HYTEC-TN-LIGO-34

LIGO-T980128-00-D

SEI/BSC INSTALLATION PROCEDURE

W.K. Miller, Tim Thompson

Dec 1, 1998

Abstract

This document provides an overview of the fixtures used in the assembly of the BSC SEI system. The assembly fixtures are under design for the LIGO Project, sponsored by the National Science Foundation. This report documents the approach for installing the BSC hardware. It incorporates the theory, fixtures, and the sequences proposed in the BSC Assembly Sequence PDR Design Review Document, and reflects changes brought about from Hytec's Assembly of the BSC first article. Assembly and fixture designs for the HAM are provided in a separate document. Detail fixture drawings exist for the assembly steps outlined.

HYTEC Inc.
110 Eastgate Dr., Ste 100
Los Alamos, NM 87544
(505) 661-3000, Fax (505) 662-5179

LIGO PROJECT

Table of Contents

List of Figures

1. INTRODUCTION

HYTEC is designing the seismic isolation system (SEI) for the BSC and HAM components used in the LIGO project. An assembly procedure, including all assembly jigs and fixture hardware, has been evaluated with the completions of the BSC and HAM 1st articles. This document is a revision of the BSC Assembly Sequence PDR Review Document. It reflects the improvements made to the BSC Assembly Sequence.

The following sections deal with a brief overview of the general assembly procedure for the BSC. The Assembly of the BSC hardware is performed in two phases: phase 1 is the installation of the external hardware while the chamber is closed, and phase 2 is the installation of the internal hardware done while the chamber is open (and under a cleanroom chamber). Illustrations are included for assisting in the presentation of the fixture concepts.

2. PHASE 1 ASSEMBLY SEQUENCE: EXTERNAL HARDWARE

Phase 1 of the assembly sequence governs the placement of the external hardware: the piers, the actuators, and the crossbeams. This sequence will be done while the BSC chamber remains closed.

Some improvements and sequence changes (to the original proposed PDR BSC Assembly Sequence) have come about from HYTEC's assembly of the BSC 1st article. In general, most of the ideas, and concepts expressed in the PDR document have been retained where possible. This document will explain deviations from the original sequence where applicable.

2.1 PIER INSTALLATION AND ALIGNMENT

Two BSC Piers (at one time) are located in position relative to the BSC chamber. These piers are not being critically located. The Piers are nominally positioned (X, Y, and Z) relative to the BSC chamber's 14.0" dia. D-Nozzle Ports, and then are leveled (with respect to each other) with an optical level. The Pier Adapter Plate on the Piers will be critically positioned with the optical transit and some tooling bars.

Previously, in the PDR document, a sequence was not defined for installing the concrete anchors. Now, the location for the concrete anchors will be established using the BSC Pier Lifting Jig.

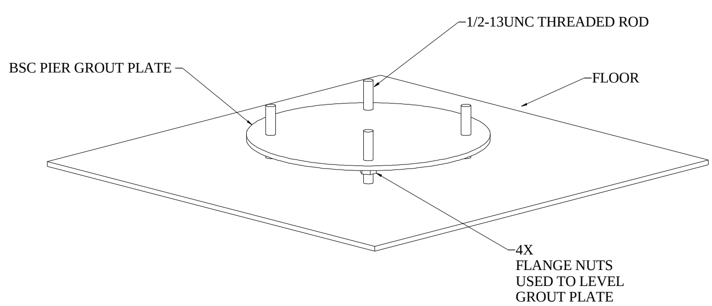


Figure 1. Pier Grout Plate

2.1.1 BSC PIER LIFTING JIG (INSTALLING CONCRETE ANCHORS)

The Pier Lifting Jig is hoisted with the bridge crane and a Spreader Beam. The Pier Centering Jig has registration surfaces that position it relative to the BSC chamber's D-Nozzle ports (described in step 2.1.4).

<u>2.1.1.1 LEVEL BSC PIER LIFTING JIG</u>

The Pier Lifting Jig should hang in a level position. There are two hoisting brackets on top of the Pier Lifting Jig, that are shifted to accommodate the jig's C.G shift (the jig used alone has a different C.G. from when it is used to hoist the Piers).

<u>2.1.1.2 LOCATE DRILL TEMPLATE</u>

Four plumb bobs are run from the jig to the floor. These plumb bobs establish the position (center of and the orientation) of a Drill Template on the floor. The Drill Template is used to mark the locations for the concrete anchors (via a starter hole or pen marking). This Jig/Template sequence can get the location of the threaded anchors placed within +/- ¼”of their ideal position.

Once the locations for the concrete anchors have been marked, a vacuum HILTI diamond core drill is used to drill the concrete anchor holes per HILTI specifications.

<u>2.1.1.3 LEVEL BSC PIER LIFTING JIG</u>

The Grout Plates are initially set at an elevation that prevents them from interfering with the installation of the BSC Piers. The grout plates are not leveled. A Pier Grout Plate assembly consists of a Pier Grout Plate, four flange nuts, four regular nuts, and four washers matching the threads on the concrete anchor. Figure 1 shows a Pier Grout Plate Assembly.

2.1.2 HOISTING A BSC PIER

A BSC Pier will not be hoisted with a Lifting Plate as suggested in the old sequence. Screw two ½ inch lifting eyes into the top of a Pier. Lift the pier with a strap and the bridge crane.

2.1.3 LOCATE THE BSC PIERS ON THE BALL TRANSFER TABLES

Figure 2 shows two piers on Ball Transfer Tables and ready to be bolted down to the Pier Lifting Jig. The Ball Transfer Tables need to be spaced approximately 114” apart, and need to be level with respect to each other (level a transfer table using its 3 pedestal feet). The Ball Transfer Table has tapped holes; lifting eyes and chain slings may be used to hoist it. The Piers are placed directly on the Ball Transfer Tables, and do not sit on a hard top plate as previously proposed. There is no longer a left/right orientation of the two Piers (the Pier design has changed). The Ball Transfer Tables are used to maneuver the 1500 lb. Piers around to mate with the Pier Lifting Jig.

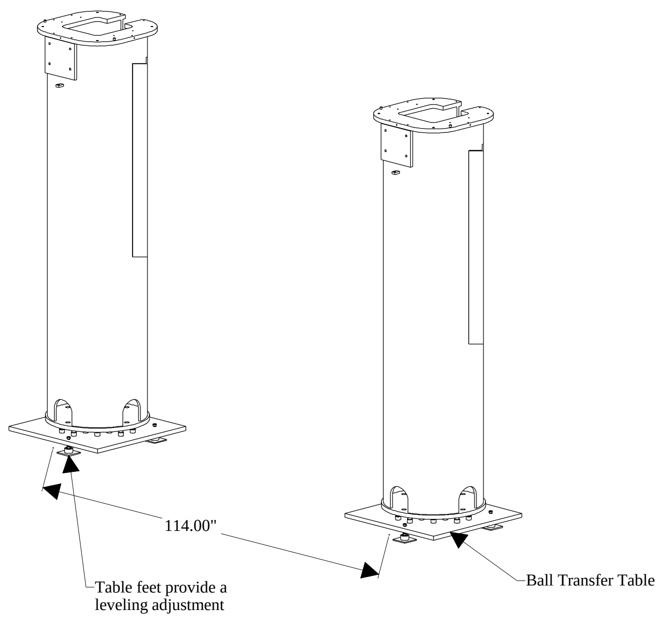


Figure 2. Piers on Ball Transfer Tables

2.1.4 PIER LIFTING JIG (INSTALLING PIERS)

Use the spreader bar and two separate chains or straps of equal length (not shown in figure) to lift the Pier Lifting Jig. As the Lifting Jig is lowered on top of the Piers, the Piers may be maneuvered around on Transfer Table to allow the two locating pins (sticking out of piers) to engage in the Lifting Jig holes. The Pier Lifting Jig spaces the Piers at 114" apart. Bolt the Lifting Jig to top of Piers to specified torque requirements.

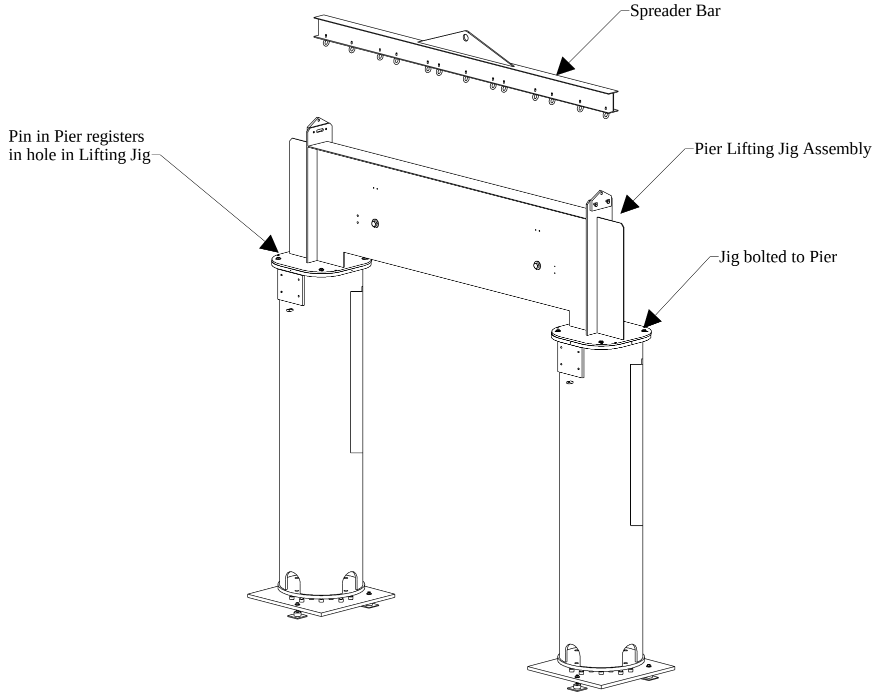


Figure 3. Pier Lifting Jig

Hoist the Pier Lifting Jig with the Piers over the Pier Grout Plates. Push and hold the Pier Lifting Jig's registration surfaces against the BSC chamber's D-Nozzle blank conflats. The Piers are now nominally located in position with respect to the BSC chamber. As the Piers hang from the Lifting Jig (and the registration surfaces are held against the chamber's nozzle ports) bring the Pier Grout Plates and flange nuts up to meet the bottom of the Piers. After the Grout Plates support the weight of the Piers, remove the Lifting Jig from the Piers. Figure 4 shows how the registration surfaces work.

2.1.5 LEVELING THE PIERS

The flange nuts below the Grout Plate are used for leveling purposes when a Pier is set on top of it. The Pier Lifting Jig has nominally set the elevation of the tops of the Piers. After the Pier Lifting Jig has been used to set this nominal elevation for all four Piers of a BSC chamber, it is important to critically level the tops of the Piers. First, one Pier is chosen to be the reference Pier, it is leveled and then the remaining three Piers are leveled coplanar to the reference Pier.

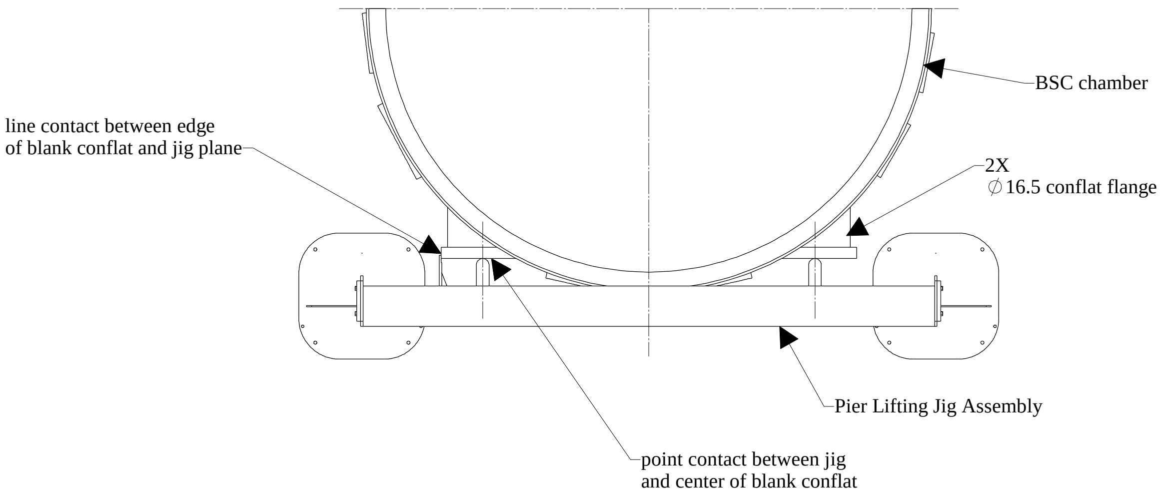


Figure 4. Pier Lifting Jig Reference Surfaces

2.1.5.1 LEVEL THE REFERENCE PIER

Set up an optical level approximately 110 inches high off the ground, in a location that can see 3 of the 4 piers. Select one of the Piers to be the reference pier. Place an optical scale (scale fixed in a bracket which holds it perpendicular to the top face of the Pier) in the 4 corners of the top of the Pier. Record the optical reading at each corner. Use these recorded numbers to level the top of the reference Pier within .015 inches total (plus/minus .0075 inch). Put nuts and washers on the concrete anchors and tighten down the Pier nuts to required torque specifications. Re-check the level of the top of the Pier.

2.1.5.2 LEVEL THE REMAINING PIERS

The reference Piers recorded optical elevation numbers are used as the reference for leveling the remaining 3 Piers. Place the optical scale on the 4 corners of the two visible Piers and level those Piers within the .015 inch profile tolerance. Move the optical level to a new position that allows for sighting of the fourth Pier. Re-sight the reference pier elevation. Moving the optical level will result in different recorded values for the reference pier due to a different optical level height. Use these re-sighted optical numbers to level the fourth Pier within the acceptable tolerance zone. Put nuts and washers on the end of the concrete anchors and tighten down the nuts to required torque specifications.

2.2 ACTUATOR COLUMN INSTALLATION

At this stage, the BSC piers have been nominally positioned and critically leveled around the BSC chamber. The actuator columns need to be located closely with respect to one another, within +/- 1mm in X and Y. The Pier Adapter Plate placed on the top of each Pier will be clocked, and translated to achieve the actuator system positional tolerance. After the Pier Adapter Plates have been critically located with respect to each other, the Piers will be grouted in place. Next, the Actuator components will be assembled in segments onto the Pier Adapter Plates. The Actuator Column will be assembled on the Pier Adapter Plate by using a pinned registration system. This process is described next.

The previous sequence did not explain in detail the optical alignment of the Adapter Plate on the Piers. The First Article assembly has also proofed the use of the Adapter Plate clocking and translation procedure and linkage. It has been decided these two steps are only necessary for the alignment of the reference Piers Adapter Plate. The remaining three Adapter Plates will be critically aligned to the reference Piers Adapter Plate via some Tooling Bars and a transit.

2.2.1 SETTING UP TRANSIT

Set up the transit on the facilities offset beamline. Sight in the offset beamline. Adjust the stand so the transit sits about 110 inches off the floor. Move the transit and stand (transit moved along the offset beamline) until the transit sights the center of the reference pier (or using an appropriate machined feature on Pier).

2.2.2 CLOCKING THE PIER ADAPTER PLATE

A transit will be used to site the position of the reference Pier Adapter Plate. Figure 5 shows the linkage configuration used to rotate the Pier Adapter Plate.

Loosen the Pier Adapter Plate mounting bolts. Align the plate until the bracket pins slide through slots in the Adapter Plate and seat in the pinholes in the Pier. Put both pin brackets in position. The pins and slots constrain the Pier Adapter Plate to a rotational motion about the Pier center. Place the Optics Plate on top of the Pier Adapter Plate. The optical plate should be tightly bolted down, and should remain so until Adapter Plate has been located in its final position. Put nuts on threaded ends of bracket #1 and #2. Leave ¼ inch of thread exposed on each bracket. Put 3/8” nut and washer and thread at least 2 ½ inch on end of push pull rod. Feed push pull rod through bracket #2 and then thread another 3/8” washer and nut on end of rod. Screw bracket #1 into Pier Adapter Plate until the nut roughly seats against the plate and the slot is pointing in the general direction where the second bracket will be placed. Screw bracket #2 with push pull rod into bracket #3. Maintain same height as bracket #1 has with pier plate adapter and same orientation technique. Bring push/pull rod and bracket assembly down so that push/pull rod sleeves slot in bracket #1. Bolt bracket #3 to side of pier. Torqueing either nut on push/pull bracket forces the plate to move. The pin bracket forces the plate to move in a rotational motion. After clocking the Pier Adapter Plate to its correct orientation (scribe line in center of Optics Plate is sighted perpendicular to the offset beamline) tighten down the Pier Adapter Plate mounting bolts.

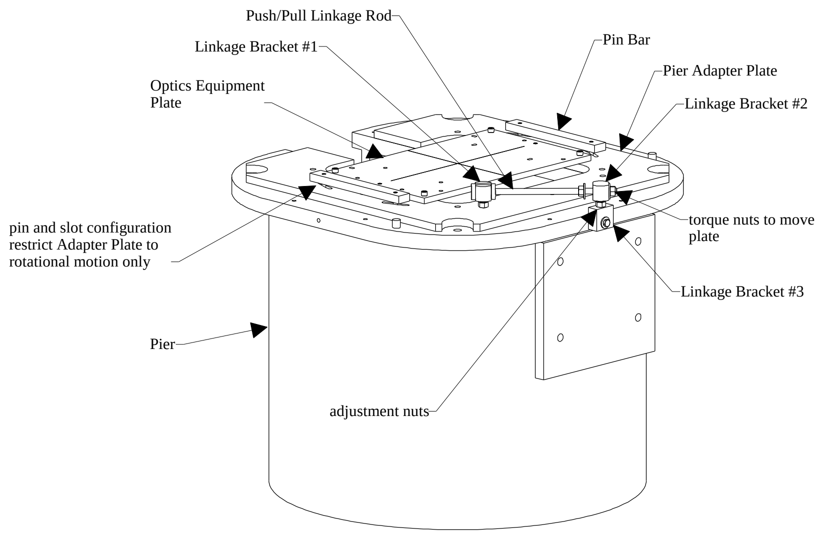


Figure 5. Clocking the Pier Adapter Plate

2.2.3 TRANSLATING THE PIER ADAPTER PLATE ALONG THE BEAMLINE

The Pier Adapter Plate may be translated using Guide Blocks (Guide Blocks constrain Adapter Plate to linear motion) and the same linkage used to clock the Adapter Plate. The Pier Adapter mounting bolts should be tight (to keep plate from moving). Remove the Push/Pull Linkage assembly and re-assemble this linkage (as described above in 2.2.2 clocking the Pier Adapter Plate) in the position shown in Figure 6. The Guide Blocks are tightly bolted down (against the Adapter Plate) in a direction consistent to allow the plate linear motion. Loosen Adapter Plates mounting bolts. Drive nuts on Push/Pull Rod to provide motion desired. Linkage Assembly and Guide Blocks are assembled in perpendicular configuration to provide a transverse linear motion. After Adapter Plate is in position desired, torque down Adapter Plate mounting bolts.

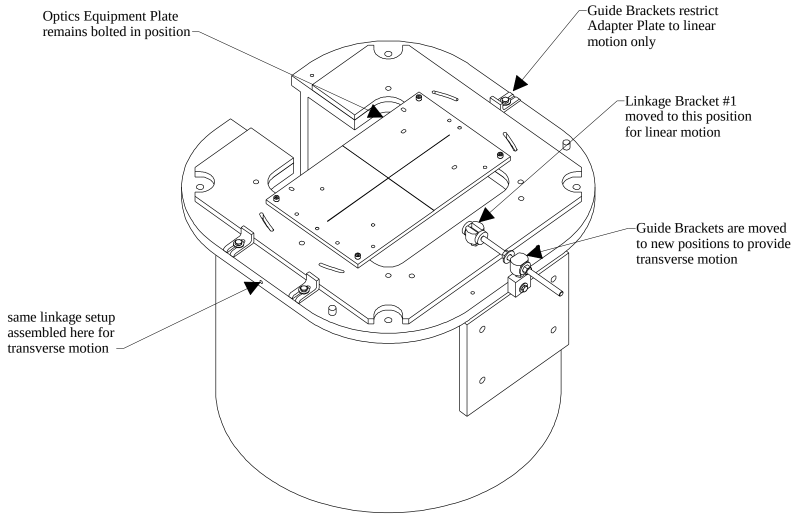


Figure 6. Translating the Pier Adapter Plate

2.2.4 RELOCATE THE TRANSIT

The transit still needs to be about 110 inches off the floor. Move the transit (and stand) to sight the center of the reference pier (in a position perpendicular to transit position in step 2.2.3).

2.2.5 TRANSLATING THE PIER ADAPTER PLATE TRANSVERSE TO BEAMLINE

Repeat the translation procedure described in step 2.2.3 until the Adapter Plate is positioned in the center of the Pier. Lock down the Adapter Plate brackets to required torque specifications. Remove the linkage assembly.

2.2.6 POSITIONING THE REMAINING ADAPTER PLATES

The clocking and translation steps described in 2.2.2 to 2.2.5 were done to critically position an Adapter Plate on the Reference Pier. The remaining three Adapter Plates need to be critically positioned square to this Reference Pier Adapter Plate (114 inches +/-.039). This task will be accomplished with some Aluminum Tooling Bars. The Tooling Bars have pins (critically positioned) in them that register in a hole-slot configuration in the Adapter Plate's Optic plate.

2.2.6.1 TOOLING BARS

Place the remaining three Adapter Plates on top of the Piers. All four of the Tooling Bars are identical. Lower a Tooling Bar down over two Adapter Plates. As the Tooling Bar Pins register in the Adapter Plates' holes and slots, the Reference Pier's Adapter Plate (Optics Plate) constrains the Tooling Bar in position while the other Adapter Plate (and it's Optics Plate) is moved to meet the Tooling Bars pins. Repeat this step in a perpendicular direction, inserting the 2nd Tooling Bar into the Reference Piers Adapter Plate (Optics Plate) and another Adapter Plates (Optics Plate). Again, repeat this procedure for the two remaining Tooling Bars. The four Tooling Bars position the Adapter Plates at their 114" dimension. Use the transit to verify that the tooling bars are mutually perpendicular. Lock the Adapter Plates down to the Pier with the Adapter Plate Mounting Clamps. Remove the Tooling Bars, and the Optics Plates. Figure 7 shows the Adapter Plate mounted on top of the Pier with the Adapter Plate Mounting Clamps.

2.2.7 INSTALL THE ACTUATORS

The original sequence stated the Actuators would be installed as a pre-fabricated unit, but this has changed; in fact each actuator column will be assembled from the bottom-up in units.

Each stage has pins that critically register it relative to each other. The three major units are (in order of assembly): the Scissors Table Assembly, the Fine Actuator (Flexure Mount) Assembly, and the Coarse X-Y Driven Translation Assembly. There is a specific orientation for all of the assemblies relative to each other. Each BSC Actuation System consists of four Scissors Table Assemblies, four Fine Actuator Assemblies, two Coarse X-Y Driven Translation Assemblies and two Coarse X-Y Floating Translation Assemblies.

Figure 7. Adapter Plate Clamped in Place

2.2.7.1 INSTALL THE SCISSORS TABLE

The Scissors Table Assembly will be installed on top of the Adapter Plate as a unit. It can be hoisted with straps and the bridge crane. The Scissors Table is preset to a nominal height of 6.55” (top to bottom of Scissors Table). The bottom plate of the Scissors Table has pins which critically position the assembly on the Adapter Plate, and the Scissors Table has a specific orientation shown in HYTEC drawing D972001. Bolt the Scissors Table Assembly down to the Pier using the Scissors Table Mounting Clamps. Torque bolts to required specifications. Figure 8 shows the Scissors Table installed on the Adapter Plate. Figure 9 shows the Scissors Table Mounting Clamps.

2.2.7.2 INSTALL THE FINE ACTUATOR (FLEXURE MOUNT) ASSEMBLY

The Flexure Mount Assembly is installed next as a unit on top of the Scissors Table Assembly. Prior to installation, each Flexure Mount Assembly should be in the locked configuration and should be equipped with dial indicators (see Fine Actuation Stage Assembly Procedure HYTEC-TN-LIGO-35). It can be hoisted with straps and the bridge crane. The top plate of the Scissors Table has pins that critically align the Flexure Mount Assembly. All four Fine Actuator Assemblies should be mounted with their PZTs facing the same direction. Bolt the Fine Actuator Assembly down to the Scissors table and torque bolts to the required specifications. Figure 10 shows the Fine Actuator Assembly bolted on top of the Scissors Table.

2.2.7.3 COARSE X-Y DRIVEN AND FLOATING TRANSLATION ASSEMBLY

Note: Air must be supplied to the Air Bearings during their and the Crossbeams installation. Air must also be supplied to the Air Bearings if they see any motion. The Air Bearings surfaces are polished to an optical finish; and must be kept free of oil, water, and dust. Handling the Bearings requires donning special clothing (see manufacturer handling instructions). Contacting the Bearing surfaces is acceptable, within the handling instructions. However, contact should be minimized. Do not slide the Air Bearings around on their surfaces without air. The polished surfaces may be cleaned with Kleen Wipes and Isopropyl Alcohol (oil free) if necessary.

The Coarse X-Y Translation Assembly consists of two Coarse X-Y Driven Translation Assemblies and two Coarse X-Y Floating Translation Assemblies. The two Driven Assemblies are located diagonally from each other (see drawing D972001).

Installation of the Air Bearings for the Driven and Floating Translation Assemblies is identical. The Driven Translation Assembly mounting plate will have the translation components pre-set and installed; the Floating Translation Assembly mounting plate does not have Translation Components. Both floating and driven assemblies will be installed in 4 pieces.

The assembly will be installed in this order: Mounting Plate (with or without Coarse X-Y Translation components), the Air Bearing Base Surface, the Air Bearing Mid Surface, and the Air Bearing Spherical Surface. After the Air Bearing components are in place, a Flexural Jig will be temporarily installed (for the installation of the Crossbeam). The Flexure will replace the Flexural Jig after the Crossbeam is in place.

Figure 8. Scissors Table Installed

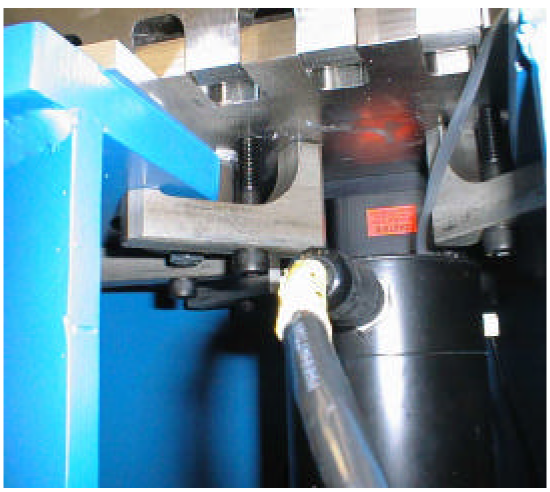


Figure 9. Scissors Table Clamp

Figure 10. Fine Actuator Assembly Installed

2.2.7.3.1 COARSE X-Y MOUNTING PLATE

Position the Mounting Plate (Driven or Floating Translation Assemblies) on the Fine Actuator Assembly. This Mounting Plate will be installed by hand. The pins in the Fine Actuator Assembly critically locate the Air Bearing Mounting Plate. The Coarse X-Y Floating Translation Assembly Mounting Plate has no specific orientation. The Coarse X-Y Driven Translation Assembly Mounting Plates are orientated such that the X Translation Stage and Stepper Motor are mirror images of, and are facing one another (see drawing D972001). Bolt the

Mounting Plate down to the Fine Actuator Assembly and torque to required specifications. Figure 11 shows the Coarse X-Y Mounting Plate installed.

2.2.7.3.2 AIR BEARING ASSEMBLY

Each Air Bearing assembly will be installed in 3 units (listed in order of assembly): the Air Bearing Base Surface, the Air Bearing Mid Surface, and the Air Bearing Spherical Surface. The Air Bearing units will be assembled by hand. **Do not slide the Air Bearings around on their surfaces without air. Air must be set between 20 to 30 psig and supplied to the Air Bearing during installation. The Air Bearings surfaces are delicate and must be kept free of oil, water and dust; they are not to be handled with out special protective clothing.**

2.2.7.3.3 AIR BEARING BASE

Place the Air Bearing Base Surface on top of the Mounting Plate. Position the two machined flats on the side of the Air Bearing Base parallel with the two other sides of the Mounting Plates. Bolt the Air Bearing Base down on the Mounting Plate to required specifications. Figure 12 shows the Air Bearing Base installed on the top of the Mounting Plate.

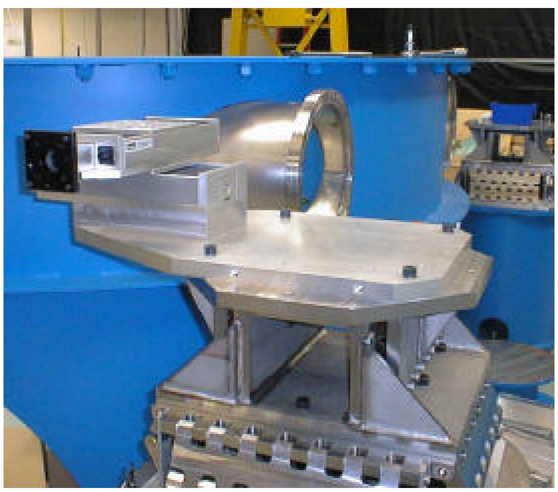


Figure 11. Coarse X-Y Mounting Plate and Translators

Figure 12. Air Bearing Base Surface on Mounting Plate

2.2.7.3.4 AIR BEARING MID SURFACE

Supply air to the Air Bearing Mid Surface (20-30psig). Put four retaining pins into the Air Bearing Mid Surface (consecutive positions). Gently slide the Air Bearing Mid Surface onto the Air Bearing Base Surface. Put the remaining four pins into the Air Bearing Base in order to keep Air Bearing Mid Surface from sliding off. The air tubing (connected to the Air Bearing Mid Surface orifice) must be oriented away from the chamber. The Air Bearing Mid Surface should slide freely on the Air Bearing Base Surface.

2.2.7.3.5 AIR BEARING SPHERICAL SURFACE

Gently lower the Air Bearing Spherical Surface on top of the Air Bearing Mid Surface. The Air Bearings convex surface should slide freely on top of the Air Bearings concave surface. Rotate the Air Bearing Spherical Surface so that the tapped holes in its side face the Coarse X-Y Translators (for Coarse X-Y Driven Translation Assembly only). Figure 13 shows an Air Bearing Assembly on top of the Flexural Mount Assembly.

2.2.7.3.6 FLEXURAL JIG

A Flexural Pivot Jig will initially replace the Flexural Pivot Assembly until the Crossbeam has been installed (this is done to prevent additional strain that could cause damage to the Flexural Pivot Assembly). Screw two shoulder bolt pins into the two center holes on the side of the Air Bearing Spherical Surface (for Coarse X-Y Driven Translation Assembly only). Slide the shoulder bolt pins (sticking out of the Spherical Air Bearing) into the center slots on the Flexural Pivot Jig (this provides the proper X, Y, and clocking alignment for the Spherical Air Bearing). Figure 14 shows the shoulder bolt pins being inserted into the Flexural Jig slots. Bolt the Flexural Pivot Jig to the Air Bearing Spherical Surface and torque to the correct specifications. Bolt the Flexural Pivot Jig to the Coarse X-Y Driven Translators. Place the Crossbeam/Air Bearing Spherical Mounting Pad down on top of the Air Bearing Spherical Surface. Repeat this process for the remaining three Air Bearing Assemblies.

2.2.7.3.7 AIR BEARING X-Y POSITIONING BRACKETS

Install the X-Y Positioning Brackets on the side of the Air Bearing Base Surface (Coarse X-Y Driven Translation Assembly only). Move the Actuator Translation Stages manually until the Air Bearing Mid Surface is seated tangentially against the X-Y Positioning Brackets. Repeat this process for the remaining three Air Bearing Assemblies. See Figure 15.

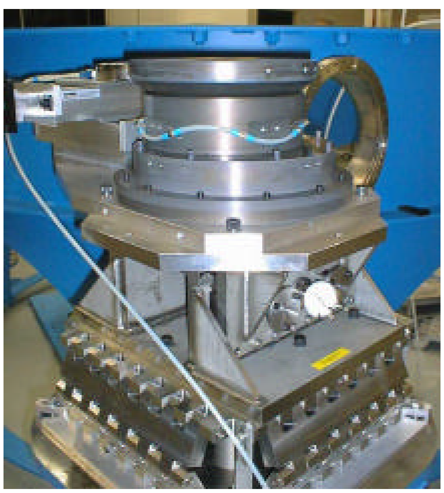


Figure 13. Air Bearing Assembly without Flexural Pivot Jig

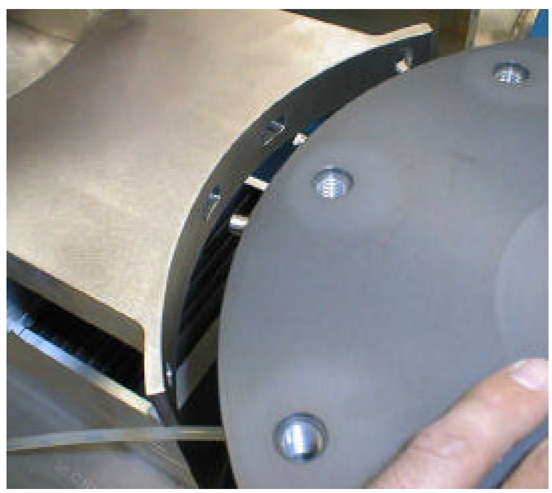


Figure 14. Air Bearing Spherical Surface Pinned to Flexural Jig

2.2.8 CROSSBEAM INSTALLATION

A Crossbeam will be installed using the bridge crane, a spreader beam, and some chains. The Crossbeam will be hoisted in a level position. The Crossbeams installed position (X, Y, and Clocking) will be determined by the Air Bearings, and not the Crossbeam Centering Jigs as previously proposed. Two Crossbeam Support Brackets will support the Crossbeams in position until they have been assembled to the Support Tubes with the V-Blocks.

2.2.8.1 INSTALL CROSSBEAM SUPPORT BRACKETS

Air must be supplied to Air Bearings from this time on in the BSC assembly installation.

The Air Bearings must have a minimum of 50psig while the Support Brackets carry the weight of the Crossbeam. Since the Air Bearings cannot handle the overturning moment imposed on them by the Crossbeam (until the Crossbeam, V-Blocks and Support Tubes are bolted together), the Crossbeam will be bolted to and supported by two Support Brackets. The Support Bracket is bolted to the Pier and remains in position.

The original design and sequence for using the Support Brackets has not changed. The Crossbeam Support Brackets are loosely installed in position before a Crossbeam can be installed. The Crossbeam Support Brackets are hoisted in position using two lifting eyes (screwed into top of bracket) and an equal leg chain sling or strap. Loosely bolt the Support Bracket to the side of the Pier. Let the bracket slide down to its lowest position.

2.2.8.2 CROSSBEAM HOISTED IN NOMINAL POSITION

The Crossbeam will be hoisted up using the bridge crane, a spreader beam, and three custom chain lengths. Two of the chain lengths have turnbuckles that provide the ability to level the Crossbeam. Lower the Crossbeam to its nominal position and about ½" above the Crossbeam/Air Bearing Spherical Mounting Pad.

2.2.8.3 CROSSBEAM CENTERED OVER COARSE X-Y DRIVEN TRANSLATION ASSY

The aluminum Air Bearing X-Y Positioning Jigs critically position the Air Bearing Mid Surface as explained in step 2.2.7.3.7 (Coarse X-Y Driven Translation Assembly only) as shown in Figure 15. The Flexural Pivot Jig has been installed to the Coarse X-Y Translators (see Figure 16). The X-Y Positioning Jigs has centered (X, Y, and Clocking) the Air Bearing (Coarse X-Y Driven Translation Assembly only) in the center of the Actuator Column.

With the Crossbeam a nominal ½" over the Coarse X-Y Driven Translation Assembly, thread the Crossbeams mounting bolts (through the clearance hole mounting pattern in the Crossbeam and Crossbeam/Air Bearing Mounting Pad) and into the Air Bearing Spherical Surface. The mating hole pattern between the Crossbeam and the Air Bearing Spherical Surface (Coarse X-Y Driven Translation Assembly) will be used to position the Crossbeam (X, Y, and Clocking). Do not tighten the bolts. Leave them loose.

2.2.8.4 COARSE X-Y FLOATING AIR BEARING ALIGNED TO CROSSBEAM

With the Crossbeam aligned to the Coarse X-Y Driven Translation Assembly Air Bearing, the Air Bearing on the Coarse X-Y Floating Translation Assembly will be moved until it is aligned with it's Crossbeam's hole pattern. Thread the Crossbeams mounting bolts (through the clearance hole mounting pattern in the Crossbeam and Crossbeam/Air Bearing Mounting Pad) into the Air Bearing Spherical Surface. Do not tighten the four bolts. Leave them loose. Slowly lower the Crossbeam down until it lightly touches down on the Crossbeam/Air Bearing Spherical Mounting Pads. Check the level of the Crossbeam (V-Block mounting pads).

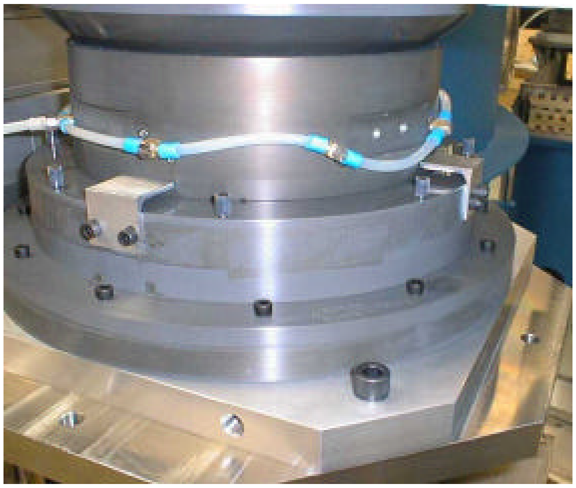


Figure 15. Air Bearing Mid Surface X-Y Positioning Jigs

Figure 16. Flexural Pivot Jig Bolted in Position

2.2.8.5 TIGHTENING SUPPORT BRACKET

Bring the Crossbeam Support Bracket up into position. See Figure 17. Align the Support Bracket's slotted holes with the mating tapped hole pattern in the back of the Crossbeam. Screw the specified bolts into the back of the Crossbeam finger tight. Bolt the Support Bracket to the Pier (use the required torque specification). Adjust the ball locating screw up until it seats against the bottom of the Crossbeam (put steel shim between ball locating screw and crossbeam). Let crane release weight of Crossbeam on Crossbeam Support Brackets. Tighten the Crossbeam mounting bolts screwed into the Air Bearing Spherical Surface to 1/3 the normal torque specification.

Figure 17. Support Bracket in place

3. PHASE 2 SEQUENCE: INTERNAL COMPONENTS

Phase 2 describes the installation of the Support Tubes, Bellows, V-blocks, Downtube and Support Table, and Isolation Leg Stacks. All work is done with the cleanroom chambers in place and the BSC chamber opened.

Some of the important sequence deviations will be described now for clarification. The first significant change to the sequence, the Support Tube centering (in nozzle ports) sequence and jigs have changed. The Support Tubes are leveled (to each other), but are not centered prior to bringing the Downtube/Support table in place. The bolted assembly (Support Tubes and Downtube/Support Table) will then be positioned to maximize the clearance between the Support Tubes and the BSC Chambers D-Nozzle ports.

Second change to the sequence, the four Bellows and Bellows Compression Clamps will be partially installed on the Support Tube before the V-Blocks are installed (the bellows installation will be completed after the V-Block connection has been completed). The V-Blocks will be installed only once and will not be removed (another deviation from the original sequence).

Third change, the sequence for bringing the Support Tubes up to and installing the V-Blocks has changed, but not significantly. Most of the rest of the procedure has been retained with some slight improvements.

Note: Care must be taken when threading clean fasteners into the in-vacuum hardware components. Due to the clean nature of the parts and their fasteners, it is easy to gall and even seize fastening hardware into in-vacuum component tapped holes.

Note: The assembly of the in-vacuum hardware is done in a cleanroom environment using approved cleanroom procedures and appropriate gowning.

3.1.1 ROLLER SYSTEM

A Roller System is used to support the Support Tubes (external to chamber) and guide the Tubes into the chamber. It will be lowered in position in front of the BSC chambers D-Nozzle ports. The Roller System has been designed to work for 3 separate cases. The 3 cases are as follows: installing the Support Tubes into the chamber while the Roller System spans over a HAM Chamber, spans over a Beamtube, or spans nothing. The Roller System vertical elevation is adjustable depending upon the chamber's floor to D-Nozzle port height. Figure 18 shows a Roller System Foot (turning the hex nut on foot provides vertical adjustment).

The Support Tubes (packed in ameristat) will be hoisted (bridge crane, a spreader bar, lifting eyes and straps) onto the Roller System prior to the Cleanroom Chamber being lowered in place[1].

3.1.1.1 ASSEMBLING ROLLER SYSTEM

The Roller System is assembled per drawing D972390. The center of a BSC chamber's D-Nozzle port height is 117.50” above the floor (according to PSI drawing V049-4-001; drawing shows chamber with a nominal 3” grout height).

This nominal elevation may change due to the facility floor being 1” too low for some BSC Chamber locations; a dimension between a BSC Chambers D-Nozzle port and the floor

[1] Lowering support tubes before installing clean rooms has been accepted in principle. This approach eliminates rather awkward maneuvers of the tubes in a confined space.

may need to be measured in order to establish the Roller Systems correct elevation. The nominal height of the roller system tolerance (+1/2”/-0).

3.1.1.2 HOISTING THE ROLLER SYSTEM

The Roller System has 4 tapped holes in the top (4 corners) of it for ½-13UNC lifting eyes. The system can be hoisted around the facility with the bridge crane, 4 long straps and the lifting eyes.

3.1.1.3 POSITIONING THE ROLLER SYSTEM

The Horizontal Leg Truss (part D972439 on Drawing D972390) will have to be temporarily removed and re-installed when positioning the Roller System over a HAM Chamber or a Beamtube.

The Roller System is set to the correct vertical elevation in step 3.1.1 which is dependant upon the chambers nozzle port centerline to floor dimension. The front of the Roller System (part facing the chamber) has the horizontal beam overhang of 16.00”.

Case 1 (Roller System spans over a HAM Chamber)

The Roller System is positioned such that the front face of the horizontal 3 X 3 tube will be 9.7” from the front face of the 16.5” blank nozzle conflat. This dimension is necessary to miss the annulus piping on top of the HAM Chamber. In addition to this position, the two rollers closest to the annulus ion pump nozzle port blanks may need to be removed due to clearance problems (TBD at facility). After the tubes have been installed, the Roller System will need to be lifted up, pushed away from the BSC System, and blocked up (to clear HAM Chamber annulus ion piping) in order to install the V-Blocks.

Case 2 (Roller System spans over a Beamtube)

The Roller System is positioned at the 9.7” dimension as explained previously, but it can also be positioned up to but no farther than 14.5” away from the nozzle port. There are some lifting plates welded to the top of the Beamtube Adapters, which may interfere with Roller System at some positions between the 9.7 and 14.5” dimensions. Again, the Roller System will need to be lifted up and pushed away from the BSC System in order to install the V-Blocks.

Case 3 (Roller System does not span anything)

The Roller System can be positioned between the 9.7 and 14.5” dimension explained above with no clearance problems. The Roller System will need to be pushed back to install the V-Blocks.

Figure 18. Roller System Foot Adjustment

3.1.1.4 LOWER SUPPORT TUBE ON ROLLER SYSTEM

Hoist the Support Tube using bridge crane, the spreader beam, straps and lifting eyes. Figure 19 shows the Support Tube being lowered onto the Roller System. As the Support Tube is lowered onto the Roller System slide a Support Tube Sleeve (D972446) under the end of the Tube (the 11.3 dia.) facing away from the chamber. This sleeve distributes the weight of the Tube onto the Roller System. It is important part of the sequence as the end Tube enters the chamber.

Figure 19. Support Tube Lowered on Roller System

3.1.2 CLEANROOM INSTALLED

The external hardware has been assembled. The Roller System is in position and has the Support Tubes on it. Any dirty external hardware can be cleaned bagged and tagged in place. The Cleanrooms are now installed in position. One or two BSC Cleanroom chambers will be needed for the installation of the in-vacuum hardware (one cleanroom over the chamber and one cleanroom over the Roller System).

3.1.3 RAIL SYSTEM

Note: Before anything is done with a Support Tube, check to see that the Support Tube Knife Edge Covers are in place. These covers must be left on until the installation of the Bellows. The AMERISTAT packaging and foil wrap must be left on the tubes to reduce contamination whenever possible.

The Rail System's function is to install and support the Support Tubes in the BSC Chamber as they are off loaded from the Roller System. The Rail System also supports the Tubes while the Downtube/Support Table is positioned, it is used to position (X, Y, and clocking) this assembly in the Chambers nozzle ports. The systems Trolley Linkages will be used to bring the Support Tube and Downtube/Support Table Assembly to the proper elevation for installation of the V-Blocks. The Rail System is also used to level the Support Table.

Pre-assemble the Rail System leaving the lower half of the Trolley Linkages off until the Support Tubes are inserted into the chamber.

HYTEC recommends using KRYTOX lubricant in the Trolley Linkage to reduce friction.

3.1.3.1 INSTALL THE MAJOR RAILS

Hoist the Major Rails (using the bridge crane and straps) and install them 114" apart on the Crossbeams. Tighten the Major Rail bolts down to the Crossbeam using the required torque specifications.

3.1.3.2 INSTALL THE MINOR RAILS

Hoist the Minor Rails (all three) on top of the Major Rails using lifting eyes, straps, and the bridge crane. Push the Minor Rails back and forth along the Major Rails to check the Major Rails separation distance. Leave the lower half of the Trolley Linkages off until the Support Tubes are being inserted into the chamber. Figure 20 shows the Rail System installed on top of the Crossbeams.

3.1.3.3 D-NOZZLE CONFLAT COVERS

Remove the D-Nozzle port blanks. Install the "D" nozzle port conflat covers. There are two halves per nozzle port. Use two bolts and nuts to per half.

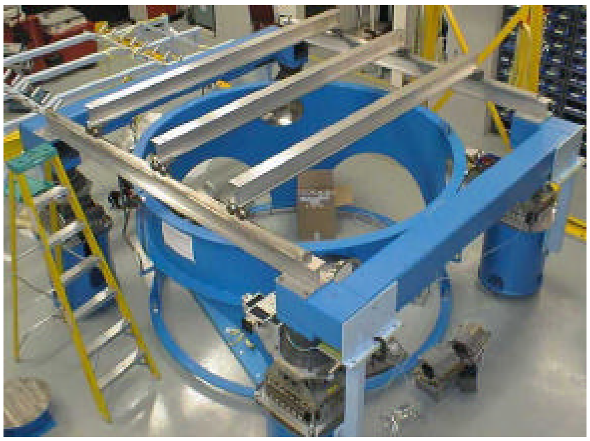


Figure 20. Rail System Installed on Crossbeam

3.1.4 SUPPORT TUBES INSERTED IN CHAMBER

The Support Tubes are supported by the Roller System (while they are external to the chamber), and then by the Rail System (while they are in the chamber). There are three distinct steps necessary for inserting the Support Tubes into the BSC Chamber. Two things have changed from the originally proposed sequence.

The first change, is the way the Support Tube mates to the Trolley Linkage. Originally, all of the Minor Rail Trolley Linkages bolted into the tapped plugs in the top of the Support Tube. Now, the Trolley Linkages that support the ends of the Support Tubes (two of the connections per Support Tube) have Linkages that pass through the Tube and support it from below with a hex nut and a large washer.

Second, the sequence for assembling the Support Table/Downtube to the Support Tubes has changed. The original sequence was to level and center the Support Tubes with respect to a BSC chamber's nozzle port, and then bring the Downtube/Support Table down on top of the Tubes. The new sequence is to level the Support tubes (to each other), then separate them at a distance (axial separation greater than 66") for easy insertion of the Downtube/Support Table.

The Downtube/Support Table will then be inserted and bolted to the Support Tubes; this assembly (Support Tubes and Support Table) is positioned in the chamber's D-Nozzle ports.

3.1.4.1 SUPPORT TUBE INSERTION STEP 1

Move all of the Minor Rails to the end of the Major Rail (Rail stops closest to Roller System) for the Support Tube insertion. Push both Support Tubes (on the Roller System) simultaneously toward the BSC chamber's "D" nozzle ports.

Push both of Support Tubes into the chamber. Figure 21 shows the Support Tubes being inserted into the chamber. Remove the Ameristat from the Support Tube as it goes into the chamber. Connect the Trolley Linkages on Minor Rail #1 to the Support Tube when the Support Tube is about 37" into the chamber. Insert the Linkage Rod through the clearance hole in the Support Tube and screw a hex nut and washer on the end of the rod. Thread the Trolley Linkage together until the Linkage starts to carry the weight of the Support Tube. Figure 22 shows the Linkage connection being made to the Support Tube.

Figure 21. Support Tubes being Inserted into Chamber

Figure 22. Trolley Linkage Connected to Support Tube.

3.1.4.2 SUPPORT TUBE INSERTION STEP 2

After both Support Tubes have been connected to Minor Rail #1 via its Trolley Linkages, continue to push the Support Tubes into the chamber. Insert the Support Tubes about 83" into the chamber. Connect the Support Tubes to Minor Rail #2 via its Trolley Linkage. This Trolley Linkage screws into a tapped Adapter Plug in the top of the Support Tube. Thread the Trolley Linkage together until the Linkage starts to carry the weight of the Support Tube.

Note: The Trolley Linkages on Minor Rail #2 must connect to (support) the Support Tubes at 11" past the tube's C.G. (C.G. of Support Tube is at 72") or it will damage the Roller System.

3.1.4.3 SUPPORT TUBE INSERTION STEP 3

Continue to push the Support Tubes into the Chamber. When the Tubes are about 107" into the chamber connect Minor Rail #3s Trolleys to the Support Tube. Use the same procedure described in step 2.3.4.3.

3.1.4.4 SUPPORT TUBE INSERTION STEP 4

Position the Support Tubes in their nominal positions. The ends of the Support Tubes should line up with the back of the Crossbeams. Figure 23 shows both Support Tubes being supported by the Rail System.

Figure 23. Support Tubes Supported by Rail System

3.1.4.5 SETTING SUPPORT TUBES LEVEL

Remove Minor Rail #2.

The Rail System supports the Support Tubes in a nominal position. A level is put on the axis of the tube (resting on the machined plugs on top of tube), and the tube is leveled using its Trolley Linkage vertical adjustment. Figure 24 shows a Support Tube being leveled. Run the level across the top of the two Support Tubes (using the machined plugs on top of the tubes). Level the second tube with respect to the first tube (reference level) by adjusting the Trolley Linkages (see Figure 25). Now both Support Tubes are level with respect to each other.

The Support Tube locations with respect to each other will become precisely fixed, when they are bolted to the Support Table/Downtube. Although the Tubes are level with respect to each other, they should be spaced more than 66” apart (centerline to centerline) so that there is enough clearance when the Support Table s lowered between them.

Figure 24. A Support Tube being Leveled. **Figure 25. Both Support Tubes being Leveled.**

3.1.5 SUPPORT TABLE/DOWNTUBE LOWERED IN POSITION

The Support Table has critical mating surfaces machined in to it for locating the Support Tubes. The Support Table will be the jig that produces the exact Tube spacing, both transversely and longitudinally.

3.1.5.1 HOISTING THE SUPPORT TABLE/DOWNTUBE

In preparation to hoist the Downtube/Support Table, put a hoisting pin (with a 1" lifting eye) in top of the Downtube. The Downtube/Support Table is shown being hoisted in Figure 26. *Optional: Screw 4 lifting eyes in top of the boxbeam. To lift the downtube use a special 5 leg chain sling (4 legs on outside longer than middle leg). The middle leg does the lifting; the 4 outside sling legs are for safety.*

Figure 26. Downtube being Hoisted

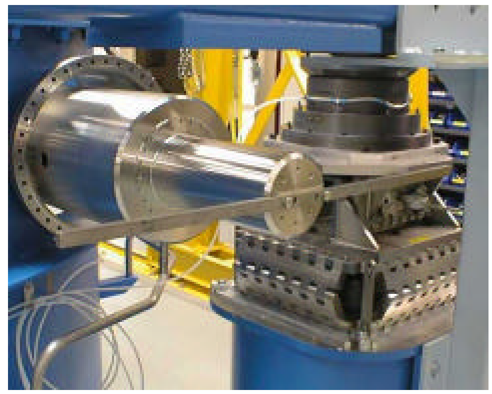


Figure 27. Support Tube being Clocked with Tool

3.1.5.2 LOWERING THE SUPPORT TABLE/DOWNTUBE IN POSITION

The middle Minor Rail from the Rail System must be removed before the Support Table/Downtube may be lowered onto the Support Tubes. The original sequence described the use of four small diamond pins (2 per support tube) that would be used to position the Downtube/Support Table on top of the Support Tubes. These pins will not be used. The clearance between holes in the Support Table and their mating bolts register the Support Table on the Support Tubes; they space the Tubes at 66.0 inches (within an acceptable tolerance). Check the level of the Support Table when it rests on the Tubes (use the machined counterbores on Support Table). Table levelness to be within 1 milliradian. Tighten bolts to required torque specifications.

3.1.5.3 BOLTING THE SUPPORT TABLE/DOWNTUBE TO THE TUBES

Note: The Support Tubes may hang slightly clocked in the Rail System. Therefore it may be necessary to rotate the Tubes in order to bolt them to the Support Table.

Loosely bolt the Downtube/Support Table to one Support Tube. Raise Downtube/Support table slightly. (This allows for easy clocking of Support Tube two.). Move Support Tube two into position. Clock Support Tube two using the clocking tool. Figure 27 shows the tool used for the clocking of Support Tube #2. Screw Support Tube two hardware in a few turns. Lower Downtube/Support table down onto both Support Tubes. Bolt assembly to required torque specifications.

3.1.5.4 FINDING CENTER OF SUPPORT TUBES IN NOZZLE PORTS

After the Support Tubes and Downtube/Support Table are bolted together as an assembly, the assembly is positioned to maximize the clearance between the four Support Tubes and the four Nozzle Ports. Measurements are taken at all D-Nozzle ports in order to determine what the best average fit will be. These measurements will also be used to establish the position of the Support Tube Centering Blocks. The blocks (bolted to the face of the D-Nozzle conflats) will constrain the Tubes in Y (allows vertical motion). There are four Centering Blocks, one for each D-Nozzle port. Use the Trolley Linkages to set the Tubes to the correct elevation (1/8" below its final position in V-Blocks).

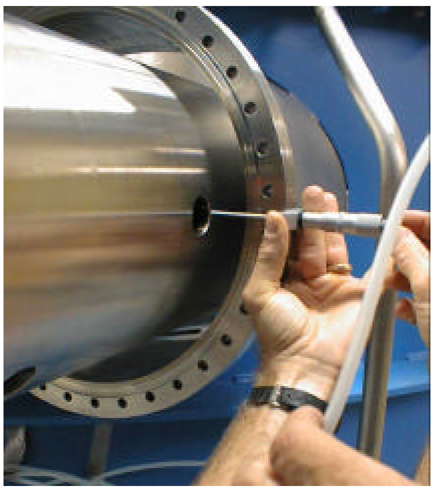


Figure 28. Measuring Clearance dimensions

Figure 29. Support Tube Centering Block

3.1.5.5 FINDING THE END OF THE SUPPORT TUBES

There will be no jig used to find the end position of the Support Tubes as previously proposed. This positioning is not critical. For each Tube (at both ends), measure the distance between the chambers "D" nozzle ports and the end of the Support Tube. Compare the two measurements, they should within 1/16" of each other.

3.1.6 PRE-INSTALLING THE BELLOWS

At this phase of construction, the Support Tubes are in place and bolted to the Support Table. The four Bellows in their Compression Clamps will be partially assembled in place (to Support Tube) prior to bolting up the V-Blocks. The V-blocks are not in place.

Note: Care must be taken not to allow anything to come into contact with the Conflat Knife edges (chamber "D" Nozzle and Bellows). Keep protective covers on the Knife edges whenever possible.

Note: Do not touch the inner surfaces of the Bellows; special care must be taken to keep the inner surfaces of the Bellows clean. A Bellows is only to be handled in a Cleanroom

Environment with approved cleanroom procedures. Each packaged Bellows has been chemically cleaned and baked. Do not allow a Bellows to be contaminated because once it has been contaminated it may have to be disposed of. Copper gaskets must also be handled with approved cleanroom procedures.

3.1.6.1 COPPER GASKETS

Remove Support Tube knife edge covers. Install a Copper Gasket in position on the Custom Conflat Knife Edge (Support Tube). Slide a 16.5 inch diameter Conflat Copper Gasket on the end of the Support Tube and let it hang on the Support Tubes 11.3 dia. step. The 16.5" diameter Conflat Copper Gasket cannot be installed (in its final position) at this time because the Support Tube Centering Block is still in place.

3.1.6.2 POSITIONING THE BELLOWS AND CLAMP

Each Bellows is assembled in a Compression Clamp. Hoist the Bellows and Compression Clamp up (with the bridge crane), and gently slide the assembly over the end of the Support Tubes Extension Jig. See Figure 30. Break the bridge crane connection and remove the hoist bar and lifting eye from the Bellows Compression Clamp Assembly. The 5.5" diameter hole in the custom conflat flange is only slightly larger than the end of the Support Tube. The Compression Clamp will constrain the Bellows in a pre-compressed state. Push the Bellows in position against the Custom Conflat Copper Gasket. Install the Custom Conflat Flange Bolts.

Tighten bolts to required torque specifications. Figure 31 shows the Bellows and Clamp bolted to end of Support Tube.

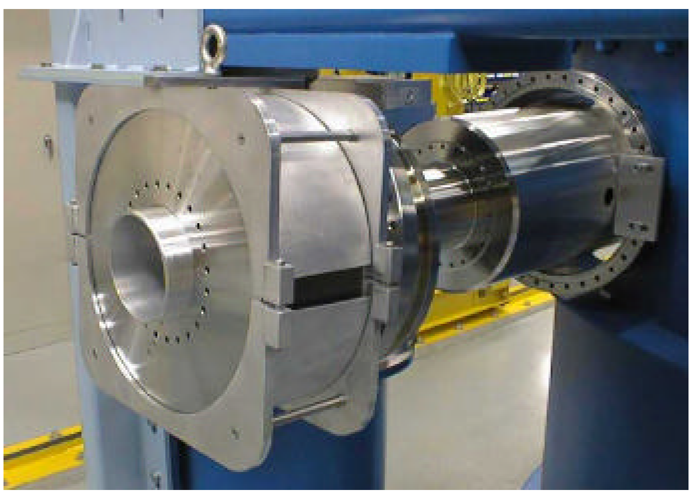


Figure 30. Bellows in Clamp and on Support Tube Extension

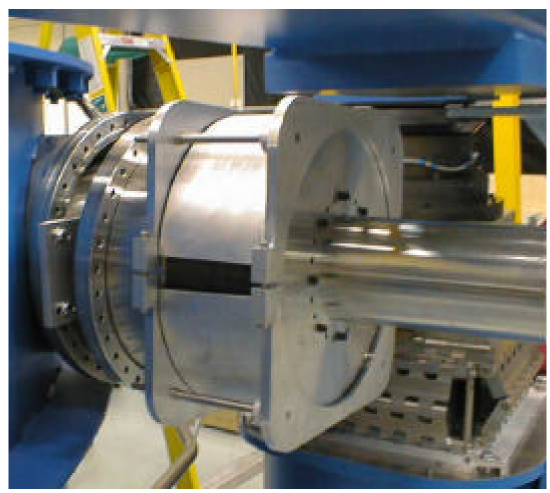


Figure 31. Bellows Pre-Installed

3.1.7 V-BLOCK ASSEMBLIES

This section describes connecting the Support Tube/Support Table to the Crossbeams with the V-Blocks. The Support Tube/Support Table assembly is being supported via the Rail

System. The V-Blocks (Support Tube Mount Base, Spherical Mount, and Mount Cap) are placed in position on the end of the Support Tubes. This assembly is raised vertically (via the Rail System Trolley Linkages) while it is constrained laterally (via the Support Tube Centering Block jigs). This procedure must be done cautiously, carefully and observantly.

Note: The final goal of this procedure is to bolt the V-Block/Support Tube connections together while maintaining the Support Table level. The system needs to be assembled strain free.

3.1.7.1 SUPPORT TUBE MOUNT BASE IN POSITION

Lower the Support Tube Mount Base and the Support Tube Spherical Mount on the Support Tube Extension Jig. The Support Tube Mount Base may be hoisted with the bridge crane; run a strap through the hole in the Support Tube Mount Base. Slide the two under the Crossbeam and tighten bolts to the bottom of the Crossbeam finger tight. Figure 32 shows the two parts on the Extension Jig and ready for insertion under the Crossbeam. The Support Tubes have previously positioned at an elevation 1/8" below their final position so the Support Tube Spherical Mount will not be flush with the Crossbeam mounting pads.

3.1.7.2 INSTALL THE SUPPORT TUBE MOUNT CAP

With the Support Tube Mount Base and Spherical Mount in position, install the Support Tube Mount Cap under the Mount Base and bolt it in place finger tight. The Support Tube Mount Cap should fit snug against the Support Tube.

3.1.7.3 RAISE THE SUPPORT TUBE MOUNTS TO MEET THE CROSSBEAM PAD

Raise the Downtube/Support Table and Support Tubes assembly using the Rail System Trolley Linkages. Crank all four Linkages up simultaneously.

Note: Observe how hard it is to turn a Trolley Linkage. Sometimes some Linkages carry the weight when others aren't (hard turning linkages carry weight; loosely turning linkages aren't carrying weight). Take care not to seize a Linkage.

As the Support Tubes are raised, carefully observe the Spherical Mounts to see that as they mate flush with the Crossbeam pads they are free to find their strain free positions. Also observe the gap between the Spherical Mounts and the Crossbeam pads. Watch to see if all of the Mounts contact the Pads simultaneously. HYTEC suspects that three of the Spherical Mount/Support Tube Mount Bases will contact the Crossbeam simultaneously, and that there will be a gap between the fourth Spherical Mount and it's Crossbeam pad. This connection will have to be shimmed (between the Mount and Pad). A gap of more that .010 must be shimmed. After all of the Mount-Pad connections are assembled, tighten down all of the Mount Block/Mount Cap bolts to specified torque specs. Re-check the Support Table level. Figure 33 shows a V-Blocks assembled to the Tube and Crossbeam.

3.1.8 REMOVE THE RAIL SYSTEM

After the V-Blocks are bolted together, undo the Trolley Linkage to Support Tube connections. Remove the Minor Rails. Remove the Major Rails. The Support Tube Mounting Caps are now carrying the weight of the Support Tubes and the Support Table/Downtube.

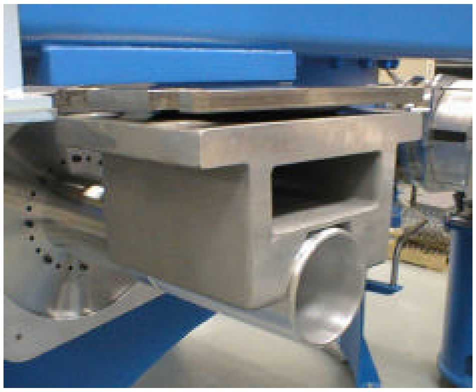


Figure 32. V-Block on Support Tube Extention

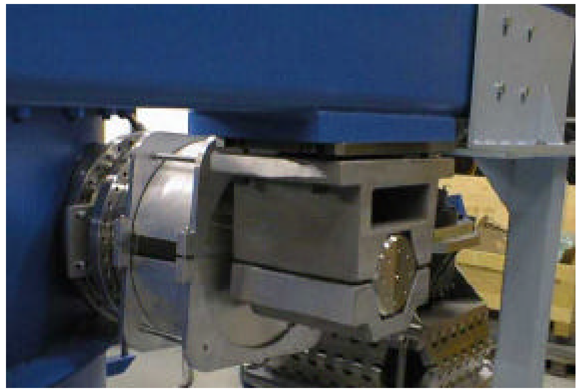


Figure 33. V-Block Bolted in Position

3.1.9 COMPLETING THE BELLOWS INSTALLATION

At this phase of construction, the Support Tubes, Support Table, and Crossbeam are an assembly via the Support Tube Mount Base and Cap. The Bellows are in position (compressed in clamp and mounted to the Support Tube) but are not installed.

3.1.9.1 REMOVE SUPPORT TUBE CENTERING BLOCK JIGS

Remove the Support Tube Centering Blocks. Remove the BSC D-Nozzle port conflat knife edge covers. Be careful not to nick the conflat knife edges (Bellows or BSC "D" nozzle port) when removing the Jigs or their bolts.

3.1.9.2 EXPAND AND INSTALL THE BELLOWS

Place the Copper Gasket in position on the BSC chamber's 16.5" diameter conflat knife edge (D-Nozzle). Back off the four Compression Clamp nuts. Backing off these nuts allows the Bellows to expand. Install bolts for 16.5" diameter conflat flange. Tighten bolts to specified torque specification. Leak checking the Bellows may be necessary.

Note: The Bellows Compression Clamp supports the Bellows and prevents it from deflecting transversely. When the Bellows is expanded and installed make sure it is constantly supported, a transverse deflection could damage the Bellows convolutions.

3.1.10 BUILDING ISOLATION STACKS

Again, the support structure is completely assembled. The Bellows are installed. The Downtube is still bolted to the Support Table (its shipped position) in a position 45 degrees off its final position to assemble the Isolation Stacks. See Figure 34.

HYTEC recommends pre-assembling the Isolation Stacks using Aluminum Spacers instead of Springs.

First, the Isolation Stacks are assembled (one Leg Stack at a time or build them up simultaneously). Next, the Downtube is rotated, placed on top of the Leg Stacks, and is connected to the Leg Stacks via it's Safety Pins. A bracket assembly will be installed on the side of the Downtube. This bracket assembly will constrain the Downtube to vertical motion only. The Downtube is hoisted up until the Conical Safety Pins carry the weight of the Leg Elements. The Aluminum Spacers are removed and the Springs are inserted in place. The Downtube is then lowered (constrained by brackets) to its original position while the weight of the Downtube and Leg Stacks are imparted upon the Springs.

The original sequence proposed using a Downtube Centering Structure that constrained the top of the Downtube. It has been determined that this jig is not needed.

3.1.10.1 INSERTING CENTERING PINS

Screw three Centering Pins into a tapped hole pattern in the Support Table. Align three Aluminum Spacers at approximately 120 degrees apart and tangent with the circumference of the circular counterbore in the Support Table (see Figure 35).

3.1.10.2 LOWERING LEG ELEMENT IN POSITION

Screw three Brass Adapter Plugs (lifting eyes are part of the Adapter Plug) into a Leg Element. Hoist the Leg Element using a three equal leg chain sling. Lower the Leg Element down over the three Centering Pins and position it on top of the Aluminum Spacers.

3.1.10.3 REPLACE CENTERING PINS WITH SAFETY PINS

Remove the Adapter Plugs from the Leg Element. Screw the same three Centering Pins into the tapped holes in the Leg Element where the Adapter Plugs were. Remove the Centering Pins from Support Table and replace them with three stage 1 Safety Pins (note: Safety Pins for stage one have straight head; all other stage Safety Pins have conical head). Tighten Safety Pins with a flat head screwdriver about finger tight. Place three Aluminum Spacers down on top of the Leg Element at approximately 120 degrees apart and tangent to the Leg Element's circumference. See Figure 36.

3.1.10.4 ASSEMBLE STAGE 2 AND 3 OF LEG STACKS

Repeat step 3.1.10.3 (for Leg Element stages two and three) until an Isolation Leg Stack is assembled. Then repeat this procedure for the remaining three Stack Isolation Legs. Figure 37 shows a stage one, two, and three of Leg Stack assembled.

Figure 34. Support Table ready for Leg Stack Assembly

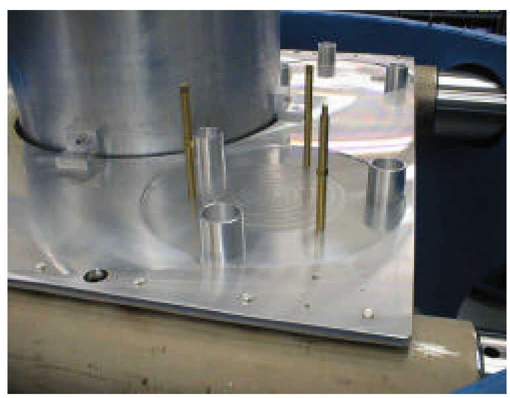
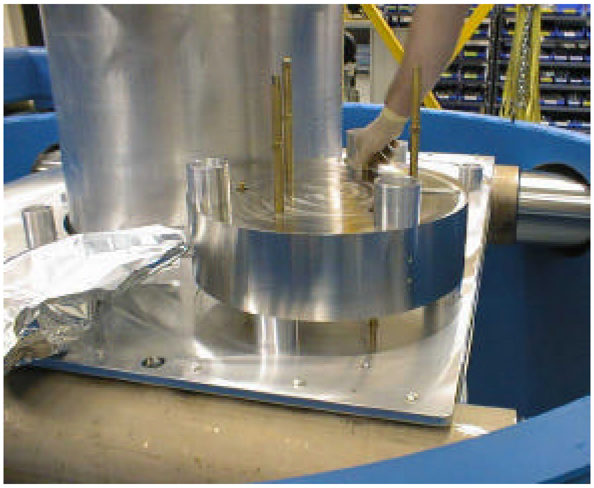


Figure 35. Preparation for Leg Element #1



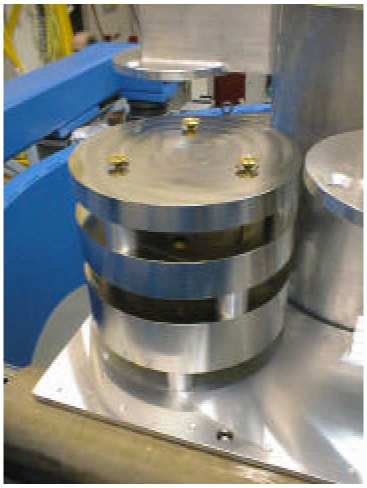
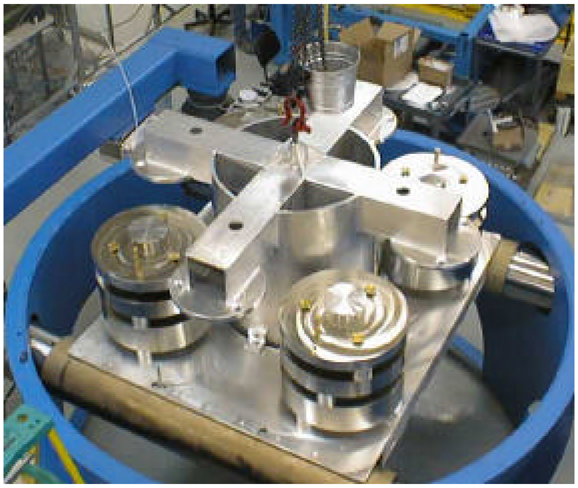


Figure 36. Preparation for Leg Element #2 **Figure 37. Stage 1,2, and 3 of a Leg Stack Assembled**

3.1.10.5 PUT STACK SHIM IN POSITION

Put an Aluminum Spacer on the top center of Leg Element #3 (position is not critical). Center the Aluminum Shim and Viton Shim on top of the Aluminum Spacer. Repeat for all four Leg Stacks.



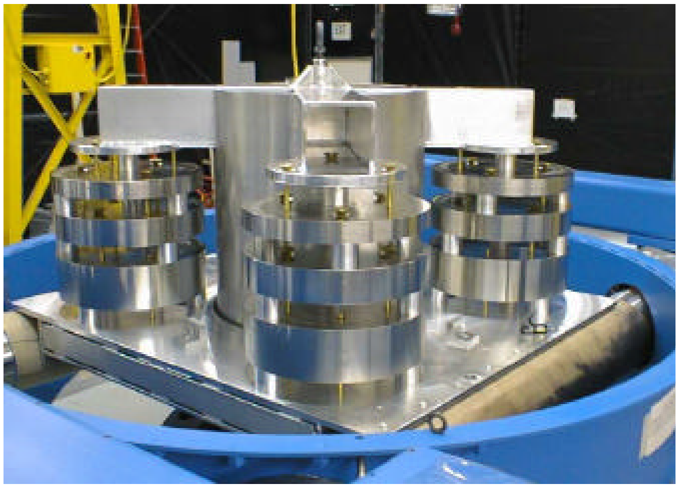


Figure 38. Leg Stacks Assembled **Figure 39. Downtube ready for Spring Insertion**

3.1.10.6 DOWNTUBE CENTERING PINS

Screw three or four Downtube Centering Pins into the tapped holes in the top of the Leg Element #3 (one Centering Pin per Leg Stack). Location of the Centering Pins is not important. Figure 38 shows the Downtube and four Isolation Leg Stacks assembled (the Leg Elements, the Aluminum and Viton shims, and the Downtube Centering Pins shown) on the Support Table.

3.1.10.7 ROTATE THE DOWNTUBE

Unbolt the Downtube Shipping Brackets bottom bolts. The Downtube is still in position (held by these brackets), but now can be hoisted up. Hoist the Downtube up (using the bridge crane) enough to remove the Shipping Brackets. Continue to lift the Downtube up till the Boxbeam Pads clear the Centering Pins in the Leg Elements. Use a rubber shim (placed between the Downtube diameter and the Support Table) to keep the two from contacting each other. Rotate the Downtube 45 degrees (by hand). Slowly lower the Downtube down (over the Leg Stacks). Lower the Downtube down (pins will sleeve the Boxbeam Pad holes) until the Boxbeam Pads rest on top of the Viton and Aluminum shims.

3.1.10.8 INSTALL SAFETY PINS

After the Downtube has been rotated, centered up on the Centering Pins, and lowered down in position on the Aluminum and Viton Shims, replace the Centering Pins with conical head Safety Pins. Torque pins down finger tight with a flat head screwdriver. Figure 39 shows the Downtube in position on top of the Leg Stacks.

3.1.11 FINAL CENTERING OF DOWNTUBE WITH SPRINGS

The Downtube is resting on and centered over the four Leg Stacks (which are now carrying the weight of the Downtube). Two bracket assemblies (180 degrees apart) are now installed on the side of the Downtube. These bracket assemblies sleeve some pins that are threaded into the Support Table. This assembly constrains the Downtube in position (in X, Y and Clocking) while it is vertically hoisted for spring insertion. After the Springs have been positioned in the Leg Stacks, the Downtube is lowered to its original position.

<u>3.1.11.1 INSTALL DOWNTUBE CONSTRAINING BRACKETRY</u>

Screw two Downtube constraining pins into the Support Table. Loosely bolt together the Downtube bracketry, allowing the middle plate to float freely in the assembly. Slide this assembly over the constraining pin in the Support Table, and then fit the bracket pin into the side of the Downtube. Once the bracketry sleeves the pin in the support tube and is mounted to the side of the Downtube, tighten up the bolts to the specified torque specifications. See Figure 40.

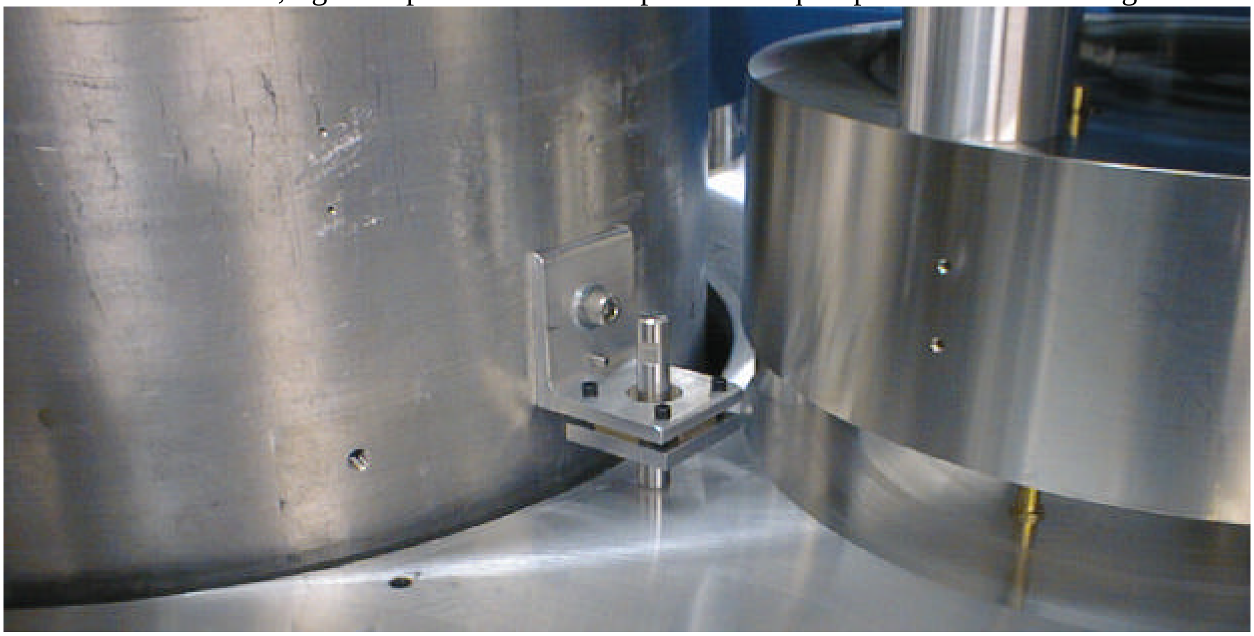


Figure 40. Downtube constraining bracketry

<u>3.1.11.2 PUTTING THE SPRINGS IN LOCATION</u>

All springs (viton seat diameters) are to be inserted with a Spring Centering Jig. The Spring Centering Jigs have pins in them that register tangentially to the O.D. of a Leg Element, or to the I.D. of the Support Table counterbore. The Spring Centering Jigs are designed to overlap each other by one Spring. After all of the Spring Centering Jigs has been installed in place, position each Spring Seat tangential to each edge of the "V" feature in the Centering Jigs. After all of the springs have been put in place, remove each jig carefully as to not bump the Springs out of position. Each BSC Leg Element stage has its own set of Spring Centering Jigs because each stage has a different number of springs. See Figure 41.

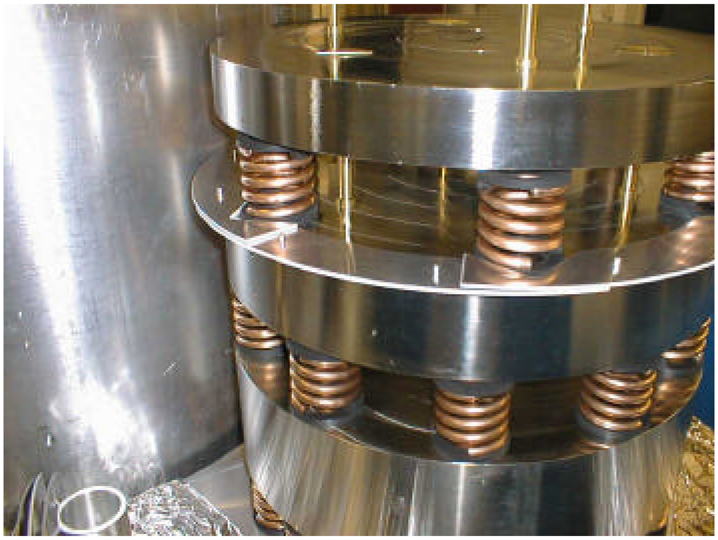


Figure 41. Spring Centering Jigs

3.1.12 LOCATING THE DOWNTUBE IN IT'S FINAL POSITION

After all of the springs have been located in position, the Downtube is slowly lowered. The Downtube is constrained by the bracket assembly, and be forced to its original position. It will lower down and compress the Springs. Remove the Downtube Constraining Brackets, and Hoisting Pin. See Figure 42.

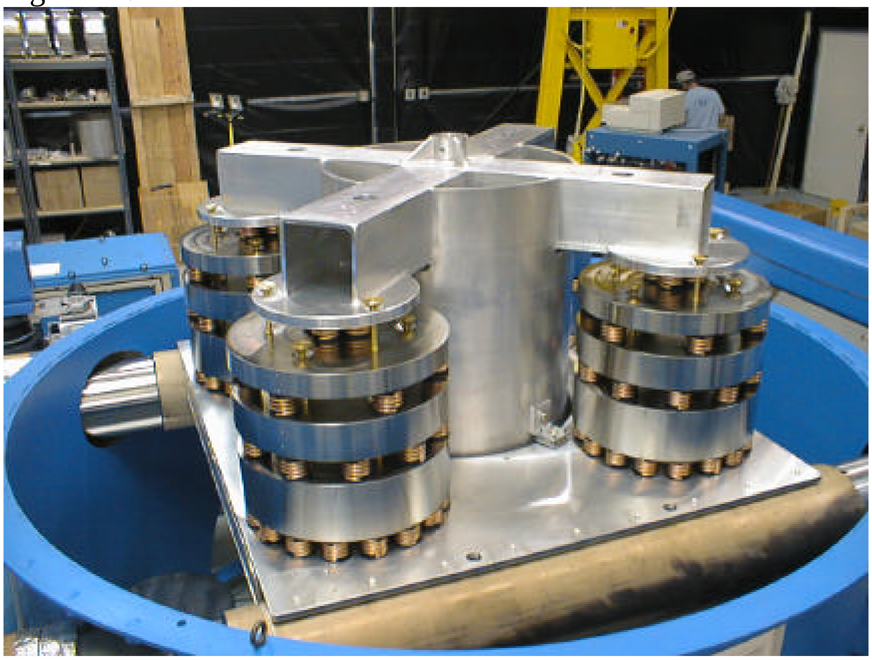


Figure 42. Downtube in Final Position

Note 1, Linda Turner, 09/03/99 02:58:52 PM
LIGO-T980128-00-D