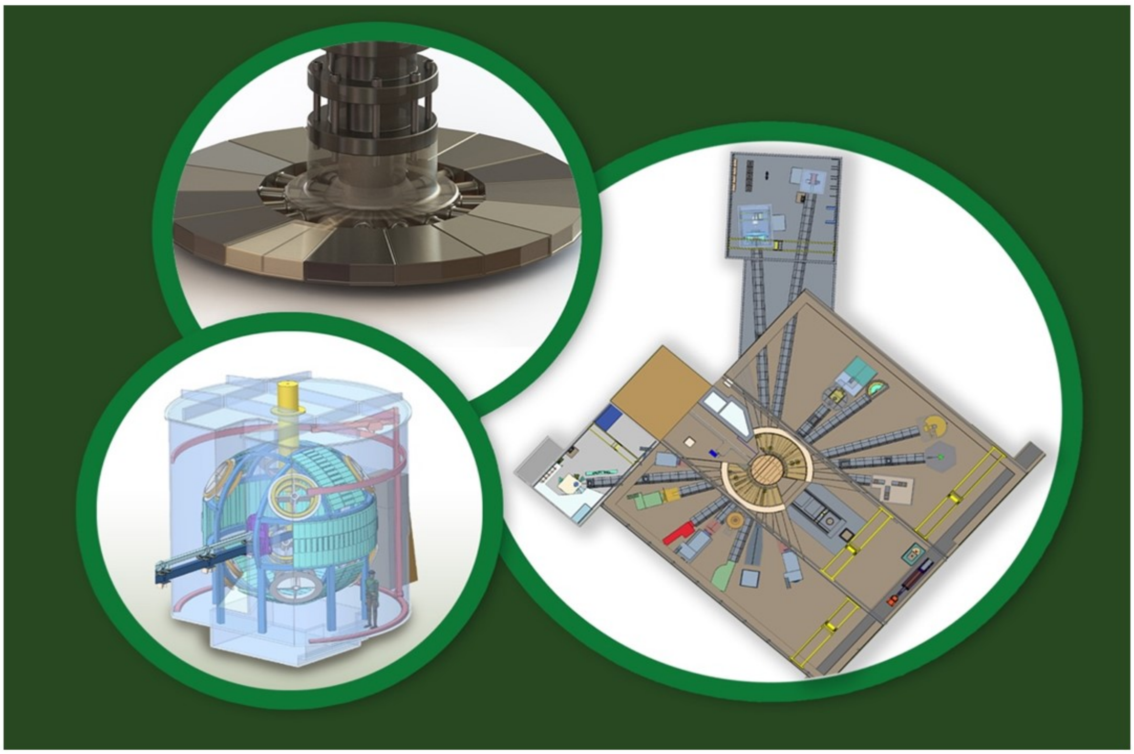
S03010000-IST10001

Second Target Station Interface Sheet Target Assembly & Vessel Systems



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June 17, 2026

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SECOND TARGET STATION
INTERFACE SHEET
TARGET ASSEMBLY & VESSEL SYSTEMS

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UT-BATTELLE LLC
for the
US DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

CONTENTS

1. INTRODUCTION

The core vessel and associated shielding blocks radiation during normal operation and maintenance. The target assembly is the primary source of radiation and the shielding provided by [S.03.06] shields equipment and personnel from harm. The interface between the target and shielding is complex and the requirements for shielding are not captured as an interface; they are captured in the requirements for the Target Systems. The interface captured in this document details the details of the shielding blocks that meet shielding requirements, provide adequate clearances for operation, and the supporting core vessel interfaces for the target assembly.

This document captures the details of the technical solution that are pertinent to both the target assembly [S.03.02] and the core vessel systems [S.03.06] such that detailed design can progress and such that the overall target system design performs as required.

2. ENVIRONMENTAL CONDITIONS

The Core Vessel contains a vacuum or a helium environment (depending on specified mode) for all components within the Core Vessel, including the Target Assembly. Note that the ancillary support to establish and maintain the core vessel environment is the scope of Vacuum Systems (vacuum mode) or Process Systems (Helium mode).

Table 1. Core Vessel Environment

Parameter	Vacuum mode	Helium Mode
Temperature	20 – 40°C	20 – 40°C
Pressure	1 Torr	$95kPa$
(Rotary Vacuum Seal)[a]	0.1 $Torr/L/s$	0.1 $Torr/L/s$

[a] Leak rate of Helium into the Core Vessel

3. MAINTENANCE COOLING REQUIREMENTS

During maintenance (when water flow is not available), the Target Assembly requires external air cooling to remove the energy from decay heat and maintain a temperature appropriate for the tantalum to Inconel bonds. The Target Assembly requires 400 ft^3/min of airflow across the top and bottom surfaces of the target foot. Target airflow shall be supplied with or without core vessel covers installed.

The details of providing the airflow to the target lie in the design of the core vessel shielding, gaps, and exit ports [S.03.06] and with the selection of blowers, piping, valves, and instrumentation by process systems [S.03.09]. The target assembly requires airflow in maintenance scenarios but does not have a direct interface with process systems; the interface lies between the core vessel and Process Systems to provide the required airflow (400 ft^3/min of airflow across the top and bottom surfaces of the target foot). The interface and flow requirement is noted here for context and clear communication, but is not a formal interface with the target assembly. The overall pressure drop in the core vessel shall be coordinated with process systems [S.03.09] for the blower and piping selection. The Target Assembly team will assist in development of airflow diverters and analysis.

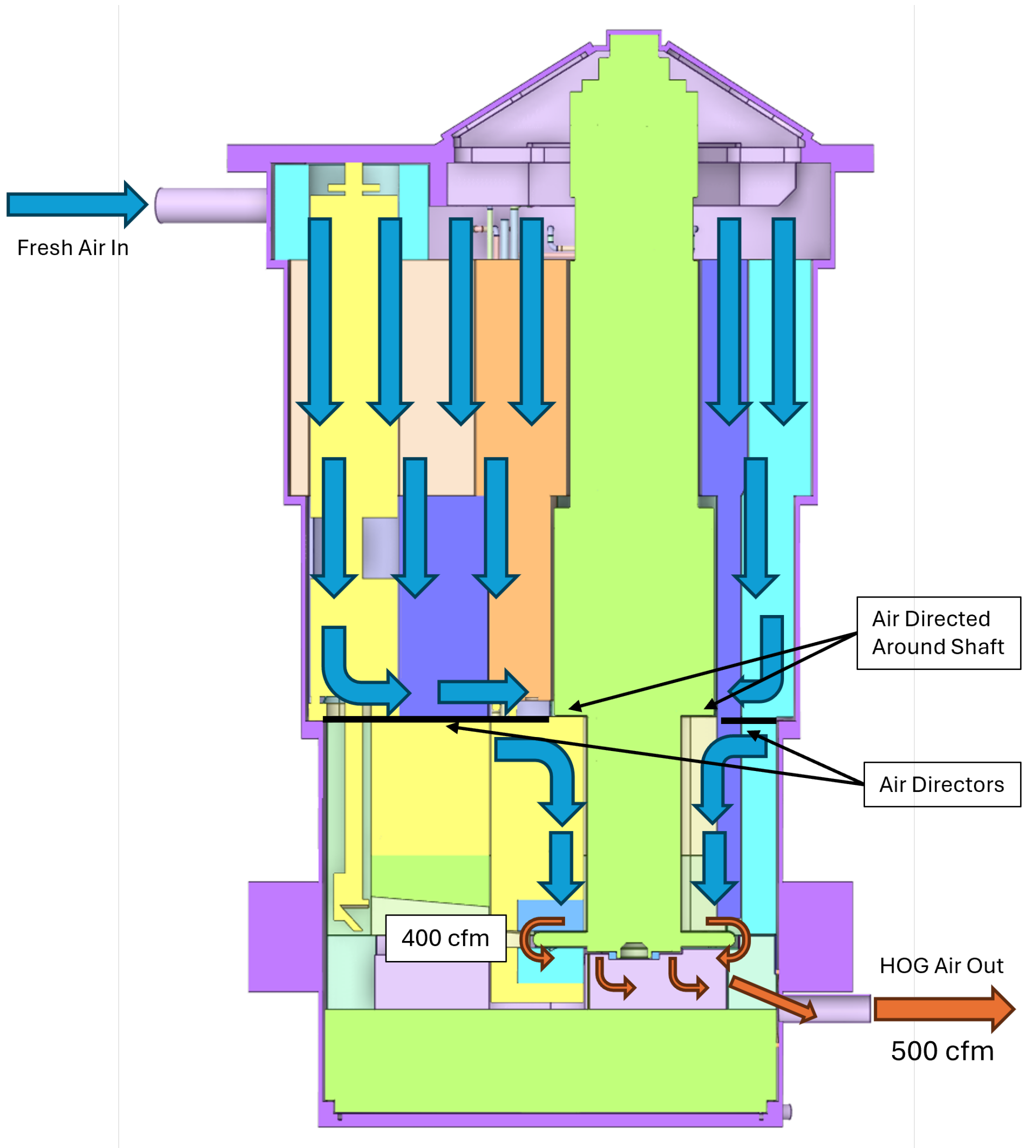

Figure 1. Core Vessel Air Flow

4. SEGMENT REMOVAL ZONE AND REMOVABLE SHIELD PLUG

Access is required to replace segments directly down-stream of the target assembly. Unrestricted vertical access must be provided to extract and install a segment. The clearance region is shown in Figure 2. This region shall be made clear to remove the segment.

Additionally, the core vessel shall provide for maintenance and installation of target assembly components:

- Access to secure and remove the segment installation bolt (Provided by hatch design and shielding design by S.03.06)
- Shielding during removal of the segment installation bolt (Provided by the gamma gate as part of S.03.06 scope)

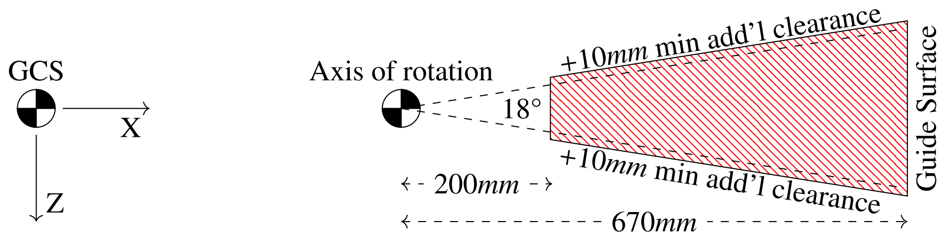

Figure 2. Segment Removal Zone

Extraction of the removable shield plug exposes a direct streaming hole from the target. In order for an operator to remove the target segment fastener, or replace it, the streaming hole must be blocked with the Gamma Gate (designed and supplied by S.03.06) and overlap into the target segment. Vertical clearances between the gate and the shaft shall comply with clearances in section 8.

The gamma gate must not deflect more than 10*mm* towards the target in a seismic event.

5. TARGET GUIDING SURFACE

There shall be a downstream feature in the shielding to guide the Target Segment pin into the segment locating feature in the lower Shaft flange. The guiding surface, with dimensions, is shown in Figure 3. The guiding surface provides rough alignment of the segment pin to assure that the final alignment features of the segment-shaft can engage.

The core vessel shielding shall ensure that the segment pin smoothly engages in the target shaft. The shielding provides rough location until the segment is engaged in the fine alignment features (pin into the shaft pocket) on the shaft. The shielding must:

- Ensure engagement of the segment pin with the target shaft. The jogs to the vertical shielding shown in Figure 3 show an appropriate guiding path.
- The maximum downstream extent of the shielding shall not interfere with the 25*mm* thick guide on the nose of the target when the target is installed; the cutout for the installation aid is shown in Figure 3

The shielding must be adequately close to the target shaft to prevent the segment pin from falling between the shaft and the shielding. This ensures that the target segment, when bolted against the shaft, is in the locating pocket and not erroneously in the space between shaft and shielding. The shielding shall provide a horizontal surface in the target installation region that is within 25*mm* radially of the target shaft and at an elevation of 60*mm* of the Global Coordinate system.

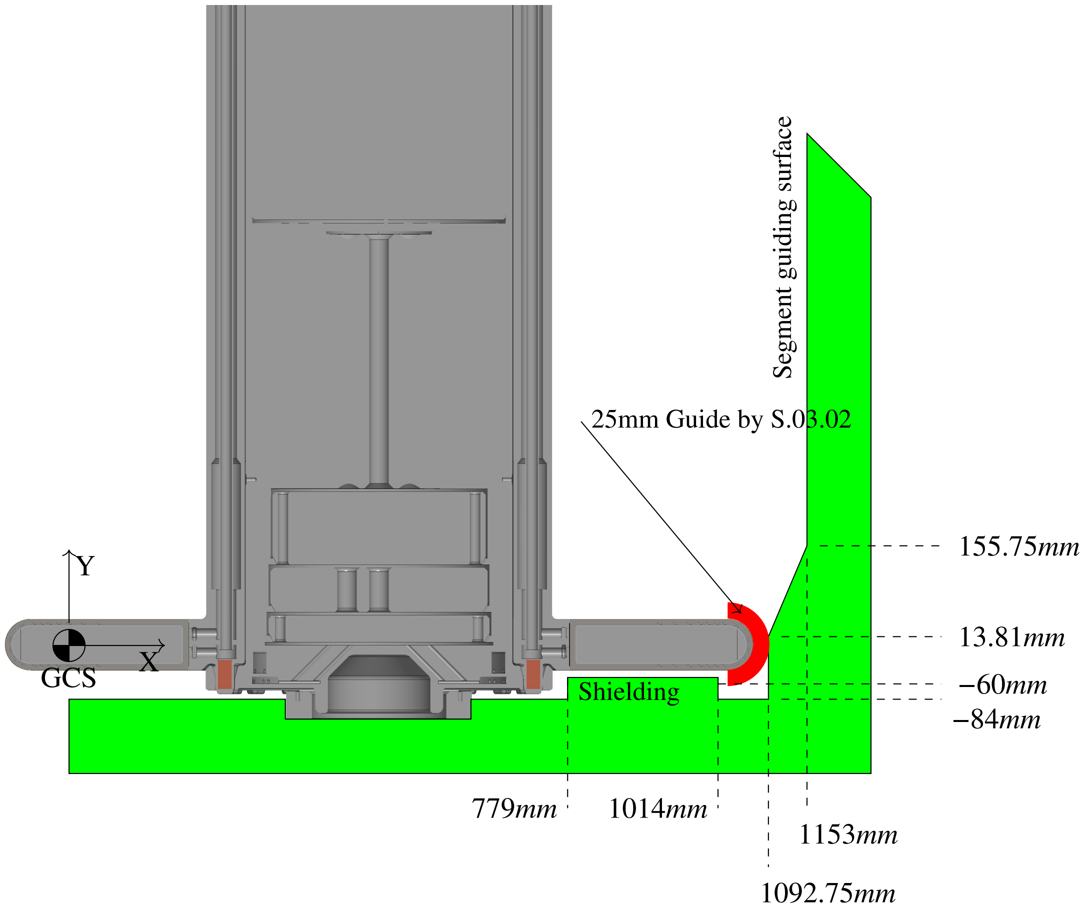

Figure 3. Cross-section along beam axis showing segment guiding surfaces and clearances. Note all dimensions are relative to the global coordinate system

The vertical guiding surfaces shown in Figure 3 shall:

- Have an installation tolerance $\leq 2mm$
- Have a surface profile (waviness) $\leq 2mm$

6. TARGET ASSEMBLY MOUNTING INTERFACE

The mounting interface is provided by Vessel Systems [S.03.06]. The target assembly mounting interface provides a stable mounting point for the target and must ensure the following:

- Prevent the target from contacting the MRA and shielding during all design basis loads and load combinations listed in ASCE 7 [1]
- Prevent contact with the snubber during normal operations.

6.1 TARGET ASSEMBLY MOUNTING INTERFACE - GEOMETRY

The Target Assembly is mounted to the Core Vessel on a support ring and outriggers as shown in Figure 4

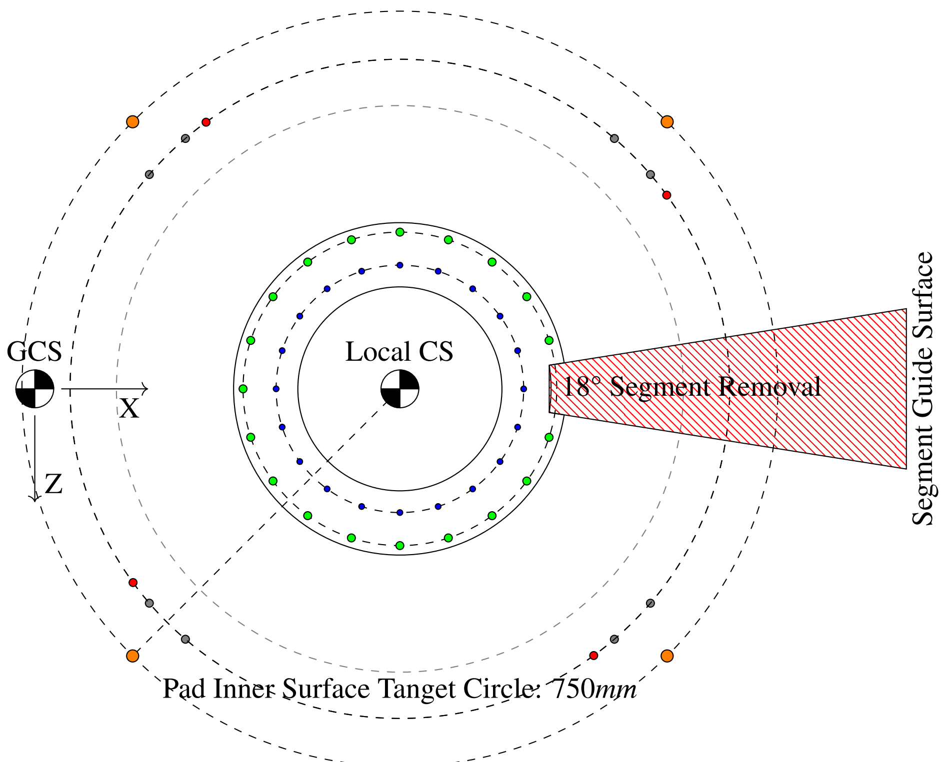

Figure 4. Upper Attachment Ring Geometry, $y = 5250mm$**. Red hatch region to be unobstructed for segment removal (see section 4 for details)**

Table 2. Target Assembly mounting interface dimensions

Parameter	Value
Mounting Elevation	$5250 \pm 3mm$
Mounting flatness	$< 0.25mm$
Mounting surface parallelism	$< 0.25mm$
Ring Center X-Location	$483 \pm 3mm$
Outside Diameter	$\varnothing 440 \pm 2mm$
Inner Diameter	$\varnothing 270 \pm 0.25mm$
Surface Finish	$R_a 3\mu m$
Structural bolting (green)	19x $\varnothing 10.5mm$ thru holes on $\varnothing 415mm$ bolt circle
Vacuum sealing bolts (blue)	20x $\varnothing 7.5mm$ thru holes on $\varnothing 327.5mm$ bolt circle
Outrigger positioning bolts (orange)	4x M16 - 2mm thread on $\varnothing 1000mm$ radial from shaft axis, starting 45 deg off plane from beam
Outrigger anchor bolts (gray)	2x per pad, 67.5mm apart, M16 x 2mm thread on $\varnothing 872.614mm$ bolt circle
Outrigger dowel holes (red)	1x per pad, $\varnothing 10mm$, drill in-situ by S.03.02.
Outrigger pad size @ each position	4x 150mm wide by 200mm long, starting 375mm from shaft axis and moving outward, $> 50mm$ thick

[a] All locations relative to global coordinate system
[b] True position of features, relative each other(local coordinate system), shall be better than 0.5mm

6.2 TARGET ASSEMBLY MOUNTING INTERFACE -LOADS IMPOSED BY THE TARGET ASSEMBLY

The target will impose the following maximum (bounding) loads to the mounting interface as shown in Table 3. Deflections listed are the projection of the core vessel motion to the STS Global coordinate system. (What deflection would an infinitely stiff target assembly experience from the interface motion?)

Table 3. Target assembly loads imposed on the primary mounting interface

Load	Abb.	F_{radial} kN	$F_{vertical}$ kN	M_{axis} kN	$M_{x/z}$ kNm	Comment
Dead	D	-	171	-	-	
Seismic	E	±50	±12	-	±55	
E-Stop	L_{Estop}	-	-	±2.0	-	
Operational imbalance	L_{imb}	±0.5	-	-	-	
Maintenance imbalance	L_{maint}	-	-	-	5	3 segments removed
Vacuum	P_{vac}	6.8	-	-	-	Opening area
Operation (thermal)	T_{op}	-	-	-	-	Negligible

[a] Directions are per the STS global Coordinate system.
[b] Forces and moments are applied at the centroid of the lid interface.

Additionally, during bearing replacement, the entire weight of the target assembly ($17400 kg$) will rest directly upon the mounting interface. The surface of the target assembly contacting the upper mounting surface has a maximum diameter of $290 mm$.

6.3 TARGET ASSEMBLY MOUNTING INTERFACE - INSTALLATION ERRORS

The target assembly has approximately $\pm 6 mm$ to account for core vessel and target assembly fabrication tolerances.

To enable accurate target assembly location, the mounting interface center point must be located within (relative to the global Coordiante System (CS) constructed from the best fit from all beam guides):

- Horizontal: $\pm 4 mm$
- Vertical: $\pm 2.5 mm$

The target assembly will be shimmed into position at installation. The target assembly will provide allowance for $\pm 6 mm$ of adjustment in both vertical and horizontal directions.

6.4 TARGET ASSEMBLY MOUNTING INTERFACE - ALLOWABLE DEFLECTIONS

Table 4. Allowable deflections of the target assembly mounting interface

Case	Load Combination	Δ_{radial}	$\Delta_{vertical}$
Operation [abcd]	$D + P_{op} + L_{rot} + T_{op}$	$\pm 2.225 mm$	$\pm 0.725 mm$
Operation + Seismic [abcd]	$D + P_{op} + L_{rot} + T_{op} + E$	$\pm 3.225 mm$	$\pm 1.0 mm$
Overpressure and test [abcd]	$D + L_{rot} + P_{MAWP} + T_{op}$	$1.625 mm$	$1.625 mm$
Thermal [e]	T_{op}	-	+0.6

[a] Deflections are measure relative to the lower flange of the core vessel (lowest shield block support). Deflections are relative to the reference state of the fully configured target system (everything in the monolith) at equilibrium (Ambient internal pressures, room temperature, no rotation).

[b] Deflections apply to the worst-case combination of stated loads (including loads imposed by the target assembly)

[c] P_{op} Operating pressure: Vacuum: $1 kPa$ or helium operations: $95 kPa$

[d] Deflections are measured at the target elevation, using infinitely stiff, zero mass representation of target assembly (projected motion)

[e] The thermal growth is to be offset by the target assembly by biasing the target segment length to compensate.

Deflections are stated in terms of unfactored loads (neither LRFD nor ASD load combinations).

Deflections are determined at the interface ring (not the outrigger pads), with loads applied at the interface ring. (This may be modified if a combined analysis representing the stiffness of the target assembly is used.)

7. SNUBBER RING INTERFACE

The snubber ring is captured within the core vessel shielding and machined to fit the shielding during installation (by S.03.02) to align with the Moderator and Reflector Assembly (MRA) and the master STS world coordinate system. The ring serves to prevent contact with the moderators and shielding in a seismic event. Contact is anticipated during a seismic event but must not touch or contact during normal operation. The following outlines the geometry, installation errors, and fabrication tolerances errors during normal operation.

7.1 SNUBBER RING INTERFACE - GEOMETRY

The snubber ring outer, inner, and top surfaces are machined to match the opening provided by the core vessel shielding. The location of the surfaces is determined relative to as-installed MRA that will be measured by fiducial and laser tracker (or similar). S.03.06 shall provide a mounting interface in the shield blocks with the nominal geometry shown in Figure 5.

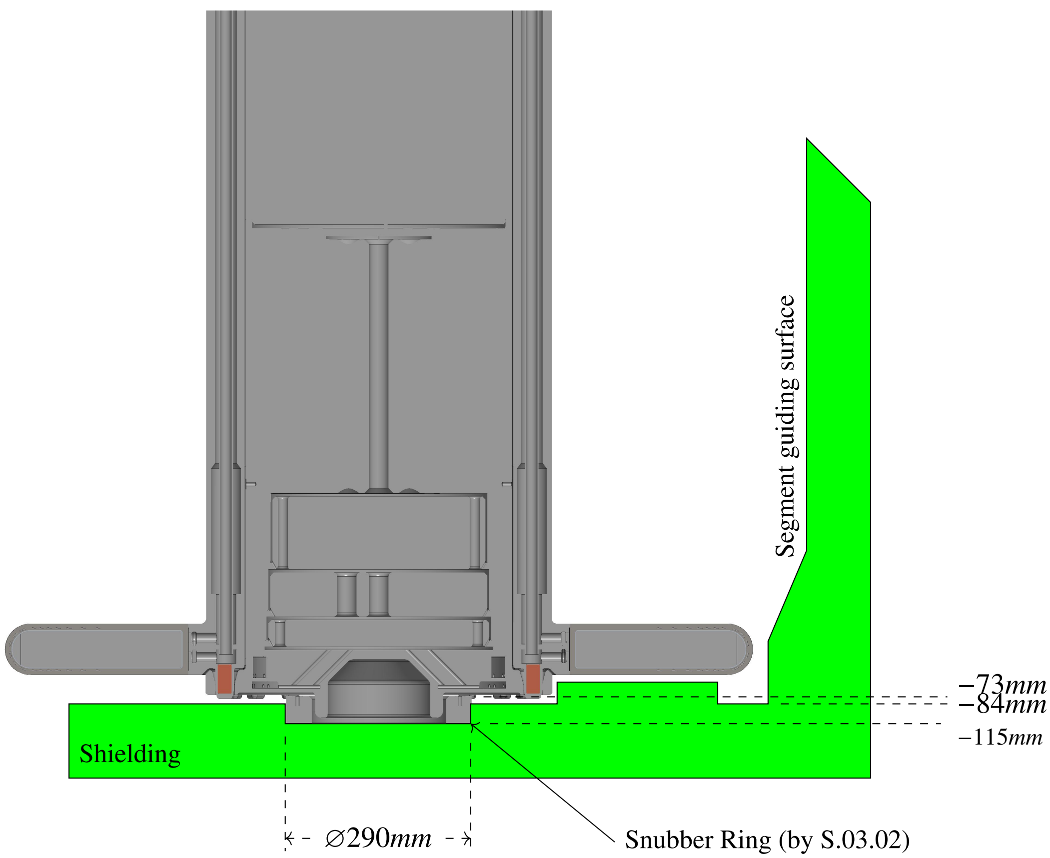

Figure 5. Seismic Restraint Ring (snubber)

Table 5. Snubber Ring geometry

Parameter	Value
Mount Elevation	$-115 \pm 1mm$
Ring Center X-Location	$483 \pm 1mm$
Shielding Hole, Female (by S.03.06)	$\varnothing 290mm$
Ring Inner Diameter (by S.03.02)	$\varnothing 210mm$
Bolt interface	6x eq. spaced M10-1.5 holes, $25mm$ deep on $\varnothing 260mm$ bolt circle

[a] All locations relative to global coordinate system

The shaft is restrained from contacting the MRA and surrounding shield blocks during a seismic event by a snubber ring. The snubber ring is supplied by S.03.02 and mounted directly to the lower shield blocks. The ring shall be provided and machined by Target Assembly [S.03.02] to match the as-installed pocket provided by the shield blocks. The pocket is provided and machined by Core Vessel systems [S.03.06]. The interface is described in greater detail below.

7.2 SNUBBER RING INTERFACE - LOADS IMPOSED BY THE TARGET ASSEMBLY

The target assembly is not intended to contact the snubber ring except during seismic events and during change-out of the crown.

Figure 6. Load Imposed on Seismic Restraining Ring by the Target Assembly

Load	Abb.	F_{radial} kN	$F_{vertical}$ kN	M_{axis} kN	$M_{x/z}$ kNm	Comment
Dead	D	-	-	-	-	No contact
Seismic	E	±35	-	-	-	Radial contact
E-Stop	L_{Estop}	-	-	-	-	No contact
Operational imbalance	L_{imb}	-	-	-	-	No contact
Maintenance rest[b]	D_{maint}	-	171	-	-	Crown replacement (unexpected)
Vacuum	P_{vac}	-	-	-	-	No contact
Operation (thermal)	T_{op}	-	-	-	-	No contact

[a] Directions are per the STS global Coordinate system.
[b] Weight of the target assembly (including segments) during exchange of the crown or bearing assembly.

7.3 SNUBBER RING INTERFACE - INSTALLATION ERRORS

The combined fabrication and installation error of the snubber ring mounting interface shall be less than:

- Horizontal:$\pm 2mm$
- Vertical: $\pm 0.7mm$

7.4 SNUBBER RING INTERFACE - PERMISSIBLE DEFLECTIONS

The allowable deflections of the snubber ring attachment are:

Table 6. Allowable deflections of the snubber mounting interface. Seismic load states are to include loads from Figure 6

Case	Load Combination [f]	Δ_{radial}	$\Delta_{vertical}$
Operation [abcd]	$D + P_{op} + L_{rot} + T_{op}$	$1mm$	$1.5mm$
Operation + Seismic [abcd]	$D + P_{op} + L_{rot} + T_{op} + E$	$1.625mm$	$1.5mm$
Overpressure and test [abcd]	$D + L_{rot} + P_{MAWP} + T_{op}$	$1.625mm$	$1.5mm$

[a] Deflections are measure relative to the lower flange of the core vessel (lowest shield block support). Deflections are relative to the reference state of the fully configured target system (everything in the monolith) at equilibrium (Ambient internal pressures, room temperature, no rotation).
[b] Deflections apply to the worst-case combination of stated loads (including loads imposed by the target assembly)
[c] P_{op} Operating pressure: Vacuum: $1kPa$ or helium operations: $95kPa$
[d] Deflections are measured at the target elevation, using infinitely stiff, zero mass representation of target assembly (projected motion)
Unfactored loads.

The Target Assembly shall have $\pm 3.5mm$ of horizontal adjustment and $\pm 1.75mm$ of vertical adjustment to compensate for errors between the target and shield block.

8. SHAFT CLEARANCES

The nominal gaps around the vertical surfaces of the target assembly, deflections, and errors are budgeted to prevent contact during operation and design basis load conditions. Note that the gaps and clearances around the target foot are handled in section 9.

8.1 SHAFT-SHIELD BLOCK INTERFACE - GEOMETRY

The nominal geometry of the target shaft is shown in Figure 7. The nominal radial clearance between the target vertical surfaces and the shield blocks is 20*mm*

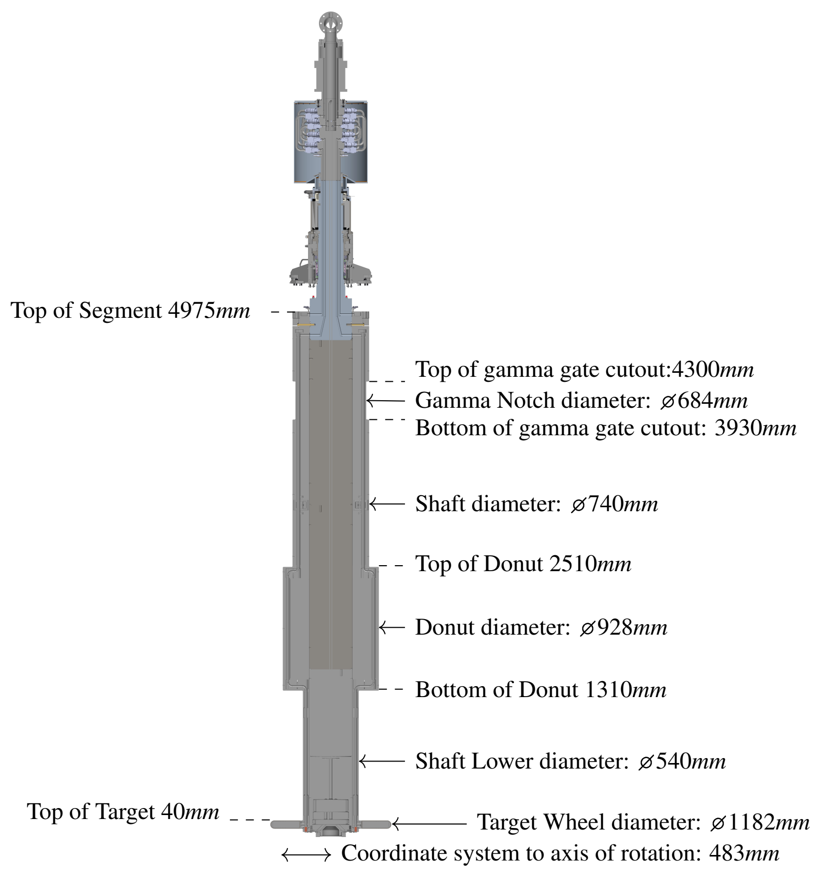

Figure 7. Shaft Clearances

8.2 SHAFT-SHIELD BLOCK INTERFACE - FABRICATION AND INSTALLATION ERRORS

The allowable installation and fabrication errors of the core vessel shielding shall not exceed:

- Core Vessel Shielding: $\pm 2mm$

Note that errors are measured from the nominal gaps located at the Global CS, located from the best-fit centers of the beam guides.

8.3 SHAFT-SHIELD BLOCK INTERFACE - DEFLECTIONS

The allowable deflections of the shield block surfaces around the target assembly are:

Table 7. Allowable deflections of the shield blocks around the target assembly.

Case	Load Combination	Δ_{radial}	$\Delta_{vertical}$
Operation [a,b,c,d]	$\mathcal{D} + P_{op} + L_{rot} + T_{op}$	$1mm$	$2.5mm$
Operation + Seismic [a,b,c,d]	$\mathcal{D} + P_{op} + L_{rot} + T_{op} + E$	$1.75mm$	$2.5mm$
Overpressure and test [a,b,c,d]	$\mathcal{D} + L_{rot} + P_{MAWP} + T_{op}$	$1mm$	$1.75mm$

[a] Deflections are measure relative to the lower flange of the core vessel (lowest shield block support). Deflections are relative to the refrence state of the fully configured target system (everything in the monolith) at equilibrium (Ambient internal pressures, room temperature, no rotation).

[b] Deflections apply to the worst-case combination of stated loads (including loads imposed by the target assembly)

[c] P_{op} Operating pressure: Vacuum: $1kPa$ or helium operations: $95kPa$

[d] Deflections are measured at the target elevation, using infinitely stiff, zero mass representation of target assembly (projected motion) Unfactored loads.

9. TARGET FOOT CLEARANCES

The nominal gaps above and below the target assembly foot are budgeted to prevent contact during installation, operation and design basis load conditions.

9.1 TARGET FOOT - SHIELD BLOCK INTERFACE - GEOMETRY

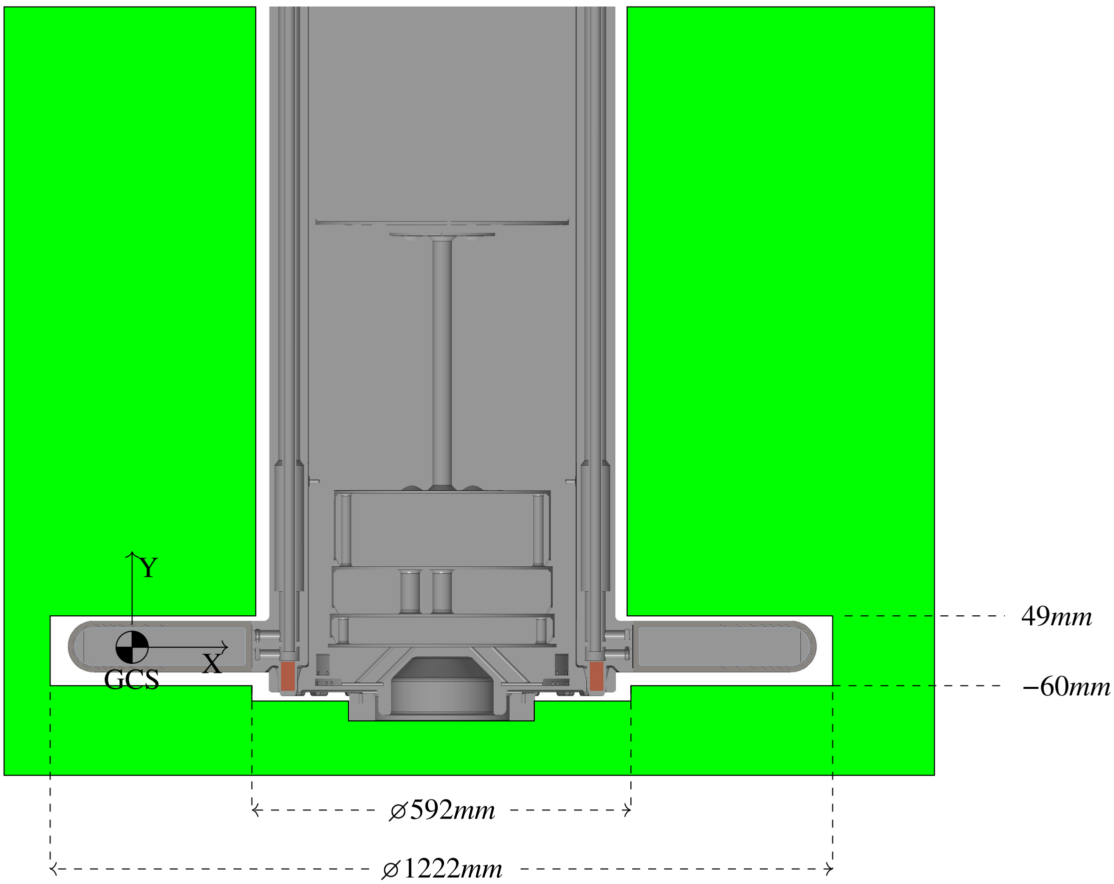

Figure 8. Shielding to target foot clearances

Nominal clearances around target foot:

- Above: 9*mm*
- Radial: 20*mm*

The radial clearances are beyond the circumscribed circle of the target; that is the arc that is created by the outermost section of the target (⌀1182*mm*).

9.2 TARGET FOOT-SHIELD BLOCK INTERFACE - INSTALLATION AND FABRICATION ERRORS

The permissible installation errors of the shield block shall not exceed:

- Horizontal: ±2*mm*
- Vertical: ±0.8*mm*

9.3 TARGET FOOT - SHIELD BLOCK INTERFACE - DEFLECTIONS

The allowable deflections of the core vessel shielding around the target foot shall not exceed:

Table 8. Allowable vertical deflections of the shield blocks around the target foot.

Case	Load Combination [c]	$\Delta_{vertical}$ [b]
Installation	D	N/A
Operation [a]	$D + P_{vac} + L_{imb} + T_{op}$	$1mm$
Operation + Seismic [a]	$D + P_{vac} + L_{imb} + T_{op} + E$	$2.5mm$

[a] Deflections apply to vacuum $1kPa$ or helium operations $95kPa$

[b] Deflections only - does not include fabrication or installation tolerances

[c] Deflections are stated in terms of unfactored loads (neither LRFD nor ASD load combinations)

10. REMOVAL OF SHIELD BLOCK RELATED TO AN OFF-NORMAL TARGET SEIZE

It is conceivable that the Target Assembly could become seized in the Core Vessel shielding in an off-normal failure scenario. In this case, rotation would not be possible, making segment removal impossible, and causing the Target Assembly and MRA to become entrapped in the shielding. In this scenario it would be necessary to unstack the Core Vessel shielding to extract the Target Assembly. The design of shielding that ensures the target and shielding can be removed from the core vessel is the responsibility of [S.03.06].

11. MRA SUPPORT INTERFACE

The motion of the shielding that supports the MRA is integrally linked to whether the target assembly contacts the MRA. While not fully within the scope of the target assembly, the deflection of the shield block supporting the MRA will be captured here for convenience. The exact nature of the interface beyond what is stated here is captured in an MRA-Vessel Interface document.

The permissible installation errors of the shield block shall not exceed:

- Horizontal: $\pm 0.5mm$
- Vertical: $\pm 0.6mm$

The allowable deflections of the shield block supporting the MRA is:

Table 9. Allowable vertical deflections of the shield block supporting the MRA

Case	Load Combination	Δ_{radial}	$\Delta_{vertical}$
Operation [a,b,c]	$D + P_{op} + L_{rot} + T_{op}$	$\pm 0.5mm$	$\pm 0.75mm$
Operation + Seismic [a,b,c]	$D + P_{op} + L_{rot} + T_{op} + E$	$\pm 0.625mm$	$\pm 0.75mm$
Overpressure and test [a,b,c]	$D + L_{rot} + P_{MAWP} + T_{op}$	$0.5mm$	$0.5mm$

[a] Deflections are measure relative to the lower flange of the core vessel (lowest shield block support). Deflections are relative to the refrence state of the fully configured target system (everything in the monolith) at equilibrium (Ambient internal pressures, room temperature, no rotation).

[b] Deflections apply to the worst-case combination of stated loads (including loads imposed by the target assembly)

[c] P_{op} Operating pressure: Vacuum: $1kPa$ or helium operations: $95kPa$ Unfactored loads.