): -20 ~ -500 Pa
- Maximum pressure (gauge): -5000 Pa (It is the maximum presume that the Detritiation System can exert)

[REQ_0.03] The VVPSS cleaning tool shall be operated in the following radioactive environment inside the VVPSS relief line:

- Dose rate (Gy/h):
  - During normal operation: Approx. 1 mGy/h
  - After accident: Approx. 10 Gy/h

For information, the dose rate during normal operation is an assumed value based on the radiation level near the relief line in the NB cell from ITER_D_TVKQAT v1.1, and that after the accident event is from the Table 16 of ITER_D_T9B45M, v4.0 (that is around 0.587mSv/h * factor 17).

[REQ_0.04] The VVPSS cleaning tool shall be operated in the following contaminated environment inside the VVPSS relief line, which are from ITER_D_WZ83SZ, v2.0, or based on assumptions.

- Dust mass on the upstream relief line during normal operation: ~350g (assume that 6μm layer deposit * (π * 0.5m^2 / 4) * 15m * 1900kg/m3 * factor 10)
- Dust mass on the downstream relief line after accident: ~3kg
- Dust composition: the main dust should consist of Be and W, with a 2:1 mass ratio W/B while the dust shape will be close to spherical (granular or globular) or flaky.
- Dust size: The dust size distribution in the ITER VV is expected as log-normal with a mass median particle diameter of 2.11 μm and a geometric standard deviation of 2.0.

<< Scenario & Operation >>

[REQ_0.05] The VVPSS cleaning tool crawlers shall be able to travel along the pipes having short radius elbows (that is, 1D radius, which means bending radius 300mm for DN300 pipe

and 500mm for DN500 pipe). The short radius elbows are according to the ASME B16-9-2001 butt welded fittings.

[REQ_0.06] The VVPSS cleaning tool shall be operated in the following scenario during normal condition:

- In case cleaning is required on the upstream line, vacuum cleaning will be performed.
- As the RDA and BLVA block the relief line, the downstream lines are not expected to be contaminated during normal conditions.

[REQ_0.07] The VVPSS cleaning tool shall be operated in the following scenario after accidental conditions:

- It is expected that the radioactive dust inside the VV flows through the relief lines and is accumulated on the internal surfaces of the relief lines and any discontinuities such as flanges, and internals of the RDA and BLVA.
- Upstream line will be cleaned by vacuuming in order not to flow water into the VVPSS Box connecting to NB front-end component and VV.
- Downstream line will be cleaned by vacuuming as a first option. However, in case vacuuming is not satisfactory and the radiation level on the north wall side of the NB cell is still high, water jet cleaning will be performed.

[REQ_0.08] The VVPSS cleaning tool shall complete the cleaning operation without needs for reconfiguration in the Hot Cell Facility except switching from DN300 and DN500 and vice versa.

[REQ_0.09] The VVPSS cleaning tool shall clean the whole internal surfaces of the relief line pipes along its reachable distance.

[REQ_0.10] The VVPSS cleaning tool shall clean the sealing surfaces of the crawler storage pipe where the closure plate of the FCT sits on.

[REQ_0.11] The reeling device of the crawler shall be coordinated with the movement of the crawler in automatic way without relying on human operators.

[REQ_0.12] The VVPSS cleaning tool crawler shall be able to travel inside the relief line flanges having stoppers (size is 10×10×30 mm, arrangement can be defined by the supplier for both VVPSS relief line and cleaning tool sides) to align closure plate.

<< Envelope >>

[REQ_0.13] The VVPSS cleaning tool shall design the enclosure such that it does not exhaust air and water outside of it

[REQ_0.14] The VVPSS cleaning tool shall integrate the enclosure which is reconfigurable for vacuum cleaning system, waterjet-cleaning system, tool storage pipes (DN300 and DN500) by human workers in the HCF. The design shall be standardized and ensure minimum reconfiguration as much as possible.

[REQ_0.15] The VVPSS cleaning tool shall integrate the DN300/DN500 tool storage pipes on the common flange of the enclosure. The common flange shall have alignment, guiding, sealing, locking features for the tool storage pipe.

[REQ_0.16] The DN300 tool storage pipe shall interface between the VVPSS cleaning tool envelope and the DN300 the relief line flanges.

[REQ_0.17] The DN500 tool storage pipe shall interface between the VVPSS cleaning tool envelope and the DN500 the relief line flanges.

[REQ_0.18] The tool storage pipes shall be closed by the closure plate that is installed by the flange closure tool. Note that the closure plate design will be provided by IO. The stoppers inside the tool storage pipes to align closure plate are necessary.

[REQ_0.19] The tool storage pipes shall have handling interfaces to help reconfiguration in the Hot Cell Facility.

[REQ_0.20] The envelope of the VVPSS cleaning tool shall have a port to connect to the pipes of the detritiation system, which is DN65 pipe. The connector is connected by the BLT manipulator.

[REQ_0.21] The envelope of the VVPSS cleaning tool shall have a 50mm of fire protection as much area as possible.

<< Fully remote operation interacting with other NB cell RHE >>

[REQ_0.22] The VVPSS cleaning tool shall be deployed by fit into the equatorial cask as defined in IS-23.05-23.03 NBRHS and CPRHS (ITER_D_9QBB9Q).

[REQ_0.23] The VVPSS cleaning tool shall integrate twist lock features for the MCS to deploy it by the monorail crane remotely. Refer the interface drawing (ITER_D_2MFPEY). Note that it is recommended to keep the same lifting location as the RDA and BLVA when it is deployed to have same lifting configuration with respect to the monorail crane.

[REQ_0.24] The CoG of the VVPSS cleaning tool shall be within the centre point of twist lock features for the monorail crane. Range of allowed CoG point is defined in the interface drawing (ITER_D_2MFPEY).

[REQ_0.25] The VVPSS cleaning tool shall not collapse during the seismic events during crane lifting and transportation. Therefore, lifting features on the VVPSS cleaning tool shall be more than 6.75 times of their own mass until rupturing as indicated in the chapter 12.7 of the NBRHS load specification (ITER_D_7JJVLK). This factor to be considered when sizing the structure of the envelope.

[REQ_0.26] The VVPSS cleaning tool shall integrate mechanical support with locking features to install on the RDA or BLVA support frame inside the TIB. Locking features will be handled by BLT manipulator. The VVPSS cleaning tool can deploy to the upstream line or downstream line by rotating itself by 180 degree. Support frame provides translational movement to connect and disconnect with the flanges.

[REQ_0.27] The VVPSS cleaning tool shall integrate alignment features for its final location. Note that the alignment features need to constraint the degree of freedom step by step.

[REQ_0.28] The VVPSS cleaning tool shall integrate RH features (e.g. guide rail, rack gear, mounting bolts, reaction features and alignment features) which location and configuration are compatible with operating together with the FBT, FCT (and BCT if necessary) to perform the VVPSS relief line flange connection and disconnection. Note that detail design of the flange interfaces are already available. Detail design will be provided by IO.

[REQ_0.29] The VVPSS cleaning tool shall integrate mounting bolts on the VVPSS cleaning tool flange to have the standard RH bolting tool interfaces (including the tightening torque and reaction features) specified in the IS-23.05-53-021(ITER_D_DSNBYF), and to be bi-hexagonal captive pop-up bolts. Note that number of bolts is less than RDA and BLVA due to the less stringent leak rate requirement.

[REQ_0.30] The VVPSS cleaning tool shall integrate RH features (e.g. gripping features, rescue features, electrical & service connecters) whose location and configuration are compatible with the BLT manipulator and RH tool (e.g. bolting tool) access to perform the rescue operation, connection/disconnection with the power and water supply.

[REQ_0.31] The bellow compression tool in the VVPSS cleaning tool shall allow compression more than 80mm. Note that 160mm gap is required to insert and remove the closure plate while installing the cleaning tool. 80mm is provided by compressing the bellows and 80mm by sliding the VVPSS cleaning tool by the RDA/BLVA support trolley.

<< Rescue>>
[REQ_0.32] The VVPSS cleaning tool shall integrate RH features for the rescue scenario. (e.g. disengagement of the scissor mechanism, manual driving socket in the motorized reel, and pulling the crawler from the pipe in the case of crawler stuck or cable entangled. The BLT manipulator in the NB cell is available to perform any required tooling.). Details rescue related design to be discussed with IO considering the feasibility.

<< Electrical & I&C design >>
[REQ_0.33] The I&C architecture shall be defined to identify on-board controllers that needs to be integrated with the VVPSS cleaning tool, and off-board controllers (eg. cubicles) that can be located outside the NB cell. The main purpose is to secure the mechanical design and spaces inside the cleaning tool for future development of the I&C system.
[REQ_0.34] The VVPSS cleaning tool shall integrate required cables in cable trays or cable chains within the system. Note that number of cables needs to be identified and the cabling space reservation needs to be implemented in the mechanical design.
[REQ_0.35] The VVPSS cleaning tool shall integrate provisions (e.g. sensors, I&C or visual indication) to monitor its operation (e.g. detection of correct installation, self-testing, alignment, and detection of abnormal conditions, etc.) as per required for proper function of the tool.
[REQ_0.36] The on-board controllers shall be rescuable by using the BLT manipulator. It is recommended to have the on-board controllers located outside of the envelope so that it can be removed remotely by the BLT manipulator.
[REQ_0.37] The VVPSS cleaning tool shall be capable of being powered up after a power outage without any need for re-calibration. Required sensors shall be identified and implemented in the mechanical design.

<< Design verification >>

[REQ_0.38] The Supplier shall identify all COTS items that are required to satisfy the defined functions of the VVPSS cleaning tool.

[REQ_0.39] The Supplier shall demonstrate the assembly process of the VVPSS cleaning tool considering the COTS items and the bespoke items by producing sequences of images. It needs to be reported in the DDD.

[REQ_0.40] The Supplier shall demonstrate the reconfiguration process of the VVPSS cleaning tool from DN300 to the DN500 configuration by producing sequences of images. It needs to be reported in the DDD.

[REQ_0.41] The Supplier shall demonstrate the cleaning process of the relief line both DN300 to the DN500 configuration by producing sequences of images. It needs to be reported in the Operation Sequence Description document.

6.2 Subtask-1: Preliminary design of the Vacuum cleaning system

Objectives

This subtask is to perform the preliminary design of the vacuum cleaning system in the VVPSS cleaning tool to demonstrate the vacuum cleaning operation in the DN300 upstream pipe to the vacuum vessel, fully remote operation in the NB cell, and the recovery and rescue sequences.

Description

The VVPSS cleaning tool has been developed in the CDR (Refer [RR-01]). The current VVPSS cleaning tool is to provide vacuum cleaning of the upstream pipes to the vacuum vessel. In addition, the downstream line will be cleaned by vacuuming as a first option before the waterjet cleaning. These lines have many bends and branch pipes that appear to exceed the operational design of the standard crawler. Therefore, a design study to identify solutions, risks and mitigation strategies, recovery/rescue sequences needs to be performed.

The VVPSS cleaning tool has a crawler that can move along the relief lines. The crawler can be equipped with a vacuum suction nozzle or a waterjet nozzle. The hose pulley feeds the hose according to the crawler movement. The vacuum cleaner is inside the enclosure in order not to exhaust air outside to the NB cell to prevent it's contamination by tritium.

This subtask is to perform the preliminary design of the vacuum cleaning system in the VVPSS cleaning tool to demonstrate the vacuum cleaning operation in the DN300 upstream pipes to the vacuum vessel, fully remote operation in the NB cell, and the recovery and rescue sequences.

Requirement

IMPORTANT NOTE:

REQ_0.XX are all applicable to the Vacuum cleaning system. In addition to those, the following requirements are specific to the Vacuum cleaning system.

<< Vacuum cleaning system>>

[REQ_1.01] The Vacuum cleaning system shall integrate a crawler with brushed vacuuming nozzle to perform the cleaning operation in the DN300 pipes. It shall be up to the VVPSS box (~15m), and down toward the VST tank as much as achievable considering the design constraints. Note that all pipes need to be cleaned as much as possible.

[REQ_1.02] The Vacuum cleaning system shall integrate suction hose to allow the crawler to travel in the upstream line, not interfere with the vacuum cleaning sequences, and rescue process.

[REQ_1.03] The Vacuum cleaning system shall be equipped with the dust canister so that the one maintenance campaign, that is, cleaning of DN300 can be carried out without empting the canister.

[REQ_1.04] The Vacuum cleaning system shall complete the upstream and downstream cleaning operation of DN300 within one day. Note that duration for deployment by the NBRHS are not counted on this duration. The estimated duration shall be reported in the DDD.

Inputs:

[1] CAD Model of the NBRHS (CM and DM) – to be sent by a DET

[2] CAD Model of the VVPSS RHE (CM and DM) – to be sent by a DET

[3] CAD Model of the VVPSS (CM and DM) – to be sent by a DET

Subtask activities:

- Design study to identify solutions, risks and mitigation strategies
  - Identify solutions, risks and mitigation strategies
  - Construct the conceptual model and basis of the VVPSS cleaning tool
  - Conceptual definition of I&C architecture
- Preliminary design of the Vacuum cleaning system
  - Produce initial operation sequence descriptions
  - Preliminary design of the crawler
  - Preliminary design of the envelope
  - Preliminary design of the RH features
  - Assembly process assessment
  - Re-configuration process assessment
- COTS items and bespoke items
  - Identify necessary COTS and bespoke items
  - Collect the specification of the COTS parts
- Sequence study
  - Produce final Operation Sequence Description document including normal and rescue operations
- Produce 3D model
- Produce configuration and interface feature drawings
- Issue design reports
- Preliminary design review

Deliverables:

- Final reports
  - Operation Sequence Descriptions
  - Design description report (including list of COTS items, calculation notes, etc.)
  - 3D CAD model
  - Configuration drawings
  - Interface drawings

6.3 Subtask-2: Preliminary design of Waterjet clean system

Objectives

This subtask is to perform the preliminary design of the waterjet cleaning system in the VVPSS cleaning tool to demonstrate the waterjet cleaning operation in the DN300 downstream pipes to the drain tanks, fully remote operation in the NB cell, and the recovery and rescue sequences.

Description

The VVPSS cleaning tool has been developed in the CDR (Refer [RR-01]). The current VVPSS cleaning tool is to provide waterjet cleaning of the downstream pipes to the drain tank. In addition, the branch pipes up to the drain tanks need to be cleaned as much as possible. These lines have many bends and branch of pipes that appear to exceed the operational design of the standard crawler. Therefore, a design study to identify solutions, risks and mitigation strategies, recovery/rescue sequences needs to be performed.

The VVPSS cleaning tool has crawler that can move along the relief lines. The crawler can be equipped with a waterjet nozzle. The hose reeling device feed the hose according to the crawler

movement. The water reservoir and the water pump are inside the enclosure. The water tap in the NB cell supplies water.

This subtask is to perform the preliminary design of the waterjet cleaning system in the VVPSS cleaning tool to demonstrate the waterjet cleaning operation in the DN300 downstream pipes to the axial valves before the drain tanks, fully remote operation in the NB cell, and the recovery and rescue sequences.

Requirement

IMPORTANT NOTE:

REQ_0.XX are all applicable to the Waterjet cleaning system. In addition to those, following requirements are specific to the Waterjet cleaning system.

<< Waterjet cleaning system>>

[REQ_2.01] The Waterjet cleaning system shall integrate a crawler with waterjet nozzles to perform the cleaning operation in the DN300 pipes with curved & vertical and branches. It shall reach up to the axial valve of the DN300 relief line in the DTR. Note that all pipes need to be cleaned as much as possible.

[REQ_2.02] The Waterjet system shall integrate electric High Pressure Unit (HPU) which has more than 500 bar (Refer [RR-01], Section 3.1.2.3) as high as possible in the given envelope design.

[REQ_2.03] The VVPSS cleaning tool shall remove any residual water inside the envelope and the crawler before disconnecting from the relief line after waterjet cleaning operation is performed in order to avoid risk of water leak and to simplify the hot cell RH operations (eg. applying a pressurized air into the water circuit, heaters to evaporate water which can be sucked by the detritiation system connected to the relief lines, etc.).

[REQ_2.04] The Waterjet cleaning system shall connect with the demineralized water (DW) service lines in the NB cell for the water supply (Service point reference is 6511DW-VG-0114. Minimum gauge pressure is 0.6MPa from the DW service line. Flow rate per valve is 2m3/h measures at standard temperature (0°C or 20 °C) and pressure (1 bar atmosphere). Amount of Cleaning Water is assumed to be 6.7m3 (80m ÷ 5mm/s × 25 liter/min). Refer details from ITER_D_2W4BLL and ITER_D_4AFSQC. There is a rigid pipe routing up the VVPSS support frame near to the lower TIB. From there a flexible host will be connected to the VVPSS cleaning tool by using BLT manipulator.

[REQ_2.05] The Waterjet cleaning system shall integrate the hose to allow the crawler to travel in the downstream line, not interfere with the waterjet cleaning sequences, and rescue process.

[REQ_2.06] The Waterjet cleaning system shall complete the downstream cleaning operation within five days. Note that duration for deployment by the NBRHS are not counted on this duration. The estimated duration shall be reported in the DDD.

Inputs:

[1] CAD Model of the NBRHS (CM and DM) – to be sent by a DET

[2] CAD Model of the VVPSS RHE (CM and DM) – to be sent by a DET

[3] CAD Model of the VVPSS (CM and DM) – to be sent by a DET

[4] Interface Sheet (IS) between Liquid & Gas Distribution (PBS 65) and Remote Handling (PBS 23) (ITER_D_2W4BLL) – to be sent by RHS

[5] Interface Data Requirement - PBS Clients Requirements for Liquid and Gas Distribution - PBS 65 (ITER_D_4AFSQC) – to be sent by RHS

Subtask activities:

- Design study to identify solutions, risks and mitigation strategies
  - Identify solutions, risks and mitigation strategies
  - Construct the conceptual model and basis of the VVPSS cleaning tool
  - Conceptual definition of I&C architecture
- Preliminary design of the Waterjet cleaning system
  - Produce initial operation sequence descriptions
  - Preliminary design of the crawler
  - Preliminary design of the envelope
  - Preliminary design of the RH features
  - Assembly process assessment
  - Re-configuration process assessment
- COTS items and bespoke items
  - Identify necessary COTS and bespoke items
  - Collect the specification of the COTS parts
- Sequence study
  - Produce final Operation Sequence Description document including normal and rescue operations
- Produce 3D model
- Produce configuration and interface feature drawings
- Issue design reports
- Preliminary design review

Deliverables:

- Final reports
  - Operation Sequence Descriptions
  - Design description report (including list of COTS items, calculation notes, etc.)
  - 3D CAD model
  - Configuration drawings
  - Interface drawings

6.4 Subtask-3: Preliminary design of the DN500 VVPSS cleaning tools by upgrading DN300 tools.

Objectives

This subtask is to perform the preliminary design of the DN500 VVPSS cleaning tools by utilizing the DN300 tool design as much as possible. It is expected that the envelope design is common and the tool storage pipe is the additional element to design.

Description

The VVPSS cleaning tool has been developed in the CDR (Refer [AD-02]). The current VVPSS cleaning tools have enclosure that is reconfigurable for vacuum cleaning system and waterjet-cleaning system, and crawler and tool storage pipe that are compatible with DN300 and DN500 VVPSS relief lines and exchanged by human workers in the HCF. This subtask is

to perform the preliminary design of the DN500 VVPSS cleaning tools by upgrading DN300 tools.

Requirement

IMPORTANT NOTE:

REQ_0.XX are all applicable to the Waterjet cleaning system. In addition to those, following requirements are specific to the Waterjet cleaning system.

[REQ_3.01] The VVPSS cleaning tools shall integrate the crawler, which is compatible with DN500 VVPSS relief lines.

[REQ_3.02] The VVPSS cleaning tools shall integrate the Tool storage pipe, which is compatible with DN500 VVPSS relief lines.

[REQ_3.03] The VVPSS cleaning tools shall integrate the common flange on the enclosure, which is same design as DN300 and DN500.

[REQ_3.04] The VVPSS waterjet cleaning tool shall reach up to the manifold of the DN500 relief line in the DTR.

[REQ_3.05] The VVPSS waterjet cleaning tool shall reach inside each Y-branch pipe up to the axial valves of the branch relief line. It is recommended for the crawler to come into each Y-branch pipe, but in case of technical difficulties, it needs to be discussed with IO.

[REQ_3.06] The VVPSS waterjet cleaning tool shall reach inside each T-branch pipe up to the axial valves of the branch relief line. It is recommended for the crawler to come into the T-branch pipe, but in case of technical difficulties, it needs to be discussed with IO. Alternatively, only injecting water jet could be investigated. In this case the rotating nozzle shall be able to position the water jet nozzle in the T-branch pipe direction.

Inputs:

[1] CAD Model of the NBRHS (CM and DM) – to be sent by a DET

[2] CAD Model of the VVPSS RHE (CM and DM) – to be sent by a DET

[3] CAD Model of the VVPSS (CM and DM) – to be sent by a DET

Subtask activities:

- Design of the DN500 tool storage pipe compatible with the DN300 tool envelope
- Design of the DN500 crawler
- Re-configuration process assessment from the DN300 to the DN500 tool
- COTS items and bespoke items
    - Identify necessary COTS and bespoke items
    - Collect the specification of the COTS parts
- Sequence study
    - Produce final Operation Sequence Description document including normal and rescue operations
- Produce 3D model
- Produce configuration and interface feature drawings
- Issue design reports
- Preliminary design review

Deliverables:

- Final reports
  - Operation Sequence Descriptions
  - Design description report (including list of COTS items, calculation notes, etc.)
  - 3D CAD model
  - Configuration drawings
  - Interface drawings

6.5 Statement of work requirements

Requirement

<< Final report >>

[REQ_W.01] The final reports shall include all source files that has been produced or used to write the final reports such as the excel sheets, calculation notes, datasheets, and program source codes developed in this task, etc.

[REQ_W.02] The report shall be prepared and submitted in Microsoft Word format.

[REQ_W.03] The report shall be written in English.

[REQ_W.04] The figures, tables, and equations in the report shall be numbered and referred automatically.

[REQ_W.05] The original editable figures in the report shall be provided. It is recommended to add texts or legends directly in the word file. The figures should be within a "Drawing Canvas" in the Microsoft Word. If the figures are from external software, the native file shall be provided.

[REQ_W.06] The design description document shall contain the expected content described in ITER_D_43S7GL, v2.2 as the minimum that are in the scope of this contract. Refer ITER_D_2M24AM, v1.2 for preparation of the design description.

[REQ_W.07] The operation sequence description shall contain the expected content described in Template for RH Operations Sequence Description, ITER_D_9B9G3C, v1.0 as the minimum that are in the scope of this contract.

<< CAD >>

[REQ_W.08] The 3D-model and the drawing shall be provided by CATIA V5 or equivalent CAD S/W in their native form together with standard forms such as STEP, PDF, etc. In case of equivalent CAD S/W, it shall support import/export of CATIA Graphics files, or support transfer through STEP files.

[REQ_W.09] The drawing (e.g. System assembly/parts drawings, System interface drawings) shall contain geometry, dimensions, tolerances and materials for the VVPSS cleaning system.

[REQ_W.10] The CAD models shall be CATIA V5 models/drawings (see §14 requirements).

7 Responsibilities

(1) IO shall be responsible for:
   a. Defining the basic design requirements relating to the VVPSS cleaning tool at the start of the task.
   b. Provide input data relevant to this task available from the concept design.

(2) The Supplier shall be responsible for:
   a. Performing the tasks outlined in section 6.
   b. Providing the deliverables listed in section 8.

c. Maintaining close contact with the ITER Task Officer to ensure that technical and quality assurance requirements of the task are met.

8 List of deliverables and due dates

The reports shall be prepared and submitted to the IO by the dates outlined in Table 3.

Table 3: List of Deliverables and their Schedule

Del.	Nature	Due Date	Acceptance criteria
D1	Quality plan	T0 + 2weeks	Report accepted by the IO TO
D2	Design study report	T0 +1month	Report accepted by the IO TO
D3	Final report on the subtask-1	T0 + 3months	Report accepted by the IO TO
D4	Final report on the subtask-2	T0 + 5months	Report accepted by the IO TO
D5	Final report on the subtask-3	T0 + 7months	Report accepted by the IO TO
	Completion	T0 + 7months	

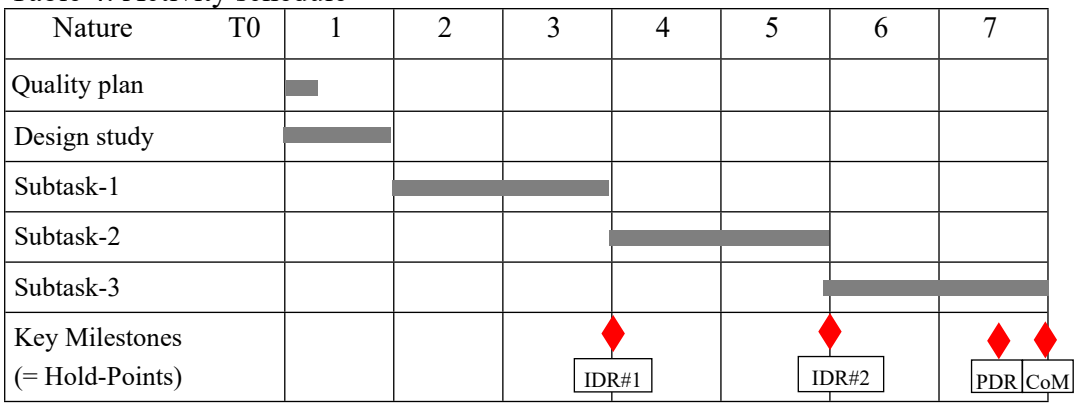
The intermediate reports shall be provided at half way to the final report. As a minimum, the intermediate reports shall include:

- a review of the requirements and latest design information.
- design of the necessary RH system(s), or preliminary analysis results
- identification of any critical design/feasibility issues

The report shall be prepared and submitted in Microsoft Word format. Any calculation sheets, analysis source files (e.g ANSYS source) shall be submitted as well. The CAD models shall be submitted in CATIA V5 models/drawings or equivalent.

The activity schedule is outlined in Table 4. Key milestones are identified in the table, and acceptance of the achievement shall be the Hold-Point to proceed to the next phase.

Table 4: Activity schedule



9 Acceptance Criteria

The reports shall be reviewed by the IO RO who shall inform the Supplier in writing of its approval or disapproval of the report within twenty (20) working days after the receipt of each report. In case of disapproval, the IO shall provide a justification to the Supplier and necessary measures for improvement shall be taken by the Supplier without delay. If no comments are made within this time frame, the report is deemed to be accepted by the IO.

10 Specific requirements and conditions

N/A

11 Work Monitoring / Meeting Schedule

See Table 3.

12 Delivery time breakdown

The task shall be monitored by the IO RO. The IO RO shall also perform the evaluation of the reports and may call on the IO responsible officers of interfacing systems and/or external experts to provide for additional review.

Meetings or video-conferences for the purpose of reviewing results before the delivery of each report will be agreed and planned at the start of this task. Details of the discussion, including date, meeting location and method shall be determined by mutual agreement between the IO and the Supplier at least one month prior to each planned meeting. The cost and expenses for the meetings, including any travel expenses incurred by the participant(s), shall be borne by each party.

The meetings will be held for this task, according to the following tentative schedule:

Meeting	Topic	Date	Location
1	Kick-off meeting	T0	Supplier/IO/Skype meeting
2	Intermediate review meeting #1	T0 + 3months	Supplier/IO/Skype meeting
3	Intermediate review meeting #2	T0 + 5months	Supplier/IO/Skype meeting
6	Preliminary Design Review meeting	T0 + 6.5months	Supplier/IO/Skype meeting
7	Close-out meeting	T0 + 7months	Supplier/IO/Skype meeting

Bi-weekly (videoconference) progress meeting shall be organized in between the Review meetings. Meeting minutes shall be delivered by the Supplier within 10 calendar days after each meeting and approved by the IO

13 Quality Assurance (QA) requirements

The organisation conducting these activities should have an ITER approved QA Program or an ISO 9001 accredited quality system.

The general requirements are detailed in ITER Procurement Quality Requirements (ITER_D_22MFG4).

Prior to commencement of the task, a Quality Plan must be submitted for IO approval giving evidence of the above and describing the organisation for this task; the skill of workers involved in the study; any anticipated sub-contractors; and giving details of who will be the independent checker of the activities (see Procurement Requirements for Producing a Quality Plan (ITER_D_22MFMW)).

Documentation developed as the result of this task shall be retained by the performer of the task or the DA organization for a minimum of 5 years and then may be discarded at the direction of the IO. The use of computer software to perform a safety basis task activity such as analysis and/or modelling, etc. shall be reviewed and approved by the IO prior to its use, in accordance with Quality Assurance for ITER Safety Codes (ITER_D_258LKL).

14 CAD Design Requirements

For the contracts where CAD design tasks are involved, the following shall apply:

- The contractor is proposed to work in Asynchronous collaboration scheme where contractor will work "File-based". See detailed information about asynchronous collaboration scheme in the Specification for CAD data Production in ITER direct contracts (P7Q3J7)
- The contractor shall ensure that all CAD Data (Schematics, Models and Drawings) delivered to IO comply with the "Procedure for the Usage of the ITER CAD Manual (2F6FTX)" , and with the "Procedure for CAD Management Plan (2DWU2M)"
- The contractor shall use the CATIA version indicated in the latest version of the ITER CAD Manual released by IO DO, CATIA V5 (R31) CAD Manual 07 - CAD Fact Sheet (249WUL). Further changes of CATIA release will be announced officially by mail to the contractor.
- The CAD data exchanges shall be performed through the appropriate Data Exchange Task Procedure for ITER CAD Data Exchanges (2NCULZ) performed by the IO.
- The contractor shall register drawings in System for Management of Diagrams and Drawings (SMDD) as follows:

For Drawing Registration, the contractor shall comply with the following IO requirements:

- Diagrams and Drawings Management System Working Instruction (KFMK2B)

For the execution of the CAD 3D models and drawings, in case the contractor does not use CATIA, the contractor shall ensure the usage of 3D models in the ITER Digital Mock Up after a possible conversion through a CAD neutral format (such as step). The contractor is requested to indicate in his offer his plans to manage the conversion of the produced CAD models and their provision to IO. The supplier shall follow the chapter 8.1.5 (Use of Multi-CAD by the Suppliers) specified in the CAD Manual 08 - Collaboration Processes (249WV4 v2.5)

15 Safety requirements

This task involves mechanical design of the relief line cleaning robot as specified in the requirements in each Subtask. The enclosure design is limited to support the function of the cleaning tool as a structural part. Design and verification of the confinement function of the

enclosure are not part of this study. IO is going to validate nuclear safety related design based on the mechanical design provided by the supplier.