EXTERNAL SEI INSTALLATION FOR HAM6

DATE: ____

PIER AND ADAPTER PLATE INSTALLATION

1 ANCHOR BOLTS INSTALLATION

Tools needed: *Plumb bob, pencil, 6' or 8' straight edge, framing square, Drill Template, marking pen, measuring tape, large radius compass, marker*
Manpower: *2 people*

1.1 Our first step is to determine the center where the Pier will be located to determine where to install the anchor bolts. Begin by hanging the plumb bob in the groove between flange and flange cover on outboard side of E-nozzle and mark point on the ground. Repeat for all four flanges. Check axial distance between pair of marks on either side of chamber (84"-door sides). Target distance = **68.5 ± .075"**.
1.2 Draw axial line beyond and between both pairs of points.
1.3 Mark points **0.345"± 0.010"** away from plum bob marks that are axially along line from above.
1.4 Make ~30" line outboard from the chamber and perpendicular to the axial line from the ***1.1.3 mark***.
1.5 On ***perpendicular line***, make mark **25.813" ± .0625"** from the ***1.1.3 mark***; this is the "Pier Center Mark".
1.6 Repeat steps 1.1.1.3-1.1.1.5 to get Pier Center Marks for other three positions.
1.7 Checks:

1) Axially between Pier Center Marks = 69.19 ± .0625"
2) 1.1.1.3-mark to Pier Center Marks = 25.813" ± .0625"
3) 1.1.1.3-mark to other Pier Center Mark (on same side) = 73.85" ± .0625

1.8 Position the Drill Template on the Pier Center Mark and find angular position utilizing the ***perpendicular line*** and scribe marks on the Drill Template. Mark anchor holes, Pier diameter, grouting limit diameter, roughing areas, and Pier Positioning Marks.
1.9 Drill holes and install bolts (see Anchor Bolt Installation Procedure). The hole depth range is **6.625-7.125".**

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2 PIER & ADAPTER PLATE INSTALLATION

SEI Components: *Grout Plate (D972126), Piers (D972609), Adapter Plate (D97290), Pier Adapter Plate Mounting Clamps (D972418)*
Tools needed: *Surveyor's level, mini tripod, elevation rods, tape measure, surveyor's level, scale (& stand), framer's square, 1 1/8" wrench, 1 1/4" Crow's Foot, Bar, torque wrench, flashlight, ½"-13 Lifting Eyes, sling*
Hardware: (16) 3/4"-10 nuts, (16) 3/4"-10 flange nuts, (16) 3/4" thick washers, (16) 1/2"-13 x 1.75" SHCS
Manpower: 2 people

INSTALL NUTS AND GROUT PLATE

2.1 At a Pier location place flange nuts and Grout Plate on anchor bolts with the top of the Grout Plate at roughly **3"** above the floor ***(or ~4" for LLO Piers).***

2.2 Set the elevation of the Grout Plates by placing the 8' level under a pair of E-Nozzles and measure the distance down to the Grout Plates w/ a framer's square. Adjust the elevation of the Grout Plate to **15.725" ± .0625"** below the pair of E-nozzles ***(or 14.725" for LLO Piers)***.

2.3 Repeat for other three locations.

2.4 Before Installing Piers, survey the elevation of all four E-Nozzle bottoms for Pier elevation confirmation; note the average of all four E-Nozzles.

INSTALL & ELEVATE PIERS

2.5 Position all four Piers on Grout Plates.

2.6 Record the elevations on the top of all four Piers. Confirm that the Pier tops are **3.555" ± .0625"** above the base of the *average elevation* of the chamber's E-Nozzles; make adjustments if necessary.

2.7 Once the elevations are set, make the individual level of each Pier, and level w.r.t. each pier **± 0.010"**.

POSITION (X, Y, YAW) PIERS

2.8 With the Framer's square, move the Pier in x & y so that the outer diameter of the Pier *bottom plate* is within ± **0.125"** of the Pier Positioning Marks, obtained from step 1.1.1.8.

2.9 Set yaw of Piers by utilizing the flat weldments on the side of a pair of Piers and a Tooling Bar. Place the Tooling Bar as close as you can get on the flat weldment plates and then rotate the Piers until the Tooling Bar/flat weldment contact is flush for both Piers.

2.10 Repeat steps 1.2.3.1—1.2.3.2 for the other pair of Piers.

2.11 Hand-tighten Piers down on anchor bolts.

2.12 Torque flange nuts up with Crowfoot wrench to 175 ft-lbs.

2.13 Take a look at the elevation of all the Piers and confirm that they are still within **± 0.10"** of each other.

ADAPTER PLATE INSTALLATION

2.14 Lay an Adapter Plate on all four Piers and install Optics Plates on each Adapter Plate; do not bolt them down at this point.

2.15 Tie together all four Adapter Plate/Optics Plate set-ups by placing Tooling Bars on the Optics Plates; try to keep them relatively centered on their Piers, to decrease the amount the Adapter Plates will have to be slid later.

2.16 With a framer's square and scales ensure the Adapter Plates are "balanced" w.r.t the chamber utilizing the E-Nozzles **(+/- 1/16").** This will be done w/ two types of measurements:

1) "LONGITUDINAL" (i.e. parallel to the large HAM door flange)
From the face of the E-Nozzle flange covers measure the distance out to the Tooling Bars for all four corners and "balance" system. Once this degree of freedom is set, it may be helpful to clamp down "guide rods" against the Adapter Plates to now limit motion of the Adapter Plates to just axial for the next measurement.

2) "AXIAL" (i.e. perpendicular to the large HAM door flange)
From the Tooling Bar to the outboard edge each E-Nozzle, make a measurement at all four positions and balance.

2.17 Secure Adapter Plates to Piers with Mounting Clamps, washers, and **1/2"-13 x 1 3/4" to 48 ft-lbs**.
DATE COMPLETED:_____ SIGNATURE:_____

SUPPORT TUBE & BELLOWS INSTALLATION

SEI components: *Support Tube (D972610), Support Tube Jack (w/ Teflon bases), Support Tube Extensions, Support Tube Tooling, (4) HAM Bellows (D972611)*
SEI Fixtures: *(4) Piping Platforms, Forklift Boom, Bellows Compression Clamp*
Tools: *9/16", 5/16", 3/4" wrench, cleaned 4' level, cleaned 6 ' level, 6" scale, 12" scale (and mount), shackle(s)*
Hardware: *Wire (for lifting Support Tube), large & small Cu gaskets for Bellows, (64) silver-plated 5/16"-24 x 1 1/2", (re-use bolts for large conflat), (15) nut plates*
Estimated Time: *1/2 day*
Manpower: *4 people*

The next phase is to begin work within the vacuum system. The Support Tube, Support Table, and Bellows are installed in order to perform a leak test on the Bellows before too much other hardware is in the way to make access to the Bellows more difficult, and before much load is attached to the Support Tubes as well.

3. SUPPORT TUBE INSTALLATION

PREPARATION FOR SUPPORT TUBE INSTALLATION

3.1 Position and energize clean room.
3.2 Install Piping Platforms on either side of chamber (adjacent to each pair of E-Nozzles).
3.3 Have Support Tube Jacks (w/ Teflon bases) ready on piping platforms.
3.4 Remove HAM doors and E-nozzle covers.
3.5 Install E-nozzle Conflat protectors (use copper wire to secure onto flanges) and O-ring protectors (if not available, use foil as a protection for these flanges).

PASSING SUPPORT TUBE INTO HAM CHAMBER

3.6 Position forklift adjacent to HAM door, with forks positioned for maximum side shift.
3.7 Clamp wire around the center of the Support Tube utilizing threaded hole tab and hook to forklift boom of forklift.
3.8 Begin threading end of the Support Tube toward its respective E-nozzle, with opposite end still outside chamber and at a significantly higher elevation for clearance reasons.
3.9 Continue to insert the Support Tube through E-nozzle until opposite end can enter the chamber and be lowered and passed through its respective E-nozzle.
3.10 Pre-located jacks take Support Tube load from forklift
3.11 Unfasten Support Tube and remove forklift.
3.12 Attach Support Tube Extensions to ends of Support Tubes
3.13 Slide jacks out so they are taking load of Support Tube at end of Support Tube Extensions
3.14 Repeat for opposite side.

INITIAL POSITIONING OF SUPPORT TUBES

3.13 Perform measurements to get Support Tubes centered within the E-Nozzles.
3.14 Using a scale, center the Support Tube in the transverse direction within the E-Nozzle by sliding Teflon-based jacks. In a clean manor, measure distance between the outboard surface of the Support Tube and inner diameter or outer diameter of the E-Nozzle flange (whichever is easiest to

read and repeat); take measurement at all four corners. Support Tube needs to be balanced within **± 0.0625" (1/6")** w.r.t. each E-Nozzle.

3.15 Similarly, adjust vertical centered-ness of Support Tube, via the Jacks, utilizing the E-nozzle flange and Support Tube surface, as done above. Support Tube needs to be balanced within **± 0.0625" (1/16")** w.r.t. each E-Nozzle; repeat for other positions.

3.16 Check for balance in longitudinal (beam) direction with 12" scale and 90-degree mount. With Mount situated on E-Nozzle, measure out to a convenient point at end of Support Tube and repeat for four positions; same target of balancing within **± 0.0625" (1/16")** applies.

3.17 The Support Tubes are now individually centered w.r.t. the E-Nozzles.

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4. SUPPORT TUBE TOOLING & POSITIONING

*With individually-centered Support Tubes, will now lightly constrain Support Tubes together via the Support Tube Tooling (**which need to be ClassA**). With this Tooling the Support Tubes will be more finely positioned w.r.t. each other. The tooling is not meant to take much load. They are for ensuring the proper alignment of the tubes; want to be careful to not move/bump the tubes. This position will need to be maintained up until the connection to the Crossbeams is made.*

4.1 Connect Support Tube Tooling between both Support Tubes. The Support Tubes may need to be tweaked around a little to ensure a proper fit.

4.2 Make another position check of the Support Tubes via the E-Nozzles (as in steps 3.14 – 3.16). If adjustments are needed, make small moves—need to be careful now that the Support Tube Tooling is attached.

4.3 Check the level of the Support Tubes optically. Place a scale on the 3/8"-24 bosses of the Support Tubes. Make measurements at several positions. Make vertical adjustments via the jacks if necessary. Make Support Tubes level to within 0.025" on the scales.

4.4 Tie down Support Tubes & secure jacks to ensure the Support Tubes do not move.

5. INSTALLING BELLOWS

5.1 For first Support Tube, prepare Bellows & Support Tube knife-edges (i.e. inspect & clean if needed).

5.2 Compress Bellows with the Bellows Compression Clamp, cover openings with foil, and set aside.

5.3 At first corner, install a 5th jack close to the small-diameter knife-edge of the Support Tube & bring this jack up such that it begins to contact the Support Tube.

5.4 As carefully as possible (want to maintain level & elevation of Support Tube) switch load to the 5th jack.

5.5 Remove outer jack.

5.6 Position large Cu gasket on E-nozzle & small Cu gasket on Support Tube

5.7 Remove E-nozzle Conflat Protector

5.8 Install Bellows such that it is on the Support Tube Extension

5.9 Being mindful of the Bellow's knife-edges, slide the Bellows toward the Support Tube

5.10 Once there is enough space, have original jack carefully take load of Support Tube from the 5th jack

5.11 Orient the Bellows such that the He-leak test window toward the bottom

5.12 Start to make connection of Bellows to the Support Tube & later the E-nozzle.

5.13 Maneuver Bellows to mate the small Bellows flange to the Support Tube; fasten three to four **5/16" 24 x 1.50"** hand-tight to lock it into place. **Be careful, this is a tricky manuever!** Don't want these gaskets to pop off during this maneuver

5.14 Make the Large conflat connection now.
5.15 Continue installing remaining bolts for both large and small conflats.
5.16 Torque down flanges.
5.17 Repeat for other (3) Bellows.
5.18 Keep Support Tube Tooling bolted to Support Tubes during pump down/leak check to help keep system tied down and aligned.
5.19 Put Doors back on chamber, pump down, and perform leak test on Bellows.
5.20 **BE CAREFUL WITH THIS ASSEMBLY. DO NOT WANT TO JEOPORDIZE ALIGNMENT AND BELLOWS ONCE THEY PASS LEAK CHECKS.**
5.21 Re-install any Bellows which fail leak check

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ACTUATION STACK & CROSSBEAM INSTALLATION

SEI components: *HAM Crossbeams (D972612), Scissors Table (D972104), Scissors Table Mounting Clamps (D972146), Spherical Bearings (D972615), V-Blocks Base (D972613), V-Block Cap (D972614), Air Bearing Mounting Plate (D972120), Air Bearing Assembly (D972103 consisting of Base, Mid, & Spherical surfaces & various hardware), Spherical Mounting Pad (D972142), Scissors Table Stop Links (and lock nuts)*
SEI Fixtures: *Crossbeam Lifting Fixture (D972878), Coarse X-Y Stage Replacement Weldment "dummies" (D972144), Crossbeam Support Brackets*
Tools: *9/16" wrench, 3/4" wrench, (2) 1/2" 13 lifting eyes, (2) shackles, (2) 6 ft straps*
Hardware: *(16) 3/8" 16 x 1.75", (16) 3/8" 24 x 1.5", (16) 1/2" 20 x 1.75", (32) 1/2"-13 x 3.5", (16) 1/2" spherical washers, (16) 1/2" 20 x 3.5", (16) 1/2" 20 x 3", (48) 1/4"-28 x 2"*
Precautions: *Lifting heavy items, steel-toed boots, hard hat*
Manpower: *2-4people*

For Crossbeam installation one must be careful with any work around the Bellows/Support Tubes because of positioning and (more importantly) vacuum issues with Bellows.

6. INSTALL SCISSORS TABLES & X-Y DUMMIES

6.1 Flip the Scissors Tables (D972104) over and choose two diagonally opposite Spring Cups; note their "thread depth" and mark this initial depth on the Spring Cup for later.
6.2 Loosen up the Spring Cups by about **2.00-2.25"**—periodically checking to see that you are not relieving to much tension in the spring; this will ease any Scissors Table adjustments later.
6.3 Make sure that dowel pins are on the Scissors Table for its positioning onto the Adapter Plate.
6.4 Place Scissors Table on Adapter Plate and bolt to Pier with 8 Mounting Clamps and **1/2" 13 x 3.5" bolts**—torque as tightly as possible, because space is too tight for a torque wrench).
6.4 Install x-y Dummies with appropriate hardware.
6.5 Swap Stop Links on Scissors Tables with turnbuckles for adjustments later. Install Stop Screw within each Scissors Table.

7. CROSSBEAM INSTALLATION

7.1 Attach the Crossbeam Lifting Fixture to a Crossbeam and lift Crossbeam with the forklift.
7.2 Carefully needle the Crossbeam into position on the x-y Dummies (remember to watch out for the Bellows and Support Tubes).
7.3 Secure the Crossbeam to the x-y Dummies with **1/2"-20 x 1.75" to 57 ft-lbs.**
7.4 Repeat for other Crossbeam.

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CONNECT SUPPORT TUBE TO X-BEAM & INSTALL AIR BEARING MOUNTING PLATE/AIR BEARING

8. INSTALL SPHERICAL BEARINGS AND V-BLOCKS

8.1 The Spherical Bearings are not fastened to the Crossbeam. They are sandwiched between the V-block base and Crossbeam bolt pad.
8.2 With **1/2" –20 x 3.50"** bolts and spherical washers loosely fasten the V-block base and spherical bearing to the Crossbeam. The loose fit here is for adjustment required for Support Tube connection later.
8.3 Loosely connect V-Block Cap to V-Block Base with **1/2"-20 x 3.00"bolts.**
8.4 Repeat steps 8.1-8.3 for other three locations.

9. V-BLOCK/SUPPORT TUBE CONNECTION

This connection will take place at all four Support Tube ends. During this step, be careful not to jeopardize the position of the Support Tubes.

9.1 Inspect V-Block/Support Tube connections.
9.2 Slowly lower the Crossbeam (via the Scissors Table) to lightly contact the V-Block Base to the Support Tube. Watch the V-Block and Spherical Bearing as the Crossbeam is lowered so that they are seated on the Support Tube without any stress; make sure the Spherical Bearing does not slide out of place. Slowly make the Support Tube/Crossbeam connection without loosing the Support Tube positions. This will likely be an iterative process.
9.3 When position of Support Tube/V-Blocks is close, torque down the V-Block caps to **57 ft-lbs**. onto the V-Block bases.

10. FASTEN V-BLOCK TO X-BEAM

10.1 Make final adjustments to Crossbeam for connection with Support Tube.
10.2 Tighten the V-Block bases to desired position and torque down (**57 foot-lbs**).
10.3 Remove Support Tube Jacks and Extensions.

11. INSTALL AIR BEARING MOUNTING PLATE AND AIR BEARING

11.1 Prepare all plumbing for Air Bearing Assembly at each Actuation Stack locations.
11.2 Use the Support Brackets to hold the vertical position of the Crossbeams; utilize Bull nose shims of Support Bracket.
11.3 Once the position of the Crossbeam is secure, compress the Scissors Table turnbuckles enough to remove the x-y dummy and install the Air Bearing Mounting Plate and Air Bearing—make sure the Scissors Table Stop Links are backed off.
11.4 Confirm that the Dowel Pins are installed on the top of the Scissors Table.
11.5 Prepare Air Bearing assemblies for installation within the clean room.
11.6 Inspect (and wipe down if necessary) Air Bearing components.
11.7 On a work bench, position the Air Bearing Base Surface on the Mounting Plate so that when installed, one flat is facing outboard of the chamber, and the other flat is on the same side as the

large cut-out section of the Pier (in other words, is *closest* to the chamber door's centerline).

11.8 Fix Air Bearing Base Surface to the Mounting Plate with **1/4"-28 x 2"** bolts and torque them to **7 ft-lbs**.

11.9 Install rubber stops on Air Bearing Base (leaving out three to ease installation of remainder of Air Bearing).

11.10 Prepare and clean Air Bearing Mid Surface, Air Bearing Spherical Surface.

11.11 Supply Mid Surface with 30 p.s.i.; keep Mid Surface "activated" whenever there is a chance of any Air Bearing surfaces may move against each other.

11.12 Carefully place the Mid and Spherical Surfaces on the Bottom Surface.

11.13 Install Remaining rubber stops.

11.14 Place Spherical Mounting Pad on Air Bearing Spherical Surface.

11.15 Orient the Spherical Surface so that it's "side bolt pattern" is on the same side as the large cut-out section of the Pier (or is *closest* to the chamber door's centerline).

11.16 Slowly raise Actuation Stack, via Scissors Tables, up to the Crossbeam; do this until the Crossbeam bolt pad and Spherical Mounting Pad are beginning to contact and are flush.

11.17 Loosely engage Crossbeam and Air Bearing with **1/2"-13 x 2.25"** bolts

11.18 Torque **1/2"-13 x 2.25"** bolts to **10 ft-lbs**.

11.19 Shut off airflow.

11.20 Bring Stop Screws up to height of Scissors Table Top Plate.

DATE COMPLETED:_____ SIGNATURE:_____