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| **SNSPPU Cryomodule Assembly Alignment Procedure** |
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# Purpose and Scope

The purpose of this document is to describe the Alignment Procedure when assembling the SNSPPU High Beta Cryomodules. The work begins with the initial alignment of the Space Frame and Thermal Shield, then the Cavity String to the Space Frame, and finally the Cold Mass inside the Vacuum Vessel. The Alignment data is captured in the Alignment Spread Sheet and uploaded into the appropriate Assembly Traveler for record.

# Terms, Definitions, and Reference Docs

Space Frame- Structural support for the Cavity String

Thermal Shield- Cu structure providing 50k thermal cooling

Inclinometer- Precision alignment device used for measuring angles

Nitronic Rods- Nitronic steel rods used to hang and align the Cavity String

Alignment Arms- Precision machined tooling used to perform this procedure

104211500-M8U-8200-A002 Cold Mass Assembly

CRM9000010-2710 Alignment Arm

End Can Alignment Arm

H0X Space Frame Alignment

# Roles and Responsibilities

The following actions are to be performed by knowledgeable, authorized Technicians only. Consult the Group Lead for details.

# Procedure

## Procedure

Space Frame & Thermal Shield Assembly

Before starting alignment, the following steps must be completed:

1. Center thermal shield in the spaceframe, nominal distance is 1.28”from Outside Diameter of thermal shield to Inside Diameter of spaceframe (±.20’ is acceptable).
2. Check that height of spaceframe relative to the rail is correct, and that spaceframe wheels-to-rail is correct.
3. Position spaceframe axially over the cavity string before installing the nitronic rods. Install nitronic and axial restraint rods, tighten top nitronic rods first, then lower to 20 in-lbs. Finally torque axial restraint rods to 20 in-lbs.
4. Remove the lollipops, monitor cavity movement by installing a dial indicator under the coupler bellows. Record any substantial movement.

After the spaceframe is in place and supporting the cavity string:

1. Install both alignment scopes and reference targets on the granite pier monuments (the monuments are equidistant [on both sides] and are set at a height at which the beam centerline lies).
2. Check inclinometer calibration by placing on granite pier (lined up against one edge) and recording the number. Rotate the inclinometer 180º and record. The readings should be within .002º.
3. Pull up the alignment spreadsheet template and save with appropriate name (s/n, date, initial inside spaceframe, etc.).
4. Record the offsets of the granite pier targets.
5. Ensure all flanges are clear of debris (tape, MLI, etc.).
6. Install alignment arms (record which arms are being used) and targets on both sides of two end flanges of one cavity.

• Place the arm against the flange in a horizontal position.

• Thread the SiBr screw into the flange hand tight.

• Ensure the arm is moving freely rotationally and horizontally.

• Torque the screw to 40 in-lbs (while the arm is supported).

• Check for freedom of arm to rotate around flange approx. 1º.

1. Install the inclinometer onto the arm so it rests against the outboard stop.
2. Using the adjustable support arm, adjust turnbuckle until the inclinometer reads 0.000 and the bubble level on the inclinometer is between the lines.
3. Note the position of the targets.
4. Adjust the nitronic rods slowly and evenly to bring the targets within +/- .030 inches without rotating the cavities. Adjust two adjacent flanges simultaneously to avoid stressing the bellows. Do not move one flange more than .050” without moving the other.
5. Torque all nitronic rods to 180 in-lbs slowly and evenly while looking at the targets to ensure they are within spec (this is an iterative process, the lower rods should be around 10-30 in-lbs less). Back the nuts off (iteratively) on all the nitronic rods to under 100 in-lbs.
6. Use the axial restraint rods to position the coupler flanges in the “z” direction within ±1/16” (as given on the CRM9000002 drawing). Do not exceed 180 in-lbs.
7. Adjust the nitronic rods slowly and evenly to bring the targets within +/- .010 inches without rotating the cavities. Adjust two adjacent flanges simultaneously to avoid stressing the bellows. Ensure the torque on all the nuts is between 100 and 180 in-lbs.
8. Repeat Steps 5 through 12 for all remaining cavities.
9. Torque the axial support rods to 100-180 in-lbs slowly and evenly ensuring axially position of cavities remains within specification(two rods for each cavity support in opposite directions).
10. Check the positions of all the flanges and record on the alignment spreadsheet.
11. Remove the alignment arms.

Vacuum Vessel Assembly

1. Install the temporary guide rail in the vacuum tank over the return end can port.
2. Secure the vacuum vessel to the rails for stability. Install the SF/TS assembly into the vacuum vessel by rolling it into the vacuum vessel. Remove the SF/TS assembly supports after the wheels are in the vacuum vessel. Center the assembly in Z by centering on the FPC port nearest the REC. Check for centering at the other three FPC ports and at the 24 lockdown locations. Trial fit the FPC top hats. Remove the temporary guide rail.
3. Install the six large lockdowns into the spaceframe at the quarter points. Check thread engagement to insure it is adequate . The two top lockdowns have tapped holes for lifting eyes. Back off the other non-tapped lockdowns as needed so that they don’t interfere with the next two steps.
4. Position the two overhead crane hooks over the tapped lockdowns and lock out the crane. Install two lifting eyes in the lockdowns and install chain falls to give precise control during lifting. Lift the assembly with the chainfalls until the weight of the SF/TS assembly is just off the vacuum vessel, 0.2 to 0.5 mm. Using the two top lockdowns set the Y position of the SF/TS by checking the positions of the beam pipes relative to the VV center. Goal +/- 1mm adjusted for the as lifted positon.
5. Install the X-Z adjusting jigs to the lock downs. Fine position the X and Z adjustment of the SF/TS assembly in the vacuum vessel. Use the beam pipe positions at the ends for the X location in the VV (Goal +/- 1 mm). Use the location of the FPC nearest the REC to set the Z location (Goal +/- 1 mm). Using the chain falls, lower the SF/TS assembly onto the VV.
6. Hand tighten the other 4 major lockdowns and recheck the X, Y, and Z position of the SF/TS assembly in the vacuum vessel. Check the locations of the other three FPC’s and the other lock downs. Trial fit top hats now or after tack welding the lockdowns?
7. Hand tighten the other 18 lockdowns. Tack weld all 24 lockdowns while monitoring the beam pipe positions. Finish welding the lockdowns by skip welding to minimize distortions.
8. Support vacuum vessel at ¼ points (same locations as supports in tunnel) on assy bench.
9. Install alignment arms and targets on flange at both ends (Flange #2 and #7) and two at the center of the module (points in vacuum tank and end cans allow this).
10. Adjust the screw feet on the module ¼ point supports to bring the targets on each side within the viewing area of the monument reference targets (get as close to 0 as possible).
11. Record the relative position of the granite piers with respect to the theoretical beam centerline.
12. Install four tooling ball blocks evenly spaced on each side of the outer shell of the cryomodule. There are features on the vacuum vessel rings to accommodate this.
13. Using theodolites, determine the positions of all four alignment rod targets per side. Determine and record the positions of the tooling balls relative to the theoretical beam centerline and the face of the upstream valve flange face.
14. Remove the alignment arms and proceed with the CM assembly.

# **Release and Revision History**

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| A | Initial version | 10/22/2021 |
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# **Approvals**

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