LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

E0900357-v28 *LIGO* August 2012

Advanced LIGO BSC ISI Assembly Procedure

Sébastien Biscans, Michael Hillard, Adrien Le Roux, Fabrice Matichard, Céline Ramet, Michael Vargas, for the SEI team

Distribution of this document:
Advanced LIGO Project

This is an internal working note
of the LIGO Laboratory.

California Institute of Technology
LIGO Project – MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – NW22-295
185 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 1970
Mail Stop S9-02
Richland WA 99352
Phone 509-372-8106
Fax 509-372-8137

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone 225-686-3100
Fax 225-686-7189

Table of Contents:

Introduction

This document details the assembly of D0901182 Advanced LIGO BSC-ISI. These instructions are intended to complement the assembly drawings, which can be found on the LIGO Document Control Center.

Before bolting parts together, always make sure there is no dust or debris in the interface.

This introduction summarizes very important information for the assembly. It recalls the clean room standards, gives information on torque values, hardware, and describes the overall assembly documentation.

1.1. Clean room standards

For a clean assembly all LIGO standards should be followed, as presented in the latest version of the **LIGO Contamination Control Plan (E0900047).** Clean room garb including UHV gloves should be worn when working with parts.

All tools that come in contact with assembly should be cleaned to class B standards.

Assembly will be done under a portable clean room. Any time a part of the assembly is not covered by the portable clean room or not being actively worked on it should be covered with appropriate clean covers. (C3 polyester or equivalent).

All parts that will be included in the final assembly must be cleaned to LIGO standards, Class A. The list of parts to be Class A-cleaned includes screws, washers, inserts, and assorted other hardware. All tooling and other parts that are not included in the final assembly, but that contact Class A parts during assembly must be cleaned to LIGO standards, Class B.

1.2. Torque Values for Bolts:

Except where noted, use a torque wrench to tighten all screws to specified torques.

Torque values are provided in blue

Table of torque values are also given in appendix D.
It is also recommended to print document T1100066 to have a sum up of SSTL torque values.

1.3. Electro-polished bolts

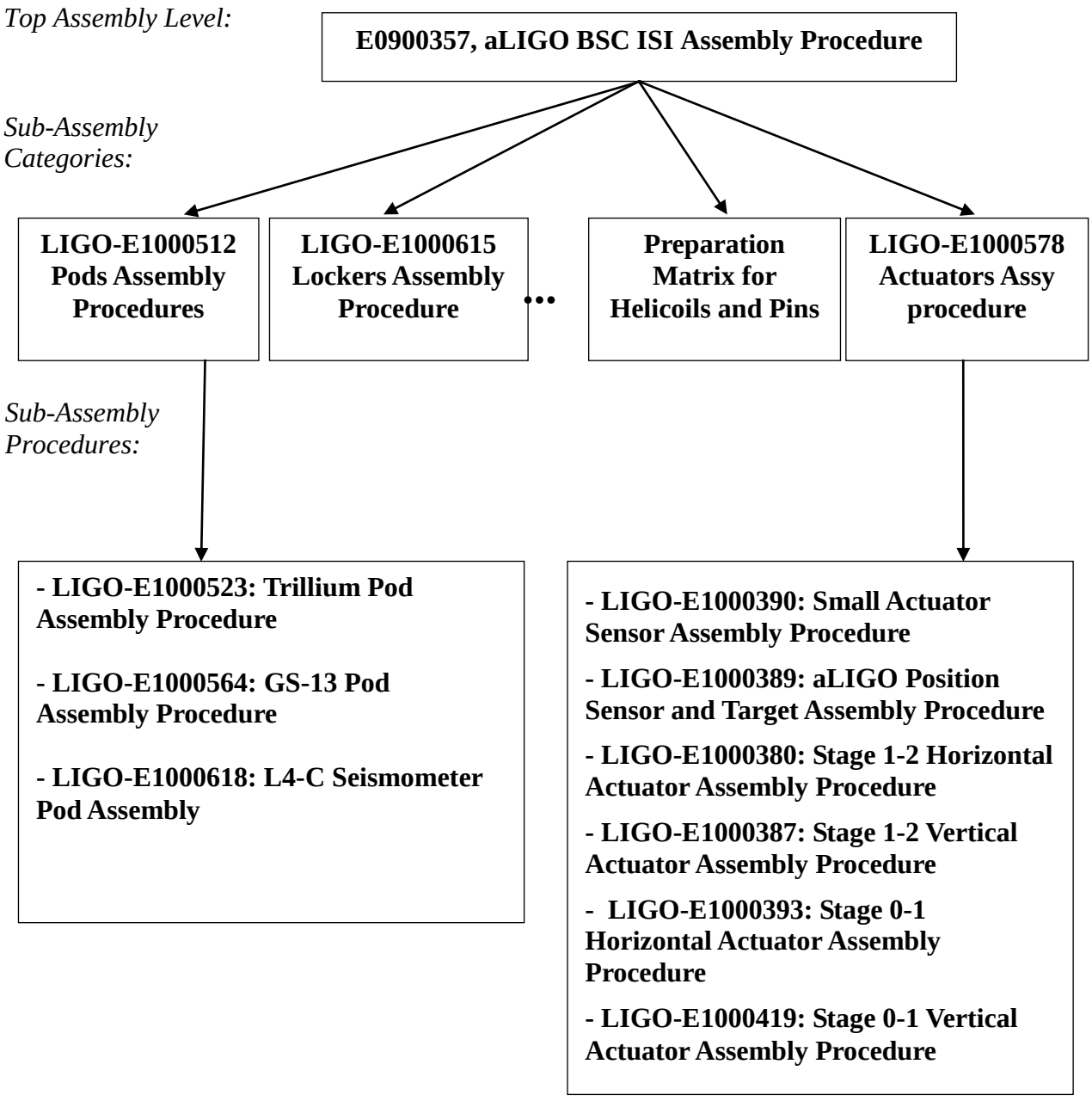
Batches of electro-polished bolts are being made to help with undersized tapped holes (either regular or helicoiled). If one finds a bolt hard to finger tight, he or she must report the defect in the JIRA for traceability, and then should try an electro-polished bolt.

1.4. Smaller OD vented washers

Assembly of Advanced LIGO BSC ISI: on occasion tolerances of screw holes may require the use of Special vented washers with small outside diameters in such a case replace the standard washers with special washers D1002990 (3/8 screw) or D1002991 (1/2 screw).

1.5. Assembly Documentation

The DCC page of the assembly procedure E0900357 is built as a tree containing links to the sub-assemblies and preparation documentation:



The sub-assemblies work to be done prior the actual assembly described in E0900357 includes the pins insertion, the helicoils insertion and the build of subassemblies (pods, lockers, actuators).

Assembly and sub-assemblies preparation

1.6. Install helicoils in all parts

They are 5063 helicoils to be installed in 40 parts. See LIGO-E1000402, worksheet on helicoils. This data sheet lists all the parts that need to receive helicoils, the type and quantities.

1.7. Press pins in all parts

375 Dowel Pins to be installed in 58 parts. See LIGO-E1000402, worksheet on press pins. This data sheet lists all the parts that need to receive dowel pins, the type and quantities.

For the large plates, special handling required. For dowel pin insertion depth see Insertion instruction E10000402. Dowels must be hammered into large plates because an arbor press cannot be used.

1.8. Actuators and Position Sensors Pre-Assembly

Assembly procedures are linked in the DCC tree. It contains:

Pre-Assembly Procedures:
LIGO-E1000390: Small Actuator Sensor Assembly Procedure
LIGO-E1000389: aLIGO Position Sensor and Target Assembly Procedure
LIGO-E1000380: Stage 1-2 Horizontal Actuator Assembly Procedure
LIGO-E1000387: Stage 1-2 Vertical Actuator Assembly Procedure
LIGO-E1000393: Stage 0-1 Horizontal Actuator Assembly Procedure

Drawings (related procedure in parenthesis):
D1000289 Stage 0-1 Vertical actuator with alignment tooling bar. (E1000419)
D1000310 Stage 0-1 Horizontal actuator with alignment tooling bar. (E1000393)
D1000642 Stage 1-2 Vertical actuator with alignment tooling bar. (E1000387)
D0902534 Stage 1-2 Vertical sensor assembly. (E1000390)
D1000717 Stage 1-2 Horizontal actuator with alignment tooling bar. (E1000380)
D0902529 Stage 1-2 Horizontal sensor assembly. (E1000390)

1.9. Lockers

Assembly procedures are linked in the DCC tree. It contains:

Pre-Assembly Procedures:
LIGO-D1000854: Stage 0-1 Locker, aLIGO BSC-ISI
LIGO-D1000855: Stage 1-2 Locker, aLIGO BSC-ISI

Drawings
D1000854 Stage 0-1 Locker assembly (E1000615)
D1000855 Stage 1-2 Locker assembly (E1000615)

1.10. Assemble seismometers pods

Assembly procedures are linked in the DCC tree. It contains:

Procedures
LIGO-E1000523: Trillium Pod Assembly Procedure
LIGO-E1000564: GS-13 Pod Assembly Procedure
LIGO-E1000618: L4-C Seismometer Pod Assembly

D047820 L4-C Pod Assembly (E1000618)
D1000525 L4-C ADL Interposer Pod Assembly (E1000618)
D0900857 GS-13 Pod Assembly (E1000564)
D0900648 Trillium Pod Assembly (E1000523)

1.11. Assemble outer wall assemblies (need some work)

Assembly procedures are linked in the DCC tree. It contains:

D1000052 see drawing and E1000402
D1000053 see drawing and section 9.13, Figure 9.7 and E1000402

Assemble D0900896 stage 0 on granite table

Parts required

Quantity	Part Number	Description	Weight
1	D0900894	Bottom Part	636 lbs
1	D0900895	Top Part	573 lbs

Note: To move these large parts, use the 1/2-13 eyebolts holes highlighted in blue on the following screen capture:

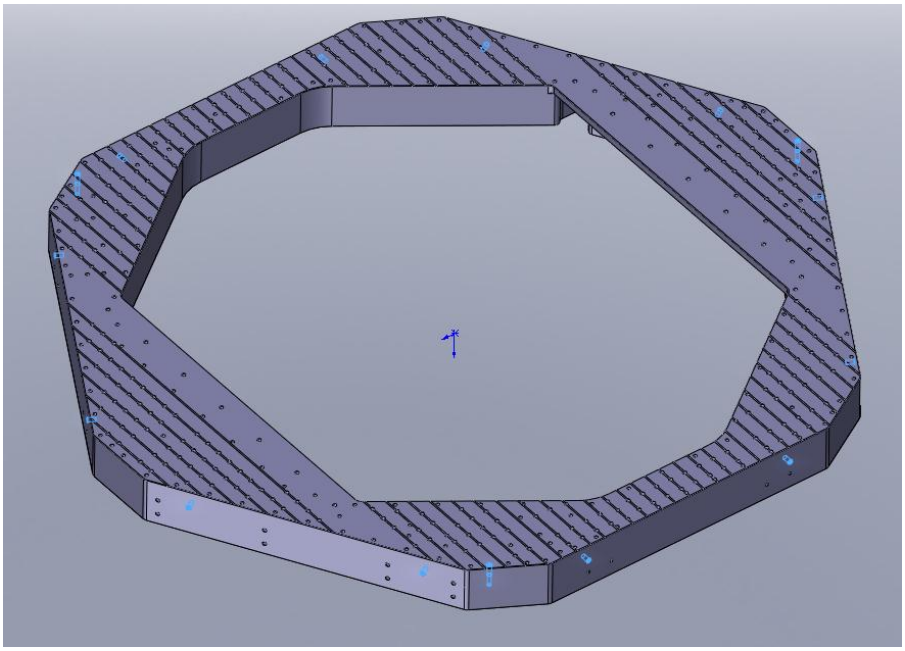


Figure 1: D0900894 Bottom Part of Stage 0 with the top and side lifting holes highlighted in blue

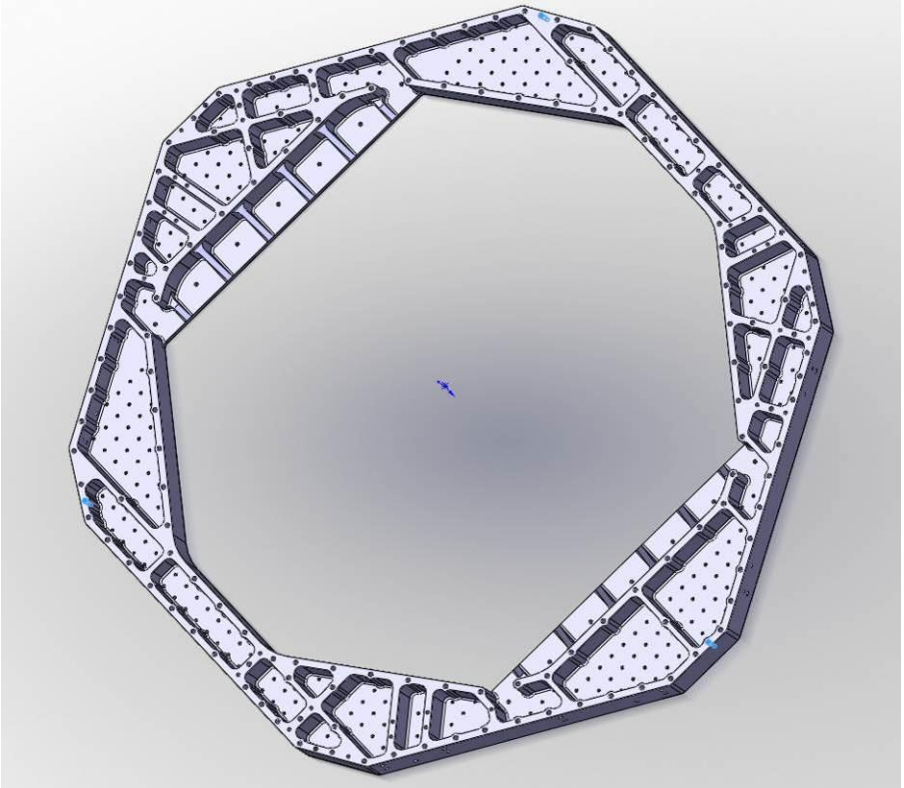


Figure 2: D0900894 Bottom Part of Stage 0 with the bottom lifting holes highlighted in blue

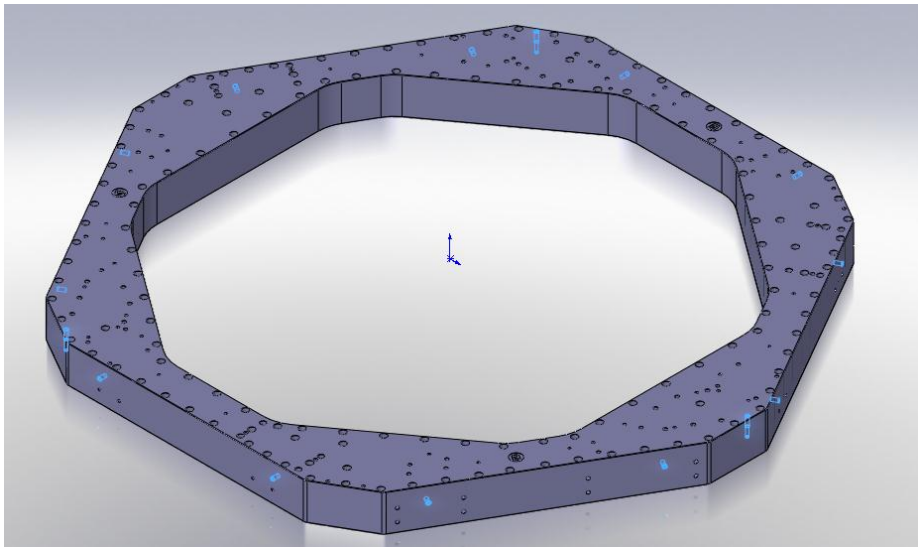


Figure 3: D0900895 Top Part of Stage 0 with the top and side lifting holes highlighted in blue

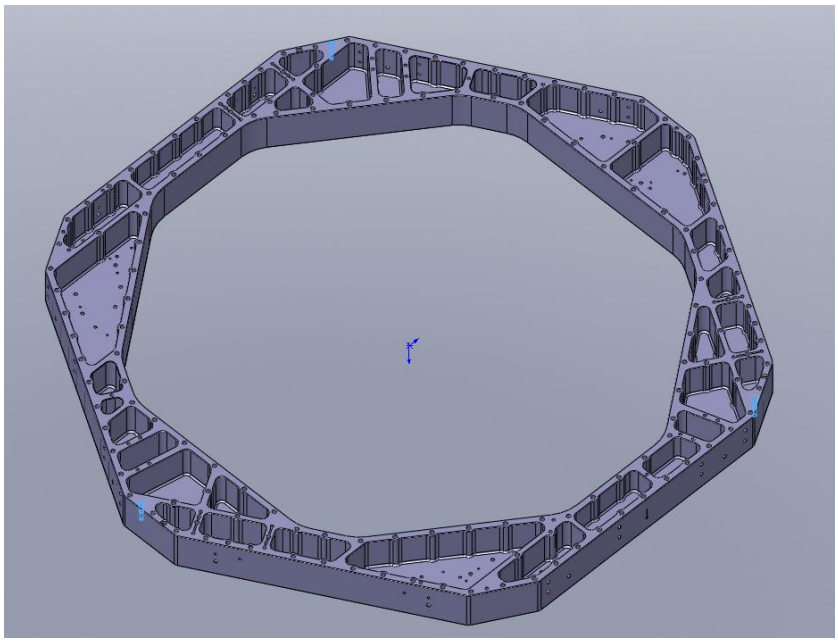


Figure 4: D0900895 Top Part of Stage 0 with the bottom lifting holes highlighted in blue

1.12. D0900894 Bottom Part of Stage 0

Place D0900894 Bottom Part of Stage 0 on level tooling blocks on granite table, ribs side down.

Prep Work:

Hardware:
(12) 1/4-20 x 2 DIA Helicoils
(309) 3/8-16 x 2 DIA Helicoils – 285 on top & 3 x 8 on the sides
(3) 1/2" x 1.25" dowel pins

- Install Nitronic 60 Helicoil threaded inserts into D0900894 as shown on Figure 5

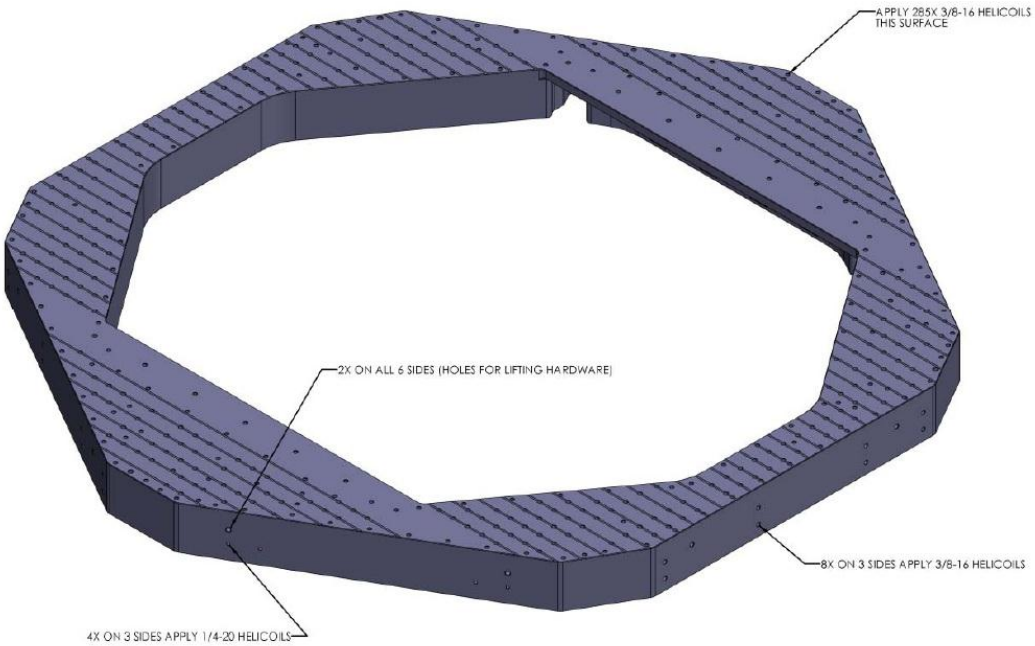


Figure 5: Insert 3/8-16 x 2DIA & 1/4-20 x 2DIA Helicoils in D0900894 Bottom Part of Stage 0

- Flip D0900894 (ribs side up) following E1100146 aLIGO BSC ISI Flipping Plate Procedure
- Press (3) 1/2" x 1.25" dowel pins into D0900894 for locating the Top Part of Stage 0. Pins should sit about 0.5" above the surface

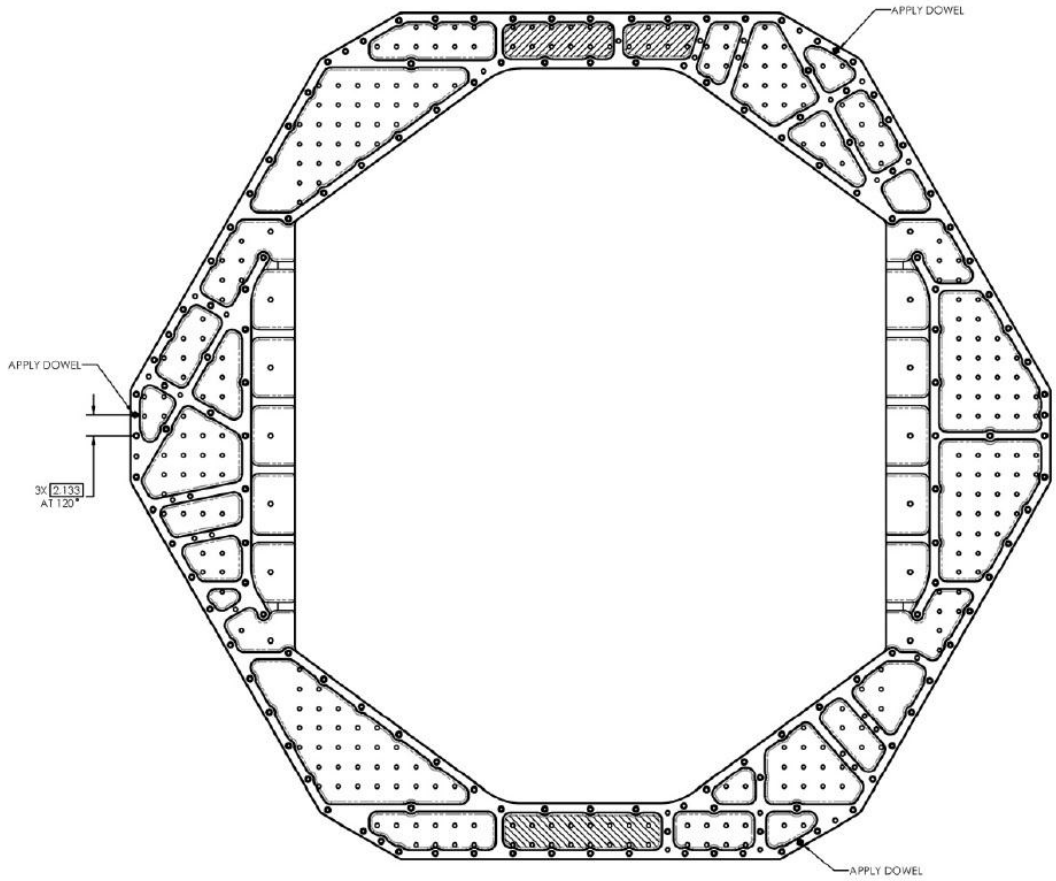


Figure 6: Press 1/2" x 1.25" Dowel Pins in D0900894 Bottom Part of Stage 0

- Place D0900894 Bottom Part of Stage 0 onto the BSC-ISI Test Stand in this configuration (ribs up as shown on Figure 6).

1.13. D0900895 Top Part of Stage 0

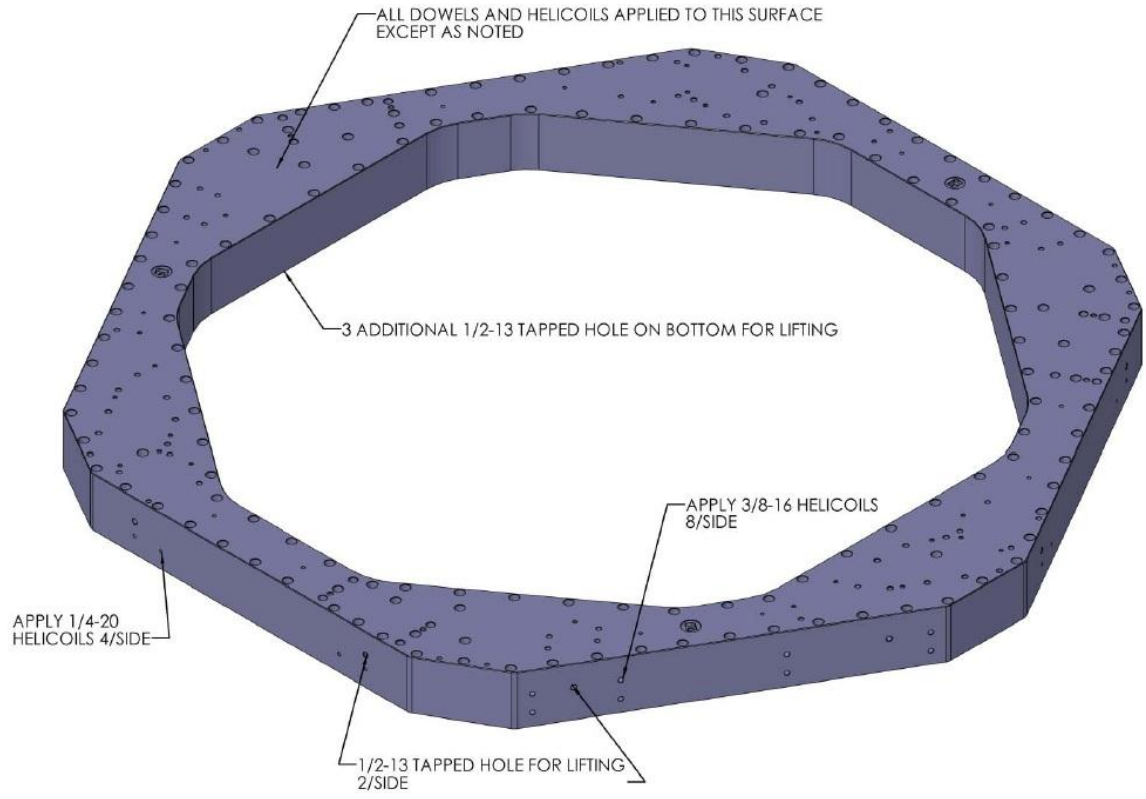
- Place D0900895 Top Part of Stage 0 on level tooling blocks on granite table, ribs side down.

Note: The Prep Work on D0900895 has to be done before putting the two parts of Stage 0 together; otherwise broken tangs will remain in the assembly!

Prep Work:

Hardware:
(15) 1/4-20 x 2 DIA Helicoils - 12 on top & 3 x 1 on the sides
(54) 3/8-16 x 2 DIA Helicoils - 30 on top & 3 x 8 on the sides
(12) 5/8-11 x 2 DIA Helicoils
(24) 3/8" x 1" dowel pins
(6) 1/2" x 1.25" dowel pins

- Install Nitronic 60 Helicoil threaded inserts into D0900895 as shown on Figure 7
- Press (6) 1/2" x 1.25" dowel pins into D0900895. Pins should sit about 0.5" above the surface.
- Press (24) 3/8" x 1" dowel pins into D0900895. Pins should sit about 0.4" above the surface.



(1/3 of the part is shown)

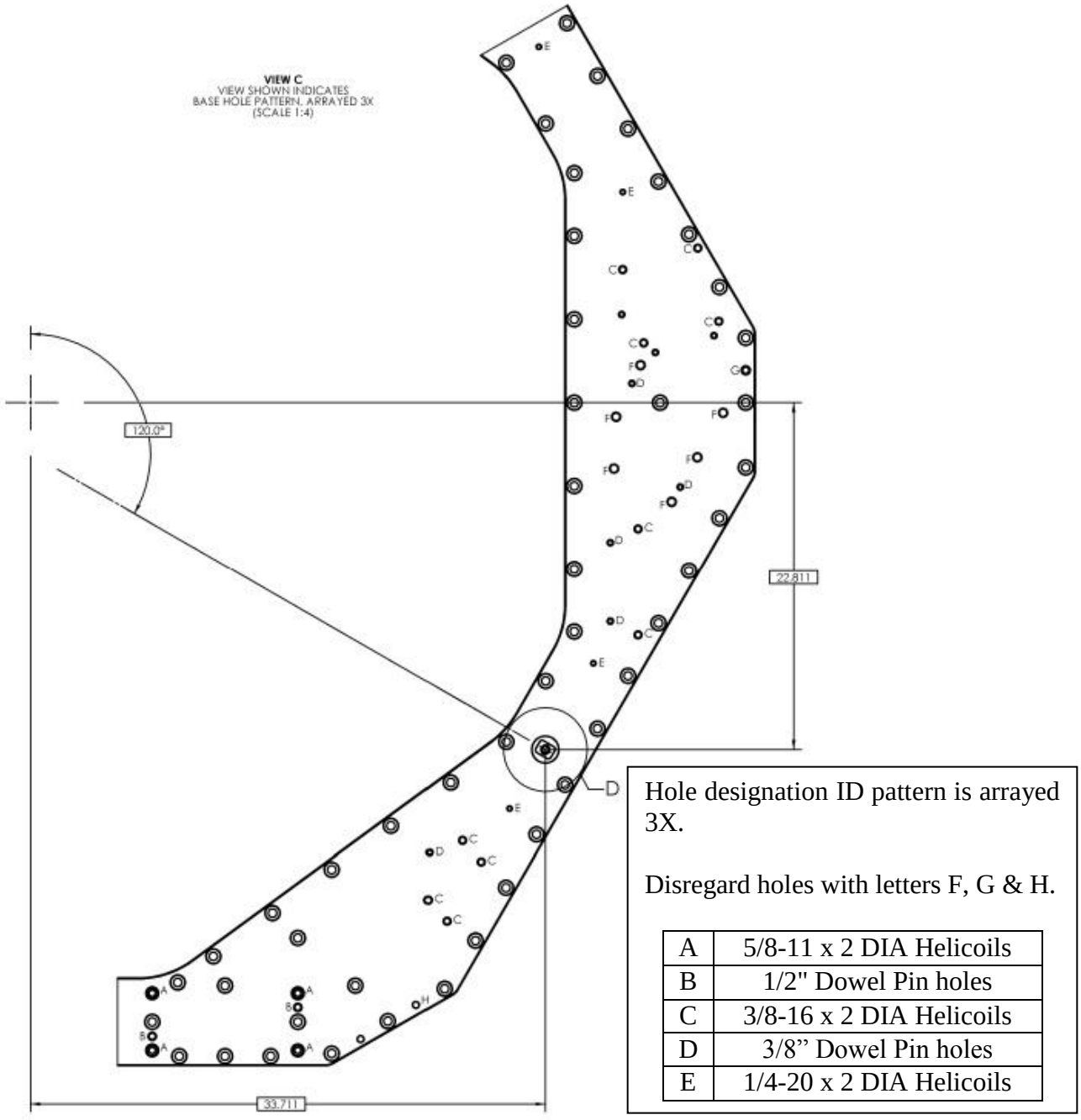


Figure 7: Prep Work of D0900895 Top Part of Stage 0

- Bring D0900895 Top Part of Stage 0 over D0900894 as shown on Figure 7 and position it by aligning the 3 dowel pins in D0900894 with the 3 slots in D0900895.

Note: There is only one position where the pins fits in the slots and all the faces of D0900894 & D0900895 are perfectly aligned (see Figure 8).

Note: **When fastening any of the Large Plates (D0900894, D0900895, D0901516, D0901517, D0901518, D0901519, D0901520, D0902273, D0902279 & D0902503), after torqueing all the bolts once, go around a second time, checking that all of them are torqued to specs. Repeat these steps until all of the bolts are fully torqued.**

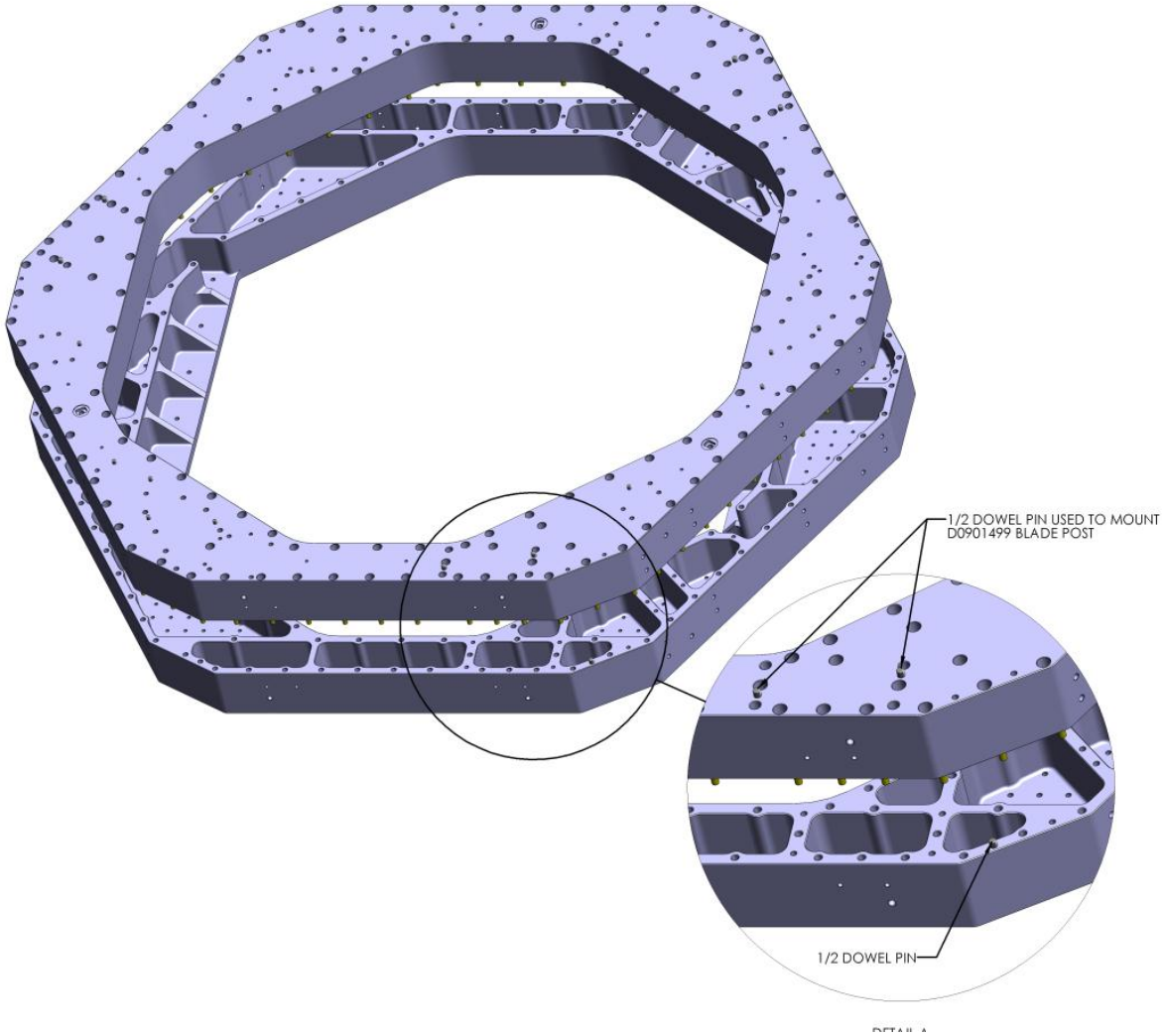


Figure 8: Stage 0 exploded view- note dowel pin locations

1.14. Attach top part D0900895

Hardware:
(142) 1/2-13x 3" SHCS – MSC 05684303
(142) 1/2" Vented washers - UCC-WFV-50

- Snug all screws and then torque to spec.

Torque value: 805 inch-lbs (67 ft-lbs).

1.15. Attach Stage 0-1 Blade Posts on Stage 0

Parts required

Quantity	Part Number	Description	Weight
3	D0901499	Stage 0-1 Blade Post	60.8 lbs

Prep Work for D0901499 Stage 0-1 Blade Post:

Hardware:
(4) 1/4-20 x 2 DIA Helicoils
(1) 1/2-13 x 2 DIA Helicoils
(2) 3/8" x 1" dowel pins

- Install Nitronic 60 Helicoil threaded inserts into D0901499 Stage 0-1 Blade Post as shown on Figure 9.
- Press (2) 3/8" x 1" dowel pins into D0901499. Pins should sit about 0.4" above the top surface.

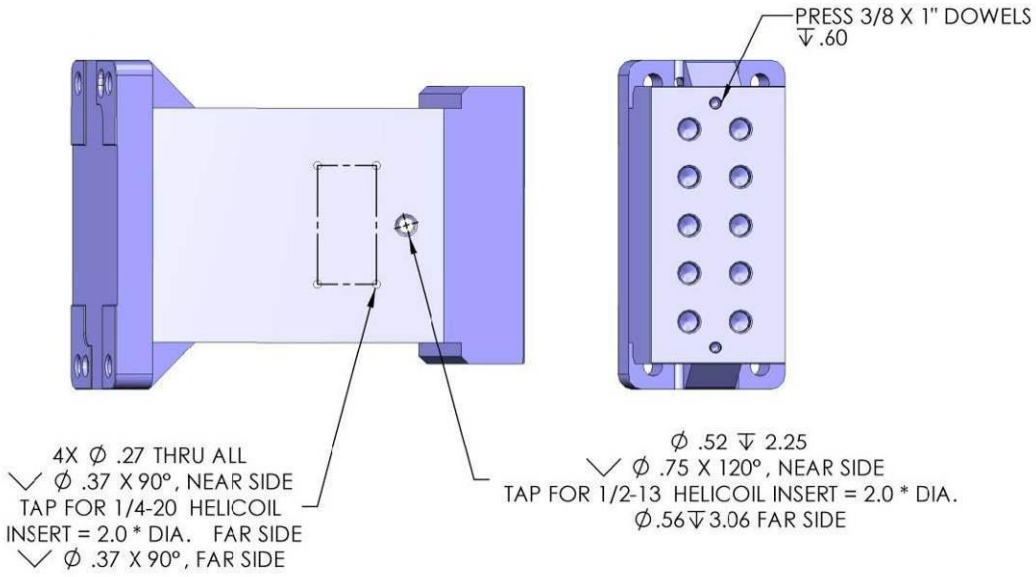


Figure 9: D0901499 Stage 0-1 Blade Post Prep Work

The posts are positioned on Stage 0 with six 1/2" dowel pins.

Hardware:
(4) 5/8-11 x 2.5" HHCS - HCS10C0408
(4) 5/8" Vented Washer - McMaster 98019A514

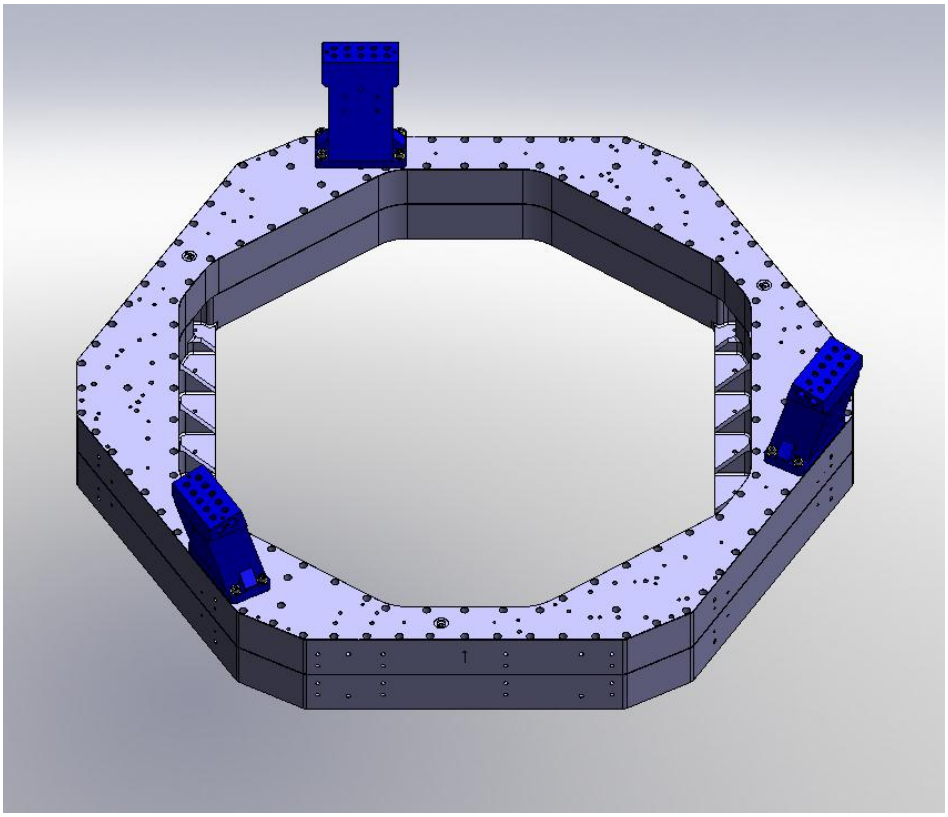


Figure 10: Stage 0 assembled with D0901499 Blade Posts

Torque to 1110 in.lbs (92.5 ft.lbs).

Assemble stage 2 Optical Table on granite table

Parts required:

Quantity	Part Number	Description	Weight
1	D0901516	Solid Optical Table (facing down)	932 lbs
1	D0901517	Cut-Out Optical Table (facing up)	685 lbs
3	D0901842	Cover 1	11 lbs
3	D0901843	Cover 2	9 lbs
3	D0901844	Cover 3	1 lb

Prep Work for D0901516 Solid Optical Table:

Hardware:
(3244) 3/8-16 x 2 DIA Helicoils – 3217 + 3 x 4 on the bottom (none ribbed side) & 3 x 5 on the top (ribbed side part)
(18) 1/4-20 x 2 DIA Helicoils
(3) 1/2" x 1.25" dowel pins

- Place D0901516 on the granite table using level blocks, ribs side down (see left view of Figure 11).
- Install Nitronic 60 Helicoil threaded inserts into D0901516 (3217 + 3 x 4 total for the 3/8-16 x 2 DIA & 3 x 6 for the 1/4-20 x 2 DIA).
- Flip D0901516 (ribs side up, see right view of Figure 11) following E1100146 aLIGO BSC ISI Flipping Plate Procedure
- Press (3) 1/2" x 1.25" dowel pins into D0901516. Pins should sit about 0.5" above the top surface.
- Install Nitronic 60 Helicoil threaded inserts into D0901516 (3 x 5 for the 3/8-16 x 2DIA).

Hole designation ID pattern is arrayed 3X.

B	3/8-16 x 2 DIA Helicoils
C	1/4-20 x 2 DIA Helicoils
E	5/8-11 Tapped holes for Lifting

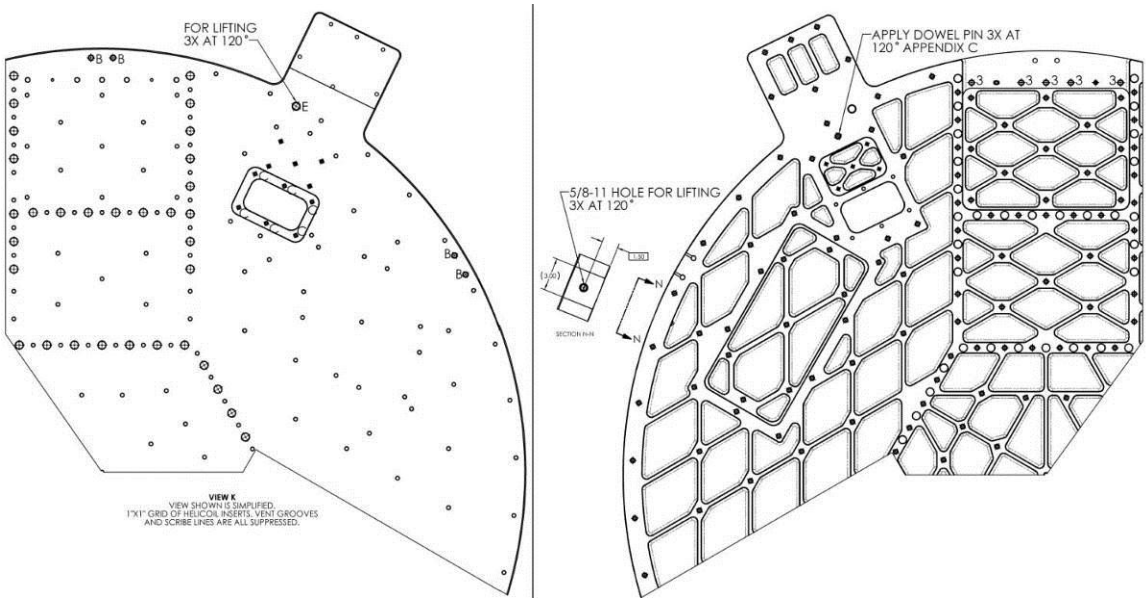
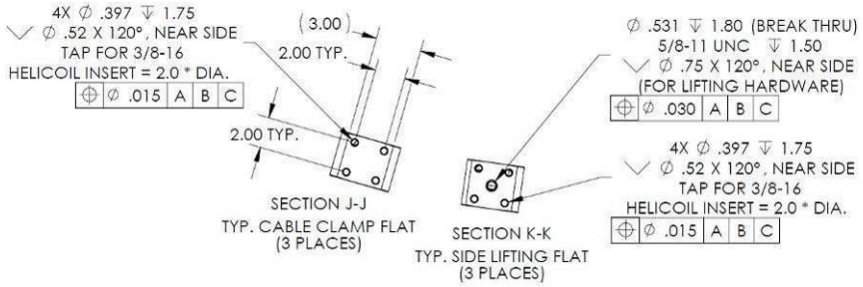


Figure 11: Prep Work for the two sides of D0901516 Solid Optical Table

Prep Work for D0901517 Cut-Out Optical Table:

Hardware:
(36) 3/8-16 x 2 DIA Helicoils
(33) 3/8" x 1" dowel pins

- Place D0901517 on the granite table using level blocks, ribs side up (see right view of Figure 12).
- Press (3) 3/8" x 1" dowel pins into D0901517. Pins should sit about 0.4" above the surface.
- Install Nitronic 60 Helicoil threaded inserts into D0901516 (3 x 4 for the 3/8-16 x 2DIA).
- Flip D0901517 (ribs side down, see left view of Figure 11) following E1100146 aLIGO BSC ISI Flipping Plate Procedure
- Press (30) 3/8" x 1" dowel pins into D0901517. Pins should sit about 0.4" above the surface.
- Install Nitronic 60 Helicoil threaded inserts into D0901516 (3 x 4 + 3 x 4 total for the 3/8-16 x 2 DIA, these helicoils are located on the side of D0901517).



Hole designation ID pattern is arrayed 3X.

B&E	3/8 x 1” dowel pins
C	1/4-20 x 2 DIA Helicoils
E	5/8-11 Tapped holes for Lifting

Hole designation ID pattern is arrayed 3X.

1	3/8-16 x 2 DIA Helicoils
2	3/8 x 1” dowel pins

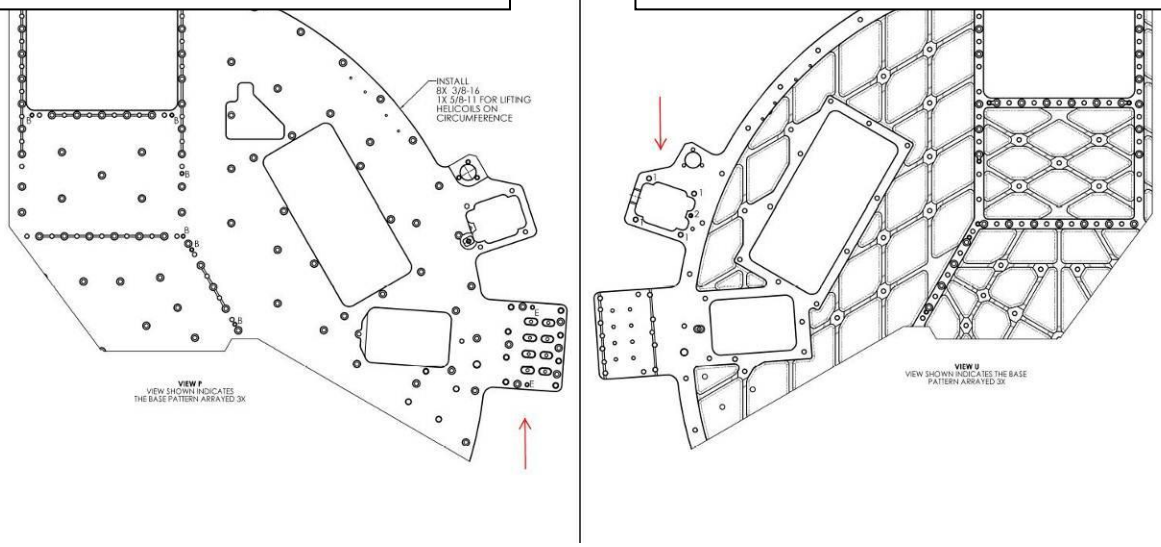


Figure 12: Prep Work for the two sides of D0901517 Cut-Out Optical Table

1.16. Attach covers D0901842, D0901843 & D0901844

Parts required:

Quantity	Part Number	Description	Weight
3	D0901842	Cover 1	11 lbs
3	D0901843	Cover 2	9 lbs
3	D0901844	Cover 3	
1	D0901516	Solid Optical Table (facing down)	932 lbs

Hardware:

(60) 3/8-16 x 1" SHCS – MSC 75464628
(60) 3/8 Vented Washers - UCC-WFV-38

- Bolt D0901842 & D0901843 to D0901516 Solid Optical Table (with the ribs side still facing up, see Figure 13).
- **Torque all the bolts up to 329 in.lbs (27 ft.lbs).**

Hardware:

(15) 1/4-20 x 5/8" SHCS – MSC 75464347
(15) 1/4 Vented Washers - UCC-WFV-25

- Bolt D0901844 to D0901516 Solid Optical Table (with the ribs side still facing up, see Figure 13).
- **Torque all the bolts up to 100 in.lbs.**

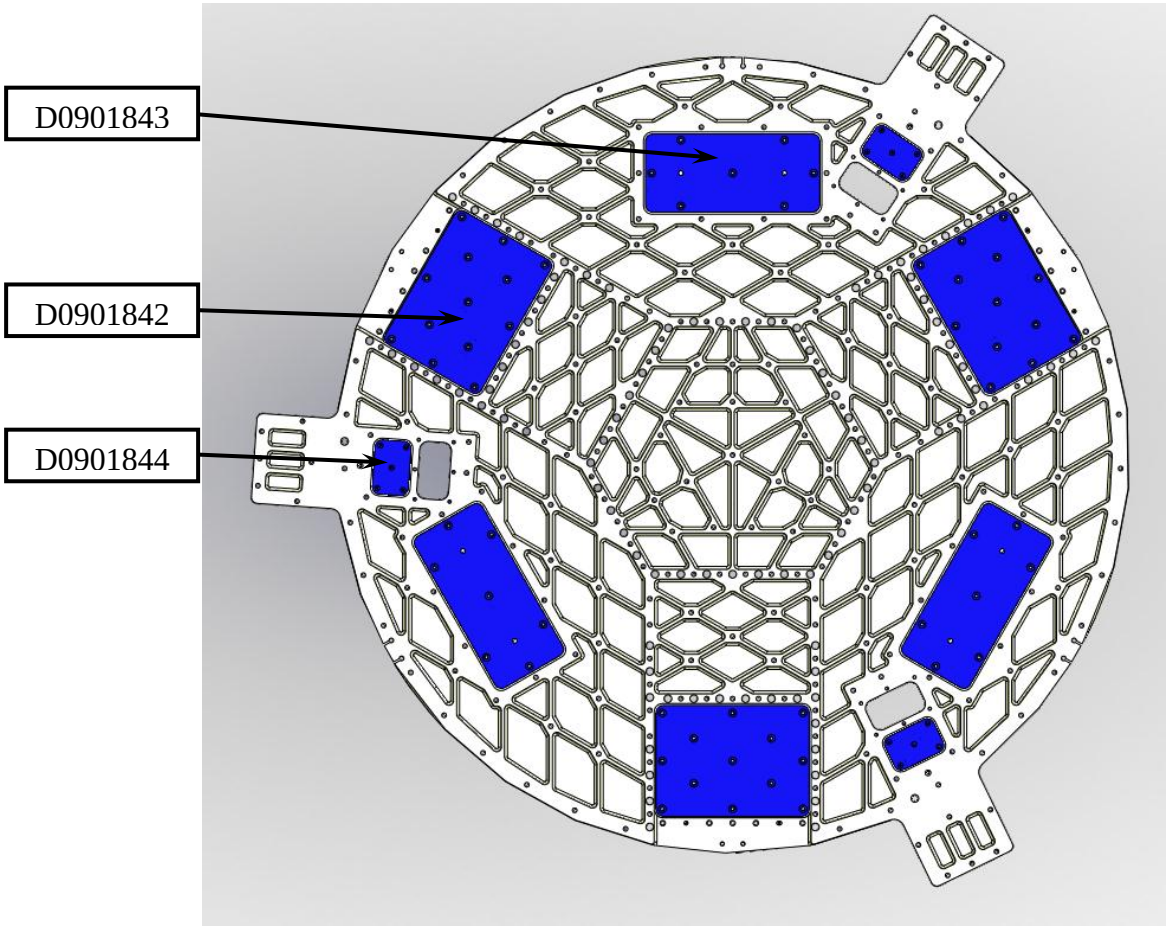


Figure 13: D0901516 Solid Optical Table (ribs side up) assembled with all its covers highlighted in blue (D0901842, D0901843 & D0901844)

1.17. Optic Tables alignment

- Place D0901516 Solid Optical Table - ribs side up - on the granite table using level blocks.
- Position D0901517 Cut-Out Optical Table – ribs side down - such that the areas of the spring blade circled in blue and red on Figure 14 & Figure 15 match. The final alignment is done by locating the 3 pins of D0901516 in the 3 slots of D0901517.

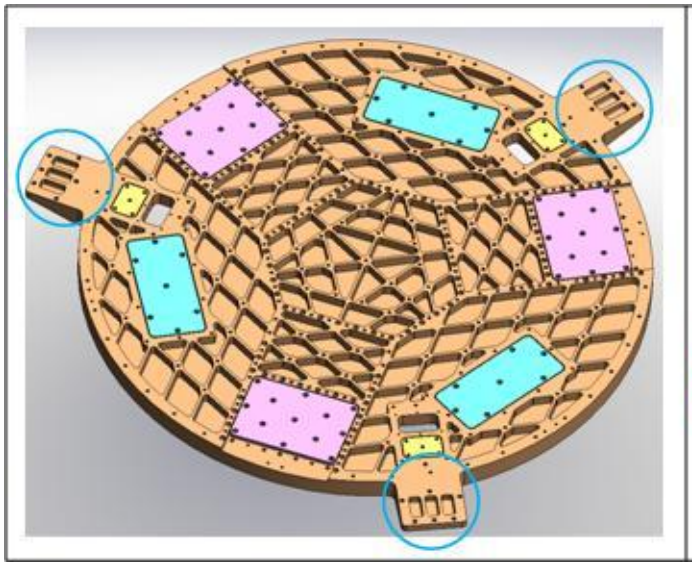


Figure 14: D0901516 Solid Optical Table (ribs side up) with covers

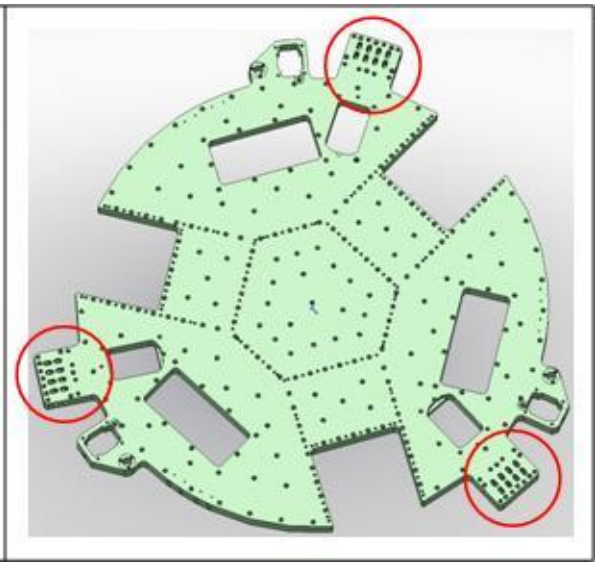


Figure 15: D0901517 Cut-Out Optical Table (ribs side down)

1.18. Attach Optic Tables

Hardware:
(306) 3/8-16 x 2" SHCS – MSC 75464701
(306) 3/8 Vented Washers - UCC-WFV-38

- Insert bolts to attach the two pieces of the Optical Table together. Bolts will go from D0901517 Cut-Out Optical Table into the threaded holes of D0901516 Solid Optical Table.
- **Torque all the bolts up to 329 in.lbs (27 ft.lbs).**

Note: **When fastening any of the Large Plates (D0900894, D0900895, D0901516, D0901517, D0901518, D0901519, D0901520, D0902273, D0902279 & D0902503), after torqueing all the bolts once, go around a second time, checking that all of them are torqued to specs. Repeat these steps until all of the bolts are fully torqued.**

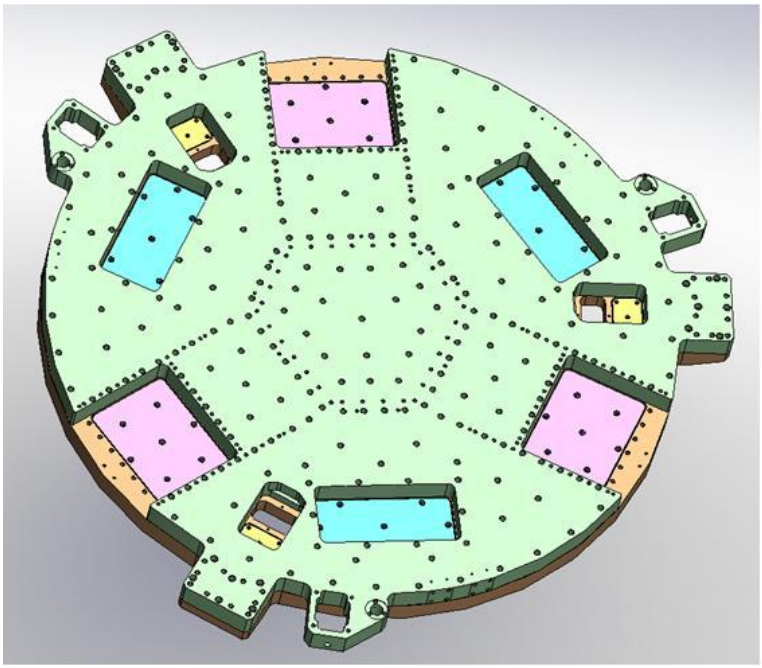


Figure 16: Optical Table

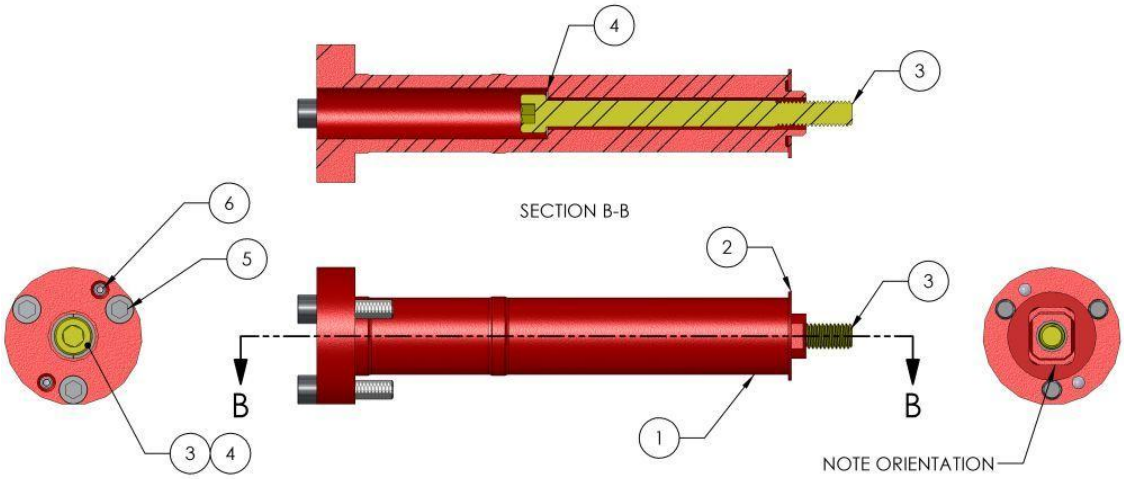
1.19. Move stage 2 optical table to assembly stand

D1001110 Stage 0-2 Alignment Pin Assembly

1.20. Alignment Pin Preassembling

Hardware:
(1) 1/2-13 x 6" SHCS (1.5" threaded) – MSC 04736195
(1) 1/2 Vented Washer - UCC-WFV-50
(3) 3/8-16 x 1.5" SHCS – MSC 75464669
(2) Set Screw 1/4-20 x 0.5" Oval Point – MSC 64102023

- Assemble D1001110 as shown on Figure 17



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ
6	McMASTER_92778A127	SET SCREW 1/4-20 X 1/2 LG OVAL POINT	18-8 SSTL	2
5	HOLOKROME_78102	SHCS, 3/8"-16x1.5"	18-8 SS	3
4	UC_COMPONENTS_WFV-50	Vented Washer, .515 ID X .87 OD X .032 THK #1/2"	18-8 SS	1
3	McMaster_92196A736	Screw SCHS 1/2-13 x 6" Lg, 1.5" threaded	18-8 SSTL	1
2	D1001111	STAGE 0-2 ALIGNMENT WASHER, aLIGO BSC ISI	304, 316 OR 302 SSTL	1
1	D050452	STAGE 0-2 ALIGNMENT PIN	17-4 PH SSTL, H 1150	1

Figure 17: Stage 0-2 Alignment Pin Assembly Drawing

1.21. Attach Optical Table to Stage-0.

- Attach three alignment pins D1001110 to Optical Table with (3) 3/8-16 x 1.5" SHCS & (3) 3/8 Vented Washers. **Torque these bolts up to 329 in.lbs (27 ft.lbs).**
- Repeat this step for the 2 other D1001110 Stage 0-2 Alignment Pin Assemblies.

Note: The use of oval point set screws to prevent the surfaces of D1001110 & D0901517 from marring, when the pins are later removed. These screws do not have to be inserted until we remove D1001110 Stage 0-2 Alignment Pin Assemblies.

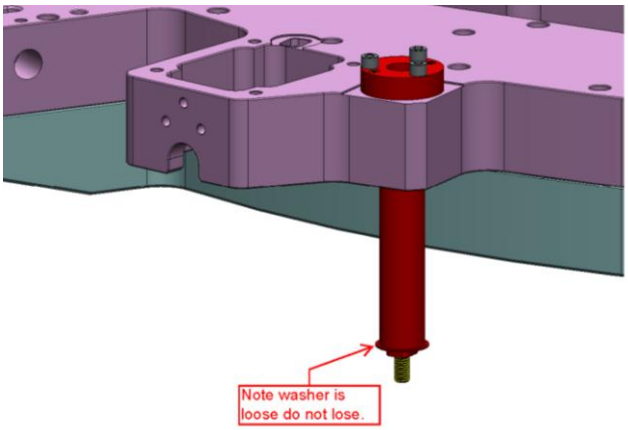


Figure 18: D1001110 Stage 0-2 Alignment Pin mounted onto D0901517 Cut-Out Optical Table

1.22. Move Stage 2 onto Stage 0

- Attach lifting rings and sling to the Assembly via lifting holes located on D0901517 (see Figure 19).
- Lift the Optical Table composed of D0901516 & D0901517 and place it on Stage 0 already on the assembly stand.

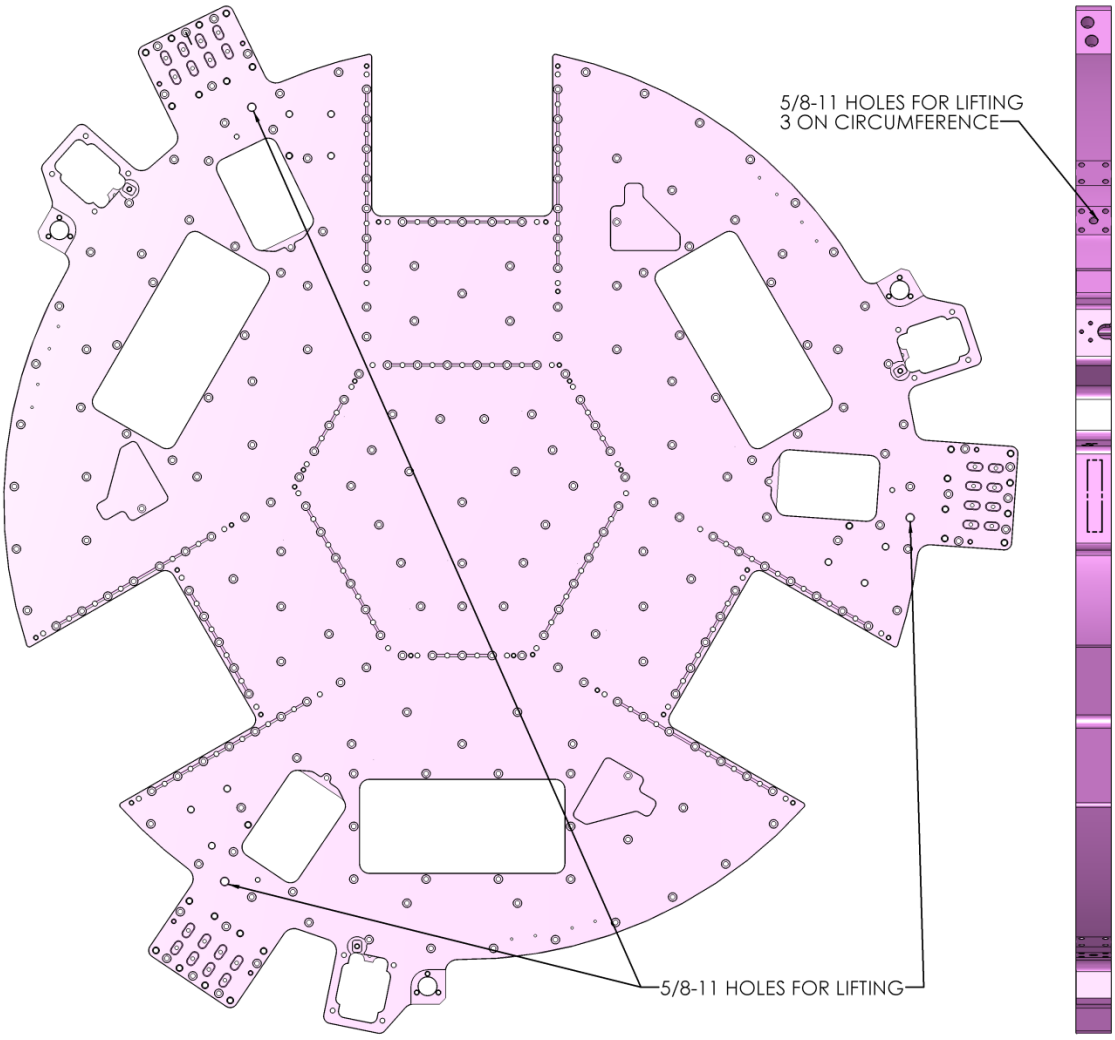


Figure 19: Location of D0901517 Lifting holes to lift the Optical Table Sub-Assembly

1.23. Set Stage 2 onto Stage 0

- Set D1001111 Stage 0-2 alignment Washers (Item (2) Figure 17 onto Stage 0 holes circled in red on Figure 20 Location for washers and positioning posts of the Optical Table on Stage 0.

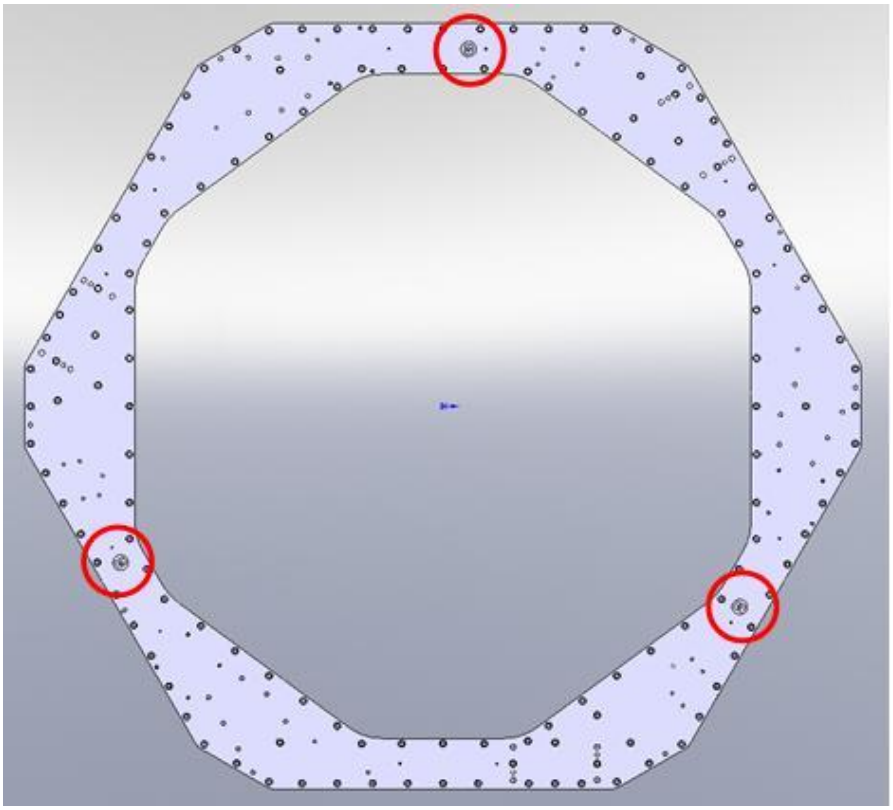


Figure 20 Location for washers and positioning posts of the Optical Table on Stage 0

- As the Optical Table is moved to the assembly stand and lowered onto stage 0, the positioning pins will be lowered onto markers on Stage 0.

Note: when lowering the optical table, set the holes direction of the lower optical table parallel to the Stage 0 pattern/crossbeams. Mark ups should help on that matter.

- Slide screws through the tower and attach pins to Stage 0 using (1) 1/2-13 x 6" SHCS & (1) 1/2 vented washer per post.
- **Torque (3) 1/2-13 x 6" SHCS up to 517 inch-lbs (43.1 ft-lbs).**

Stage 1 partial assembly

Quantity	Part Number	Description	Weight
1	D0902279	Base Plate	238
3	D0902280	Ballast Weight	43
3	D0902272	Block Links	16
3	D0902271	Angled Hex Wall	24
3	D0902282	Hex Inner Wall	12
3	D0902274	Flexure Wall	14
3	D0902278	L4C Wall	21
3	D0902425	Flexure Rod Bracket Assembly	
3	D0902443	Back Ribs Stage 1	
6	D0902441	Side Ribs Stage 1	

- Place D0902279 Base Plate on the granite table with ballast mounting surface down (see the right screen capture on Figure 21).

Note: The Base Plate must be set on blocks (~4 inches high) to mount D0902280 Ballast Weights from below. For this plate, all the prep work can be down in this position (ballast mounting surface down).

Prep Work:

Hardware:
(21) 1/4-20 x 2 DIA Helicoils – 3 x 7 on top
(42) 3/8-16 x 2 DIA Helicoils – 3 x 2 + 3 x 7 on the sides & 3 x 5 on top
(33) 3/8" x 1" dowel pins – 3 x 2 on the bottom & 3 x 9 on top
(12) 3/8" x 5/8" dowel pins – 3 x 4 on the bottom

From below:
- Press (12) 3/8" x 5/8" dowel pins into D0902279. Pins should sit about 0.09" above the surface as shown on the left screen capture of Figure 21& Figure 22.
- Press (6) 3/8" x 1" dowel pins into D0902279. Pins should sit about 0.5" above the surface as shown on the left screen capture of Figure 21 & Figure 22.

From above:
- Install Nitronic 60 Helicoil threaded inserts into D0902279 as shown on the left screen capture of Figure 21 & Figure 22.
- Press (27) 3/8" x 1" dowel pins into D0902279. Pins should sit about 0.5" above the surface as shown on the left screen capture of Figure 21 & Figure 22.

Hole designation ID pattern is arrayed 3X.

Helicoils are inserted from the same side as shown.

A&1	3/8 x 1” dowel pins & 3/8 x 5/8” dowel pins
3	3/8-16 x 2 DIA Helicoils
4	1/4-20 x 2 DIA Helicoils

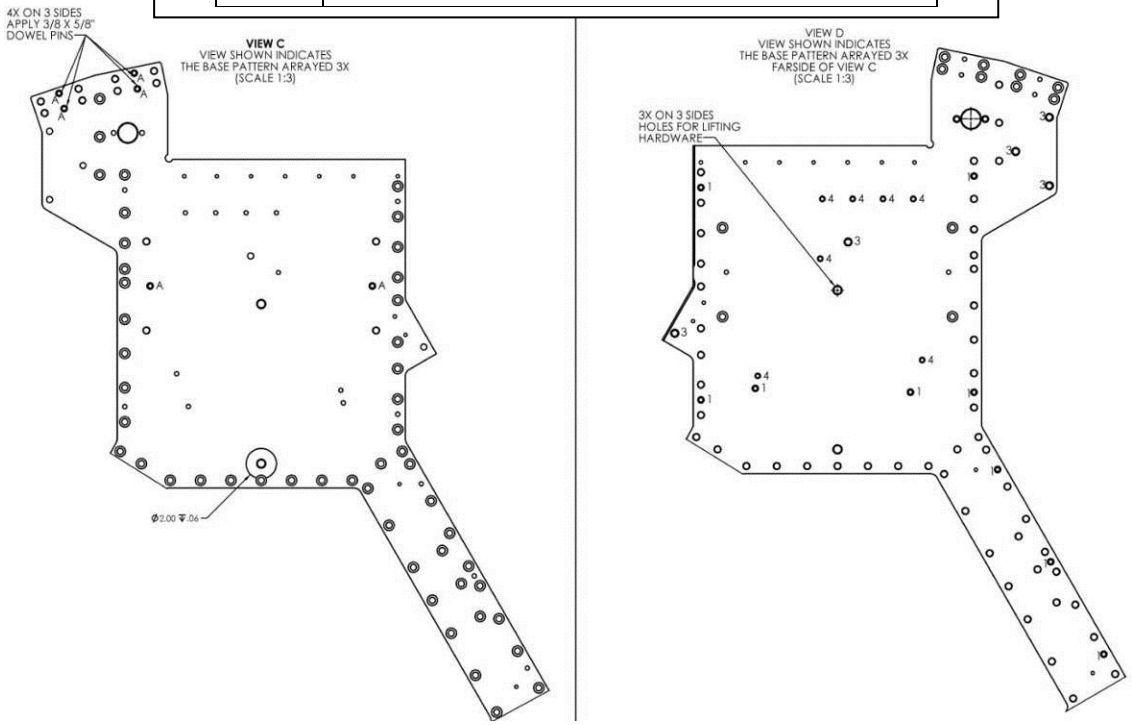


Figure 21: Prep Work for D0902279 Stage 1 Base Plate (Ballast mounting surface up on the left & Ballast mounting surface down on the right)

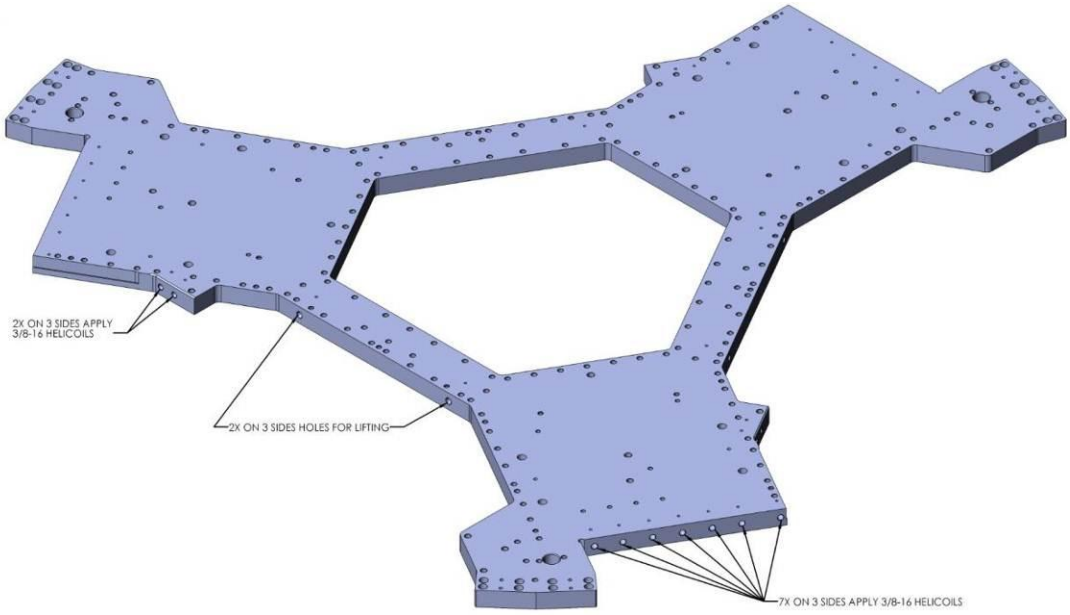


Figure 22: Prep Work for the side of D0902279 Stage 1 Base Plate

Hardware:
(12) 3/8-16 x 1.25" SHCS - MSC 75464644
(12) 3/8 Vented Washer - UCC-WFV-38

- Attach Ballast Weights D0902280 by sliding them into position under D0902279 Base Plate.
- Use the 3/8 x 1" dowel pins already inserted to put the Ballast in the right position.
- Drop bolts with washers down through Stage 1 Base Plate.
- Tighten screws to pull masses up.
- **Torque screws up to 329 in.lbs (27 ft.lbs).**

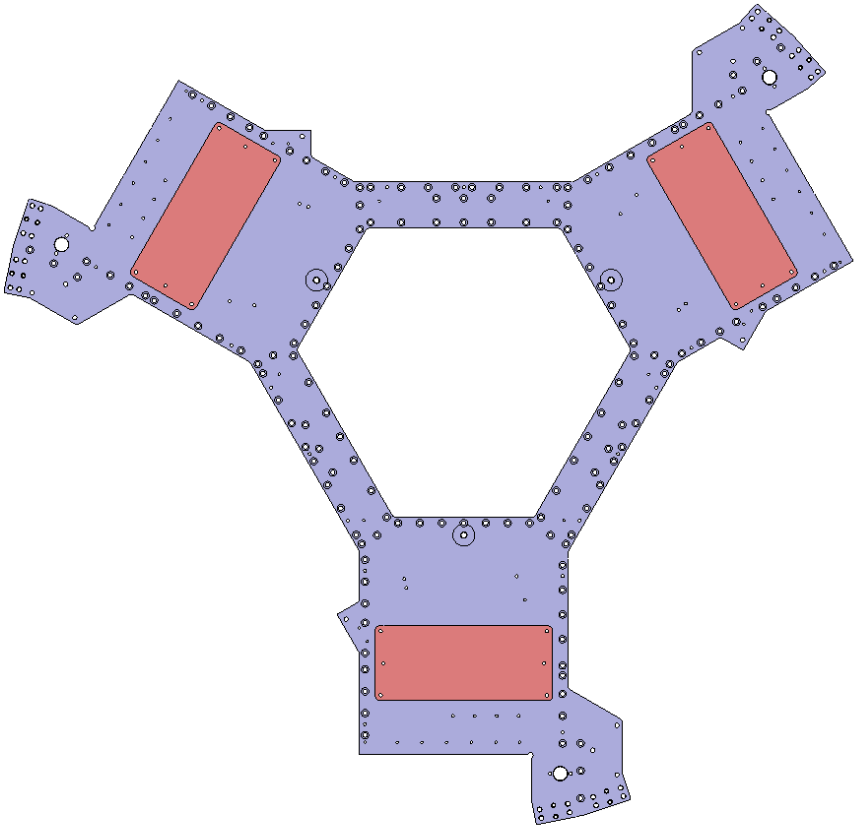


Figure 23: Ballast position view from the bottom

Stage 1 Wall Assembly

Note: See Figure 24 for wall orientation.

1.24. Install (3) D0902272 Block Links on D0902279 Stage 1 Base Plate

Hardware:
(14) 3/8-16 x 1.25" SHCS - MSC 75464644
(14) 3/8 Vented Washer - UCC-WFV-38

- Mount D0902272 Block Links on D0902279 Stage 1 Base Plate locating all walls with dowel pins already installed. Make sure pins seat properly into mating hole and slot.
- Insert all the screws from the bottom up.
- Snug, then **torque screws up to 329 in.lbs (27 ft.lbs).**
- Repeat this step for the 2 other D0902272 Block Links.

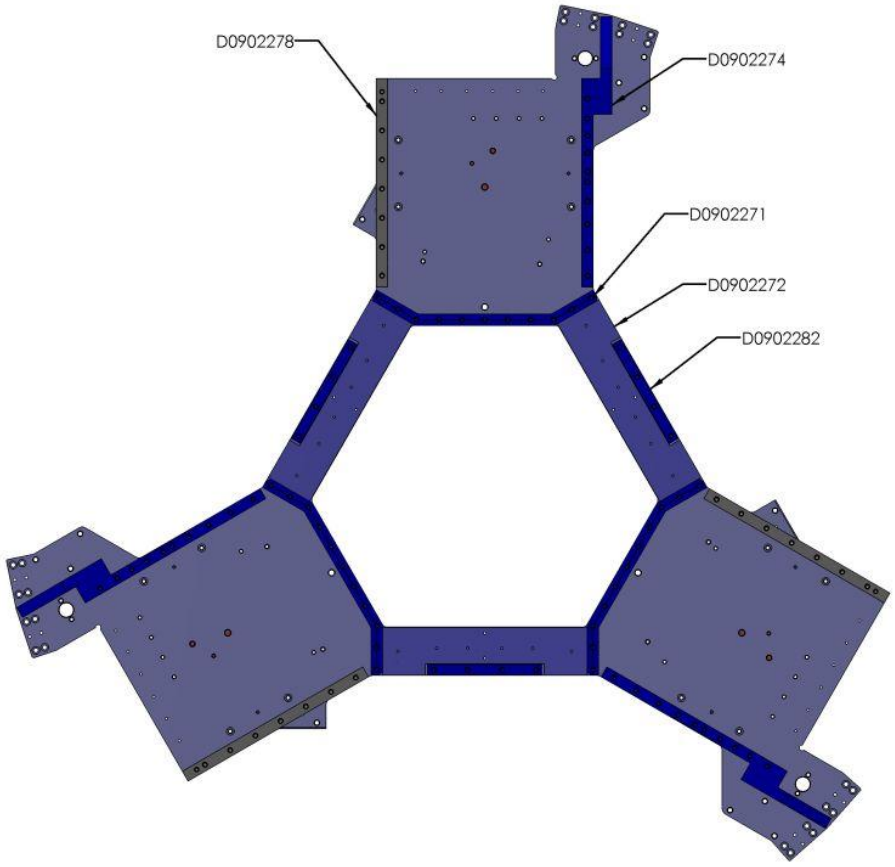


Figure 24: Top View of all the walls of Stage 1 sitting on the Base Plate

1.25. Install (3) D0902271 Angled Hex Wall on D0902279 Stage 1 Base Plate

- Mount D0902271 Angled Hex Wall on D0902279 Stage 1 Base Plate. Each D0902271 Angled Wall is positioned by ensuring contact with the 2 D0902272 Block Links it is connected to and with the D0902279 Base Plate.

Note: The orientation of the 5 counter bored holes on each side of the angled portion of D0902271 are used to bolt it to D0902272 (see Figure 25).

Hardware:
(21) 3/8-16 x 1.25" SHCS - MSC 75464644
(21) 3/8 Vented Washer - UCC-WFV-38

- Insert all screws.
- Snug the ones connecting D0902271 Angled Hex Wall with D0902272 Block Links on both sides and then the ones connecting D0902271 Angled Hex Wall to D09002279 Base Plate.
- Then **torque screws up to 329 in.lbs (27 ft.lbs)** in the same order.
- Repeat this step for the 2 other D0902271 Angled Hex Walls

Note: Check for good contact between D0902271 Angled Hex Walls and D0902279 Stage 1 Base Plate & D0902272 Block Links, by attempting to slide a .001" thick gauge between those and the Block Links. If the gauge fits in between, untorque the bolts and redo step 1.27 all over.

1.26. Install (3) D0902282 Inner Walls onto D0902279 Stage 1 Base Plate

- Mount D0902282 Inner Walls onto D0902279 Stage 1 Base Plate. They are positioned with dowel pin already inserted into D0902279 Base Plate and by ensuring contact with D0902272 Block Links.

  Hardware:
  (12) 3/8-16 x 1.25" SHCS – MSC 75464644
  (12) 3/8 Vented Washer - UCC-WFV-38

- Insert all screws (8 from the outside and 4 from the bottom).
- First while ensuring contact with D0902282 block link and the base plate. Maintain contact to both parts while torque to final spec.
- Snug the ones connecting D0902282 Inner Wall with D0902272 Block Links and then the ones connecting D0902282 Inner Wall to D09002279 Base Plate.
- Then **torque screws up to 329 in.lbs (27 ft.lbs)** in the same order.
- Repeat this step for the 2 other D0902282 Inner Walls

Note: Check for good contact between D0902282 Inner Walls and D0902279 Stage 1 Base Plate & D0902272 Block Links, by attempting to slide a .001" thick gauge between those and the Block Links. If the gauge fits in between, untorque the bolts and redo step 1.28 all over.

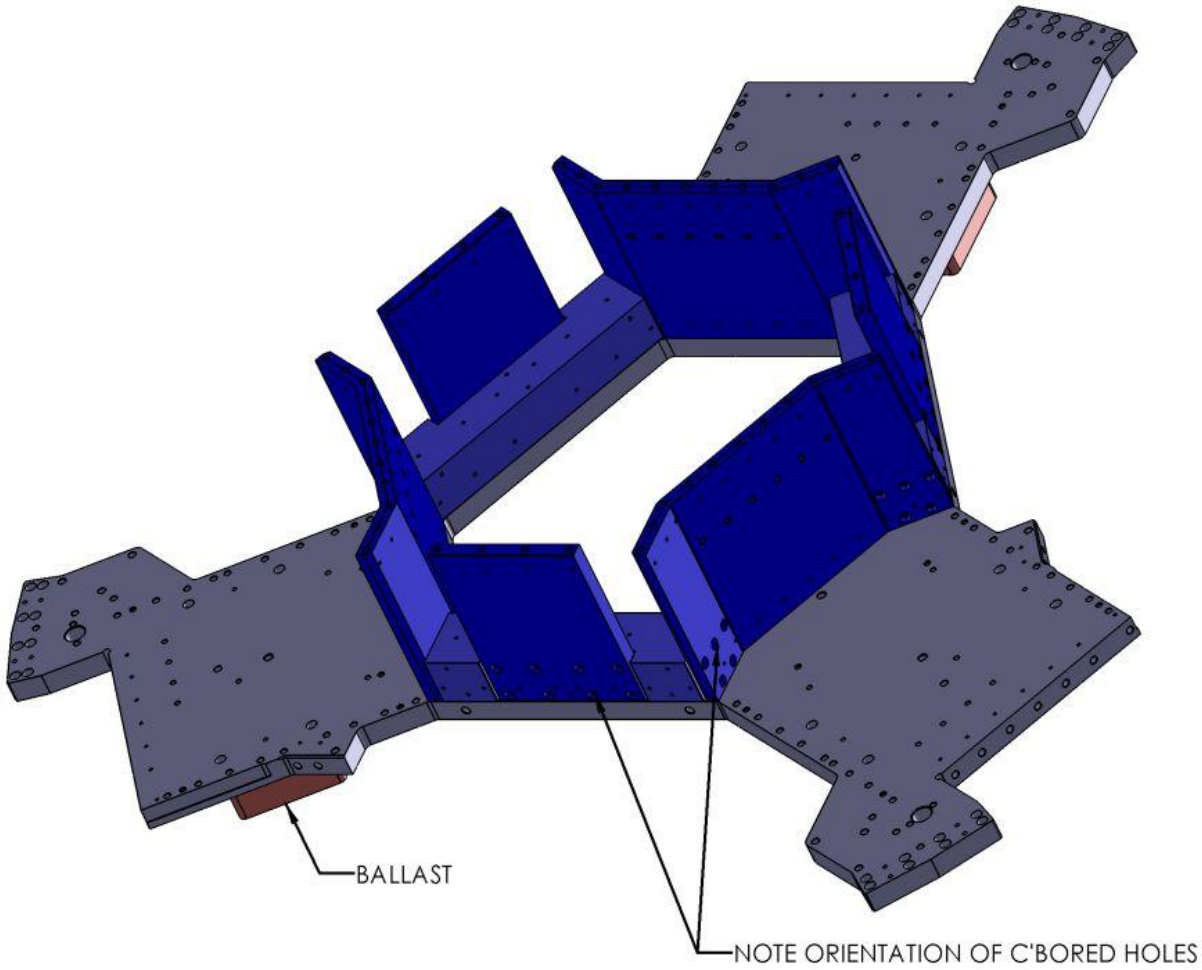


Figure 25: Position of D0902271 Angled Hex Wall, D0902272 Block Links & Hex Inner Wall D0902282 on D0902279 Stage 1 Base Plate

1.27. Install (3) D0902274 Flexure Walls & (3) D0902278 L4C Walls on D0902279 1 StageBase Plate

Prep Work for D0902274 Flexure Walls:

Hardware:
(5) 3/8-16 x 2 DIA Helicoils
(6) 3/8-16 x 1.5 DIA Helicoils
(2) 3/8" x 1" dowel pins

- Install Nitronic 60 Helicoil threaded inserts into D0902274. See Figure 26.
- Press (2) 3/8" x 1" dowel pins into D0902274. Pins should sit about 0.4" above the surface.

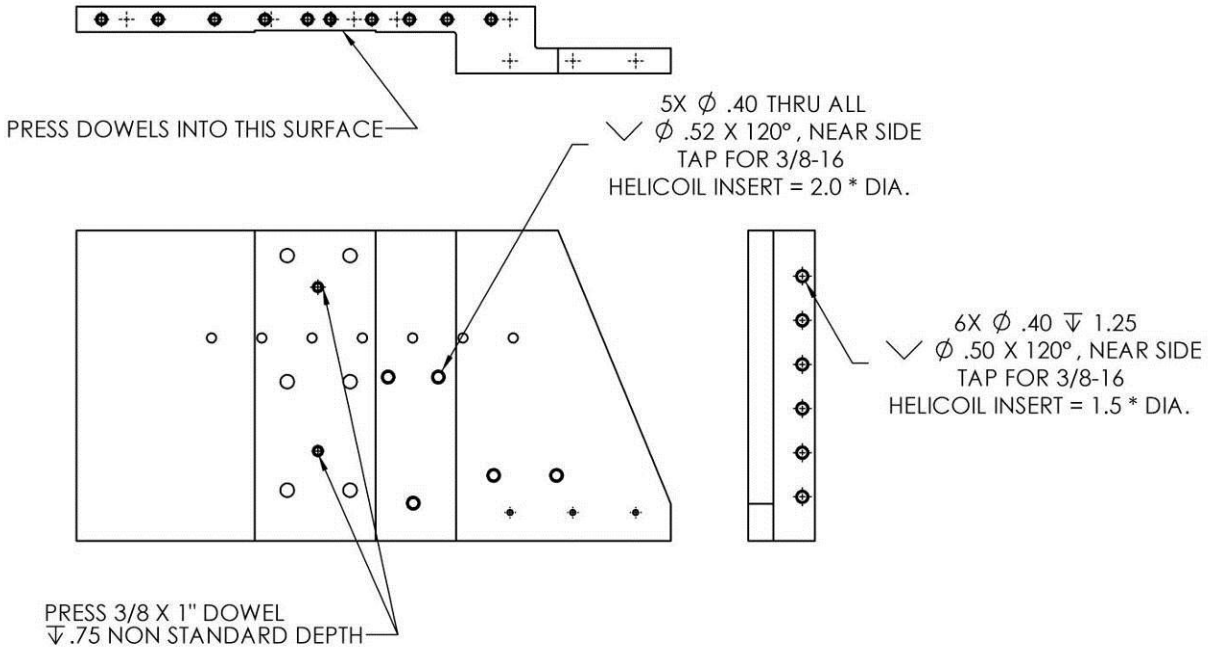


Figure 26: Prep Work for D0902274 Flexure Wall

Prep Work for D0902278 L4C Walls:

Hardware:
(10) 1/4-20 x 2 DIA Helicoils
(9) 3/8-16 x 1.5 DIA Helicoils
(2) 3/8-16 x 2 DIA Helicoils
(3) 3/8" x 1" dowel pins

- Install Nitronic 60 Helicoil threaded inserts into D0902278. See Figure 27.
- Press (3) 3/8" x 1" dowel pins into D0902278 (1 on top & 2 on the side, see Figure 27). Pins should sit about 0.4" above the surface.

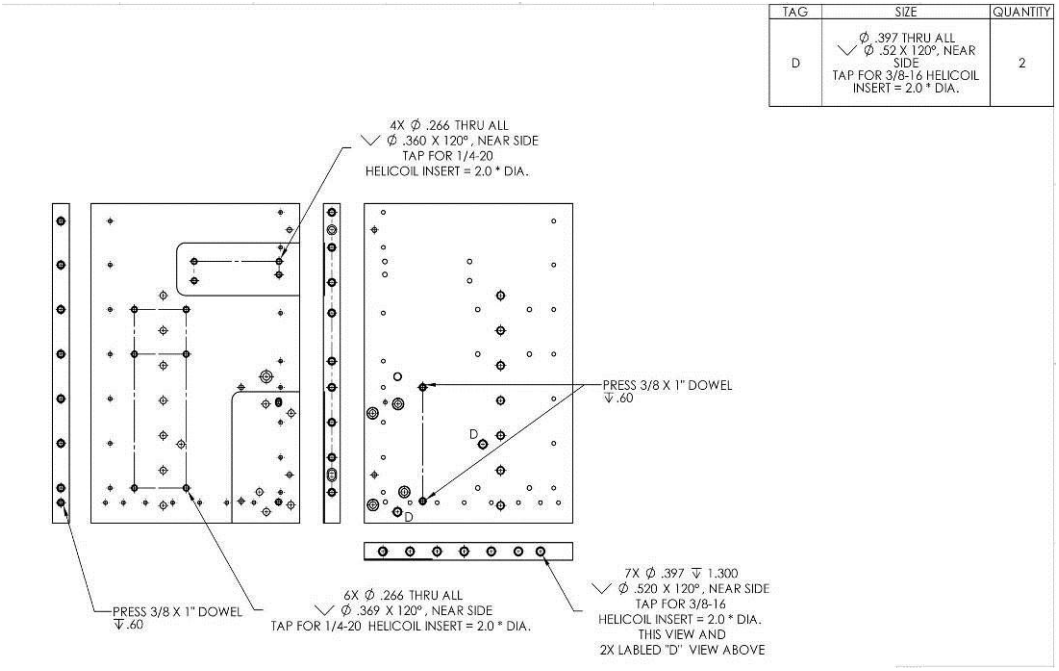


Figure 27: Prep Work for D0902278 L4C Wall

- Mount D0902274 Flexure Walls on the left of D0902279 Base Plate and D0902278 L4C Walls on the right (see Figure 28), locating all walls with dowel pins already installed. Make sure pins seat properly into mating hole and slot.

Hardware:
(21) 3/8-16 x 1.25" SHCS - MSC_75464644 – 12 for D0902274 & 9 for D0902278
(21) 3/8 Vented Washer - UCC-WFV-38 – 12 for D0902274 & 9 for D0902278

- Insert all screws from the bottom up.
- Snug them making sure there is no gap with D09002279 Base Plate.
- Then **torque screws up to 329 in.lbs (27 ft.lbs)**.
- Repeat this step for the 2 other corners.

Note: Check for good contact between D0902274 Flexure Walls & D0902278 L4C Walls, and D0902279 Stage 1 Base Plate, by attempting to slide a .001" thick gauge between them. If the gauge fits in between, untorque the bolts and redo step 1.29 all over.

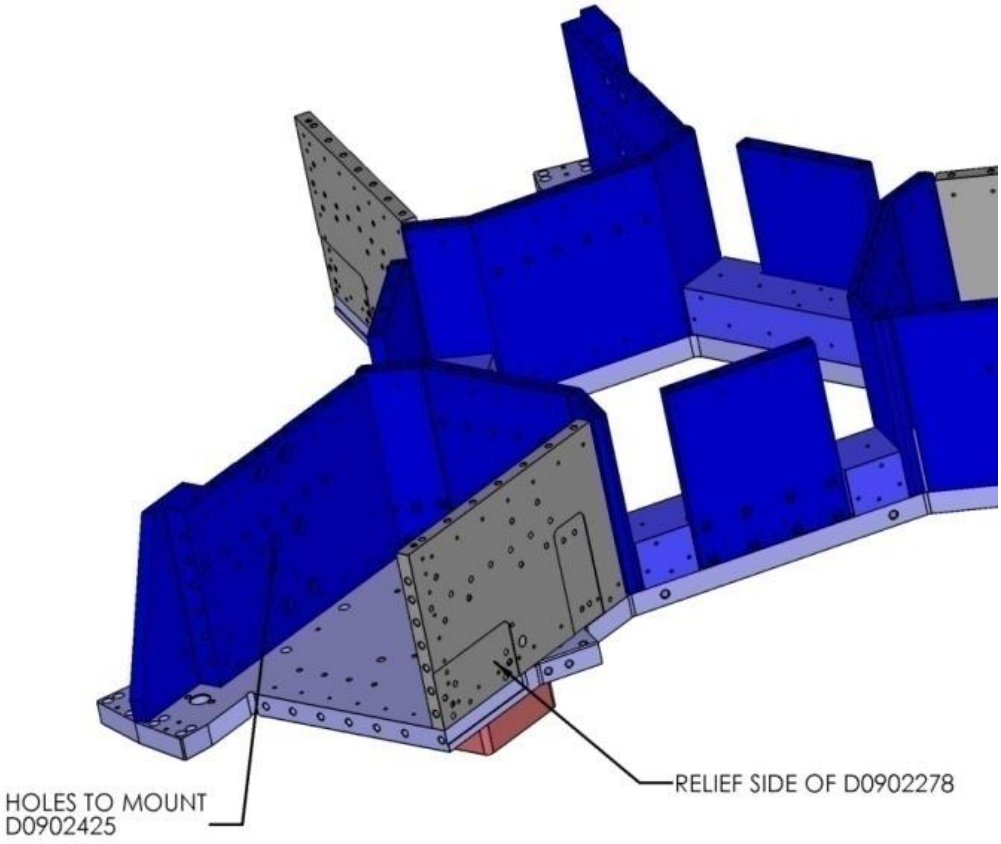


Figure 28: Position of D0902274 Flexure Walls & D0902278 L4C Walls on D0902279 Stage 1 Base Plate

1.28. Assembly: D0902425 Flexure Rod Bracket Assembly (Qty 3)

Quantity	Part Number	Description	Weight
3	D0902276	Flexure Rod Bracket	20 lbs
3	D0902277	Flexure Rod Gusset	11 lbs

Prep Work for D0902276 Flexure Rod Bracket:

Hardware:
(4) 3/8-16 x 2 DIA Helicoils

- Install Nitronic 60 Helicoil threaded inserts into D0902276. See Figure 29.

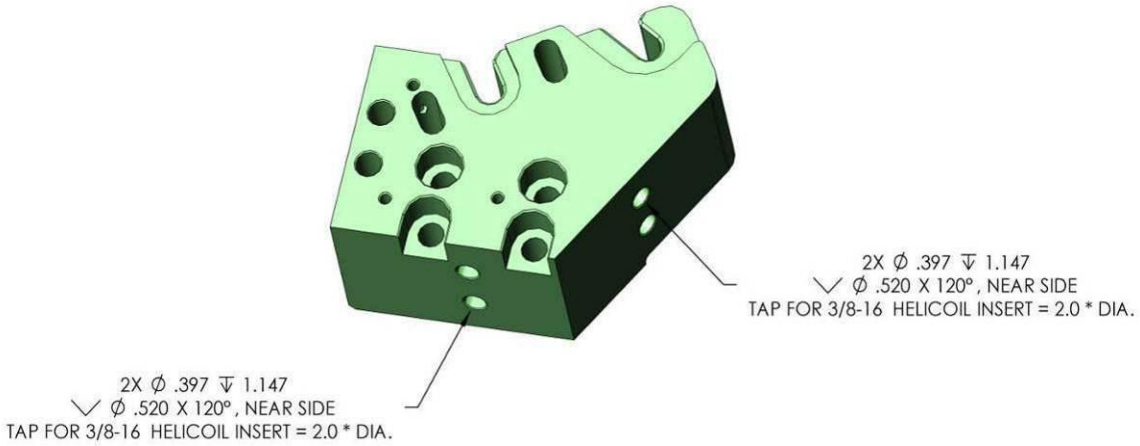


Figure 29: Prep Work for D0902276 Flexure Rod Bracket

Prep Work for D0902277 Flexure Rod Gusset:

Hardware:
(6) 5/16-18 x 2 DIA Helicoils
(1) 3/8" x 1" dowel pins

- Install Nitronic 60 Helicoil threaded inserts into D0902277. See Figure 30.
- Press (1) 3/8" x 1" dowel pins into D0902277. Pins should sit about 0.4" above the surface.

Note: This Part is made of Stainless Steel and therefore, all the bolts which will be bolted in it MUST be Silver Plated!

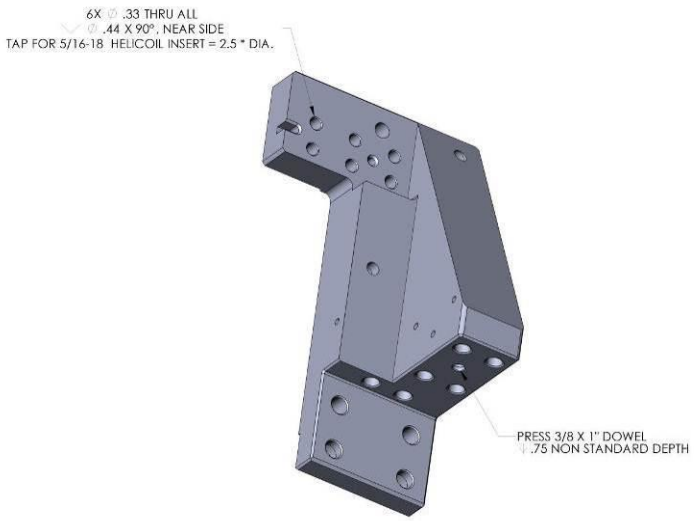
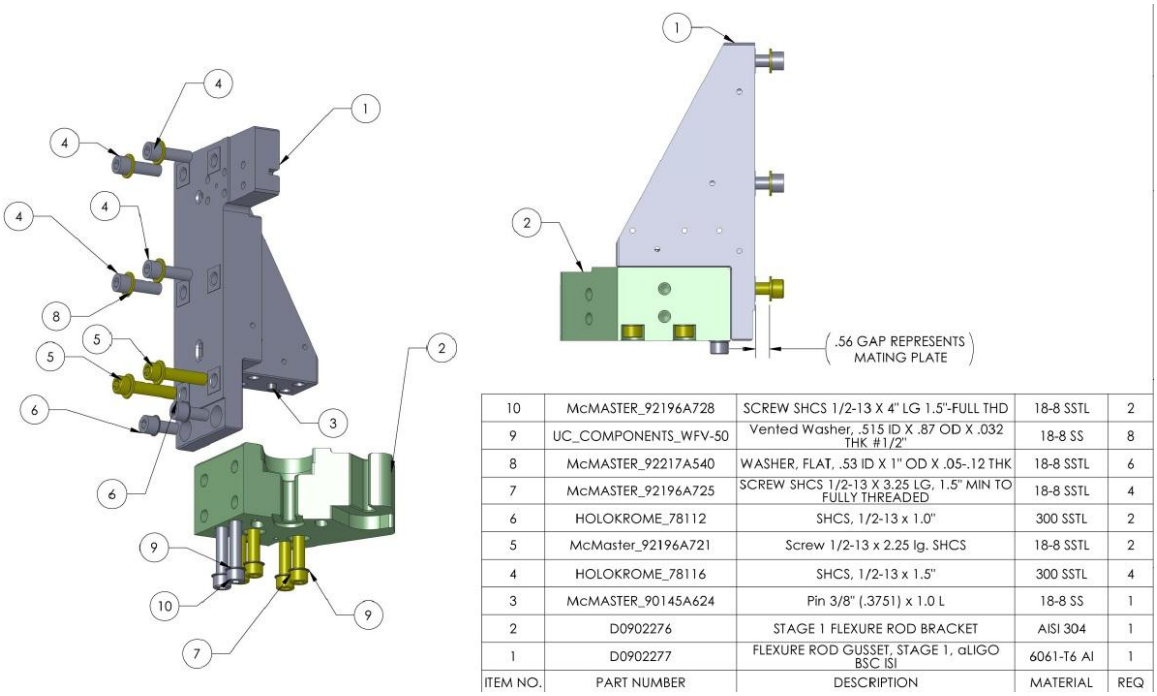


Figure 30: Prep Work for D0902277 Flexure Rod Gusset

Hardware:
(2) 1/2-13 x 4" SHCS (1.5" Full Thd) – MSC 05684402
(4) 1/2-13 x 3.25" SHCS – McMaster 92196A725
(2) 1/2-13 x 1" Ag-Plated SHCS – D1102183
(8) 1/2" Vented Washers - UCC-WFV-50

- Assemble D0902425 Flexure Rod Bracket Assembly by mounting D0902276 & D0902277 together using the pin located on D0902277 as shown on Figure 31.
- Insert all the screws, snug them and then **torque the 1/2-13 x 1" SHCS to 805 in.lbs (67.1 ft.lbs) and torque the 1/2-13 x 4" SHCS & the 1/2-13 x 3.25" SHCS to 517 in.lbs (43.1 ft.lbs).**



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ
10	McMASTER_92196A728	SCREW SHCS 1/2-13 X 4" LG 1.5"-FULL THD	18-8 SSTL	2
9	UC_COMPONENTS_WFV-50	Vented Washer, .515 ID X .87 OD X .032 THK #1/2"	18-8 SS	8
8	McMASTER_92217A540	WASHER, FLAT, .53 ID X 1" OD X .05-.12 THK	18-8 SSTL	6
7	McMASTER_92196A725	SCREW SHCS 1/2-13 X 3.25 LG, 1.5" MIN TO FULLY THREADED	18-8 SSTL	4
6	HOLOKROME_78112	SHCS, 1/2-13 x 1.0"	300 SSTL	2
5	McMaster_92196A721	Screw 1/2-13 x 2.25 lg. SHCS	18-8 SSTL	2
4	HOLOKROME_78116	SHCS, 1/2-13 x 1.5"	300 SSTL	4
3	McMASTER_90145A624	Pin 3/8" (.3751) x 1.0 L	18-8 SS	1
2	D0902276	STAGE 1 FLEXURE ROD BRACKET	AISI 304	1
1	D0902277	FLEXURE ROD GUSSET, STAGE 1, aLIGO BSC ISI	6061-T6 Al	1

Figure 31: Assembly drawing D0902425 Flexure Rod Bracket Assembly

1.29. Attach D0902425 Flexure Rod Assembly to D0902274 Flexure Walls

Hardware:
(4) 1/2-13 x 1.5" SHCS – MSC 75464842
(2) 1/2-13 x 2.25" Ag-Plated SHCS – D1102184
(6) 1/2" Flat Washers – McMaster 92217A540

- Mount D0902425 Flexure Rod Assembly to D0902274 Flexure Wall using the dowel pins in D0902425 to locate D0902425 Flexure Rod Assembly as shown on Figure 32. Make sure pins seat properly into mating hole and slot.
- Insert the screws as shown on Figure 28 & Figure 31.
- Snug them and **torque the 1/2-13 x 1.5" SHCS to 805 in.lbs (67.1 ft.lbs) and torque the 1/2-13 x 2.25" SHCS to 517 in.lbs (43.1 ft.lbs).**

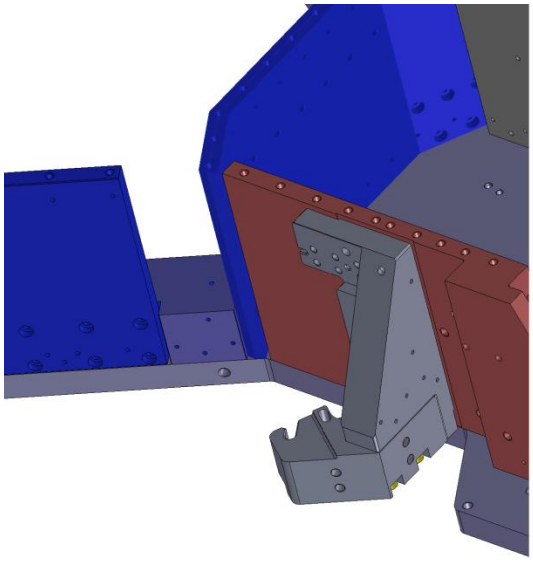


Figure 32: D0902425 Flexure Assembly mounted on D0902274 Flexure Wall

1.30. Lift Stage 1 to Assembly Stand:

Note: There are (3) 1/2-13 tapped holes in D0902279 Stage 1 Base plate available for lifting as shown in Figure 33.

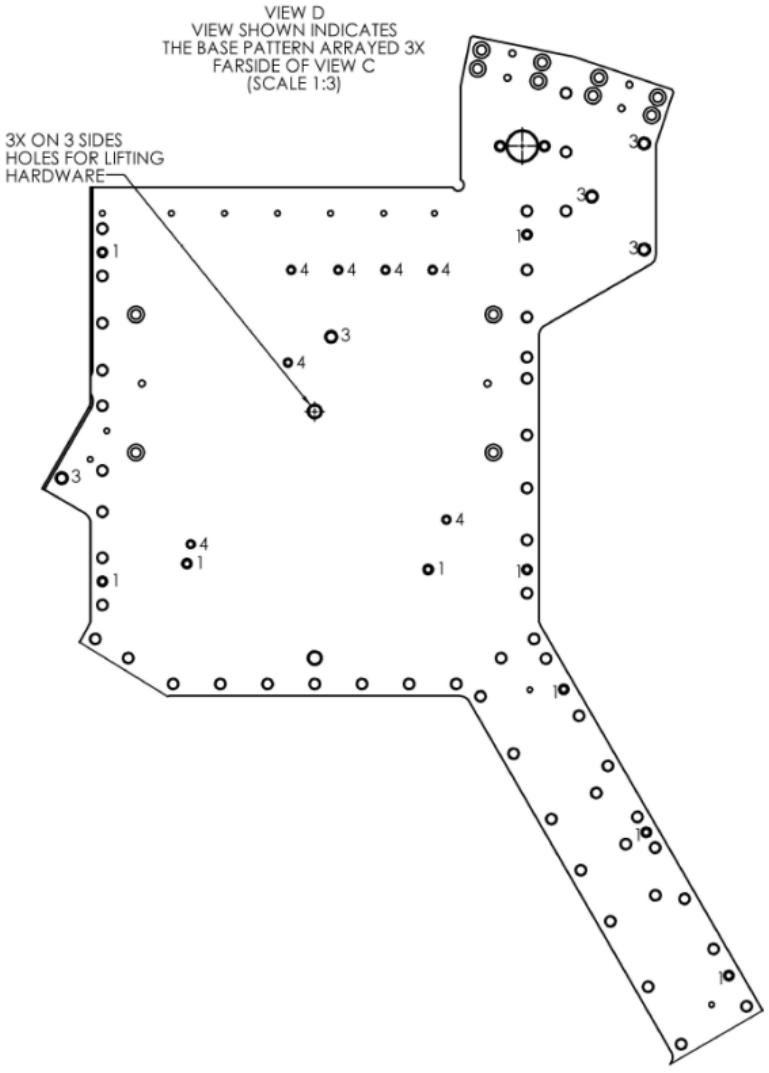
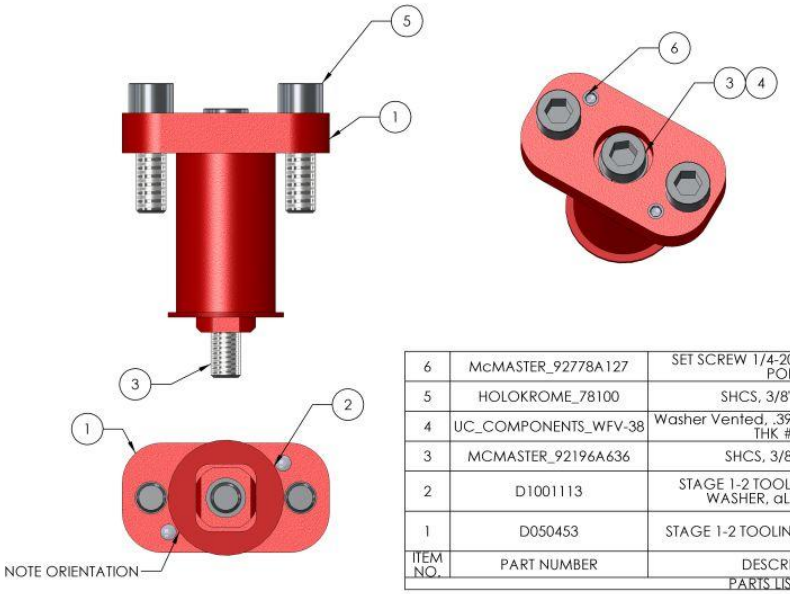


Figure 33: Locations of the (3) 1/2-13 tapped holes on D0902279 used for the lifting of Stage 1

1.31. Assembly D1001112 Stage 1-2 Tooling Standoff Pin Assembly

Hardware:
(2) 3/8-16 x 1.25" SHCS – MSC 75464644
(1) 3/8 Vented Washer - UCC-WFV-38
(1) 3/8-16 x 3" SHCS – MSC 05682307
(2) Set Screw 1/4-20 x 0.5" Oval Point – MSC 64102023

- Assemble D1001110 as shown on Figure 34.



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ
6	McMASTER_92778A127	SET SCREW 1/4-20 X 1/2 LG OVAL POINT	18-8 SSTL	2
5	HOLOKROME_78100	SHCS, 3/8"-16x1.25"	18-8 SS	2
4	UC_COMPONENTS_WFV-38	Washer Vented, .39 ID X .62 OD X .032 THK #3/8"	18-8 SS	1
3	MCMASTER_92196A636	SHCS, 3/8"-16x3.0"	18-8 SS	1
2	D1001113	STAGE 1-2 TOOLING STANDOFF WASHER, aLIGO BSC ISI	304, 316 OR 302 SSTL	1
1	D050453	STAGE 1-2 TOOLING STANDOFF PIN	17-4 PH SSTL, H 1150	1

PARTS LIST

Figure 34: Assembly drawing of D1001112 Stage 1-2 Tooling Standoff Pin

- Attach (3) D1001112 Stage 1-2 Tooling Standoff Pin Assembly to D0902279 Stage 1 Base Plate with (2) 3/8-16 x 1.25" SHCS & (3) 3/8 Vented Washers. **Torque these bolts up to 329 in.lbs (27 ft.lbs)** (See Figure 35).
- Repeat this step for the 2 other D1001112 Stage 1-2 Tooling Standoff Pin Assemblies.

Note: the use of oval point set screws to prevent the surfaces of D1001112 & D0902279 from marring, when the pins are later removed. These screws do not have to be inserted until we remove D1001112 Stage 1-2 Alignment Pin Assemblies.

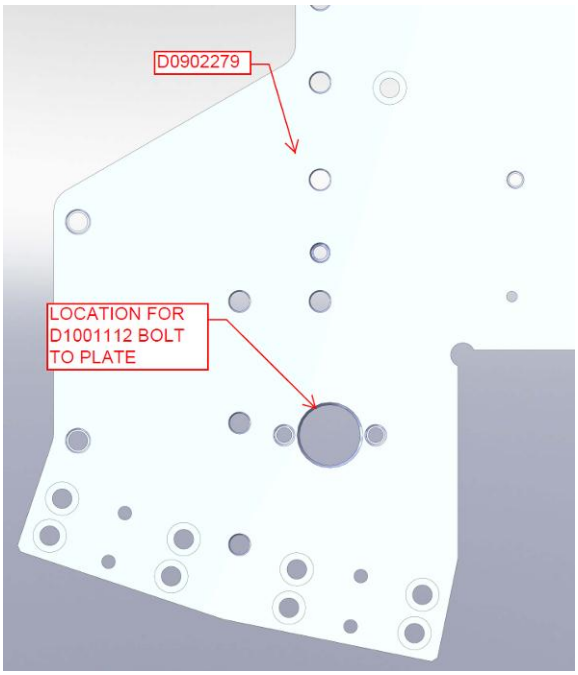


Figure 35: Location for D1001112 Stage 1-2 Tooling Standoff Pin on D0902279 Stage 1 Base Plate

Assemble D0901180 Stage 1 to Optical Plates

1.32. Align D1001112 Tooling Standoff Assemblies to datum areas on D0901517, Identified by red arrows.

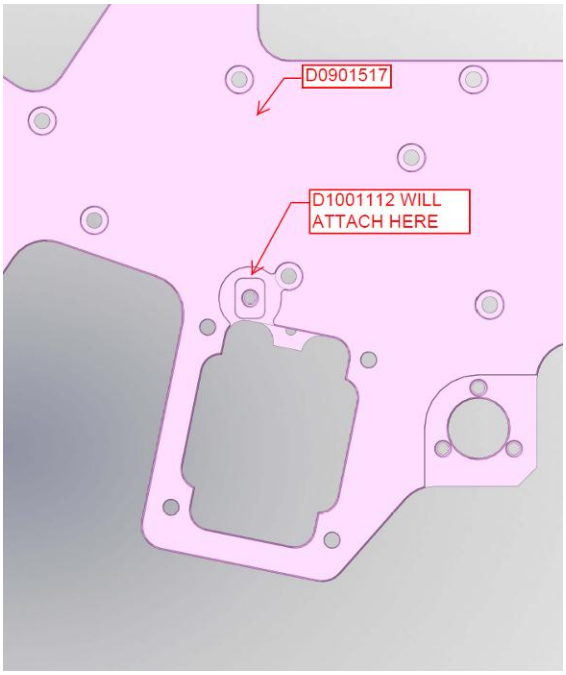


Figure 36: Location for D1001112 Stage 1-2 Tooling Standoff Pin on D0901517 Cut-Out Optical Table

- Set D1001113 Stage 1-2 Tooling Standoff Washers (item 2 on Figure 34) onto Stage 2 holes shown on Figure 36. These holes are used to locate Stage 1 onto the Optical Tables with the D1001112 Stage 1-2 Tooling Standoff Pins.
- As Stage 1 is moved to the assembly stand and lowered onto the Optical Tables, the positioning pins will be lowered onto markers on these Optical Tables.
- Slide screws through the tower and attach pins to the Optical Tables using (1) 3/8-16 x 3" SHCS & (1) 3/8 vented washer per post.
- **Torque (3) 3/8-16 x 3" SHCS up to 329 inch-lbs (27 ft-lbs).**

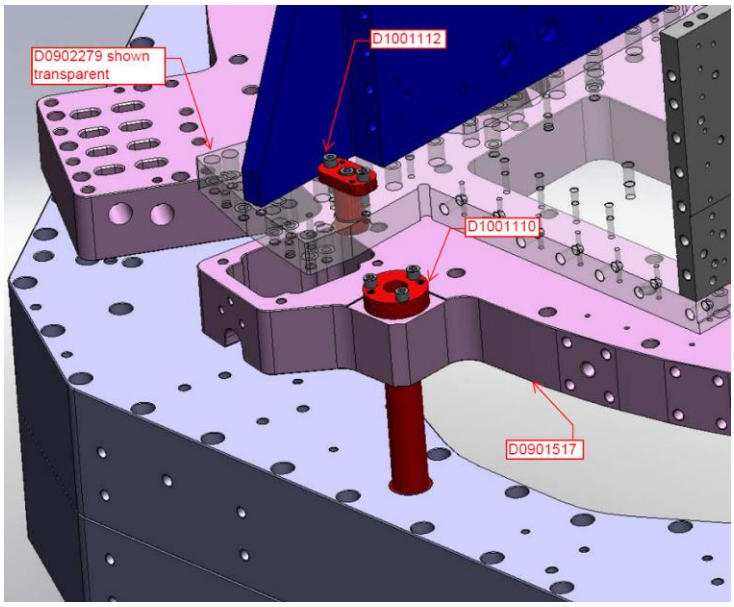


Figure 37: Final location of D1001112 and D1001110

1.33. Mounting Stage 1 to Stage 0

- Attach D1001112 Stage 1-2 Tooling Standoff Pin Assembly to D0901517 Cut-Out Optical Table by sliding the screw through D050453 Tooling Standoff Pin and threading it into D0901517 (using (1) 3/8”-16 x 3” SHCS, item 3 on Figure 34) as shown Figure 37.

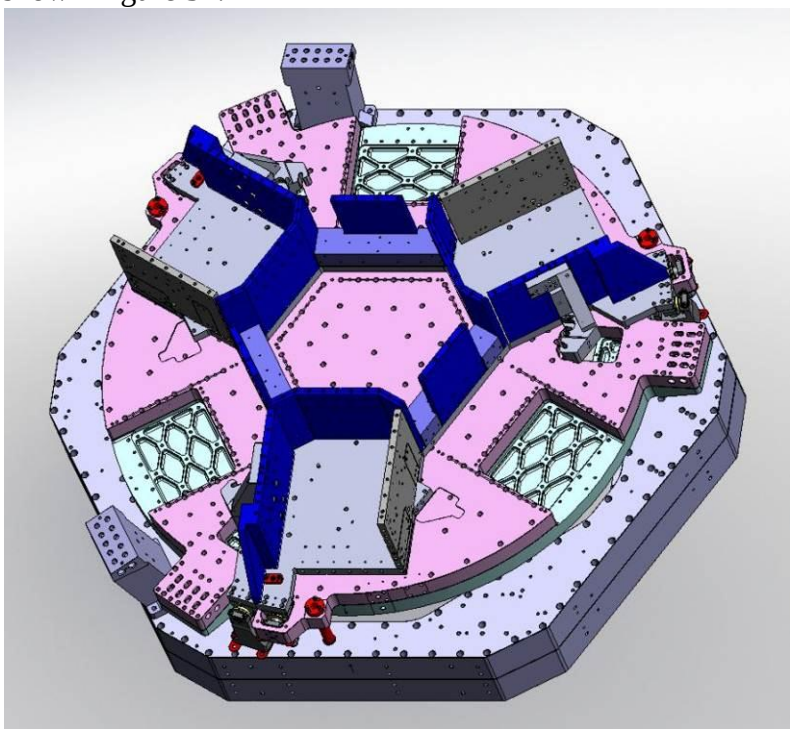


Figure 38: Starting point for Stage 2 Assembly at this point

Assemble Lockers to Stage Lockers preassembled:

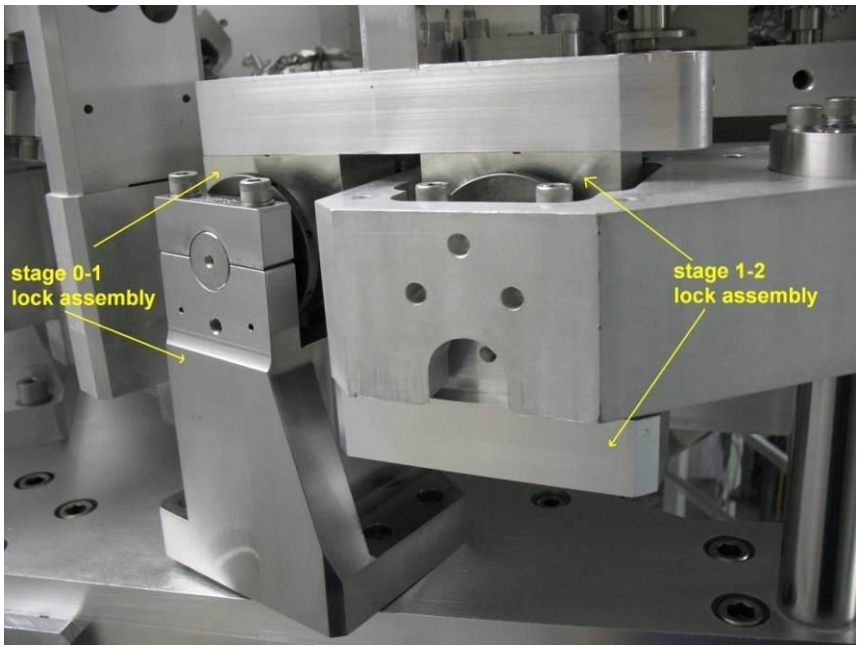


Figure 39: Lockers Assemblies

Note: To do the following steps, D1000854 Stage 0-1 Locker & D1000855 Stage 1-2 Locker must be already assembled like described in the following document E1000615-V2.

Note: **Insert (4) D1002380 Stage 1-2 Barrel Nut Bars in sides of on D0901517 Cut-Out Optical Table as shown on Figure 95 because D1000854 Stage 0-1 Lockers will be in the way.**

1.34. Position and attach D1000855 Stage 1-2 Locker Assembly to the bottom of D0902279 Stage 1 Base Plate & D0901517 Cut Out Optical Plate as shown on Figure 40 and Figure 40.

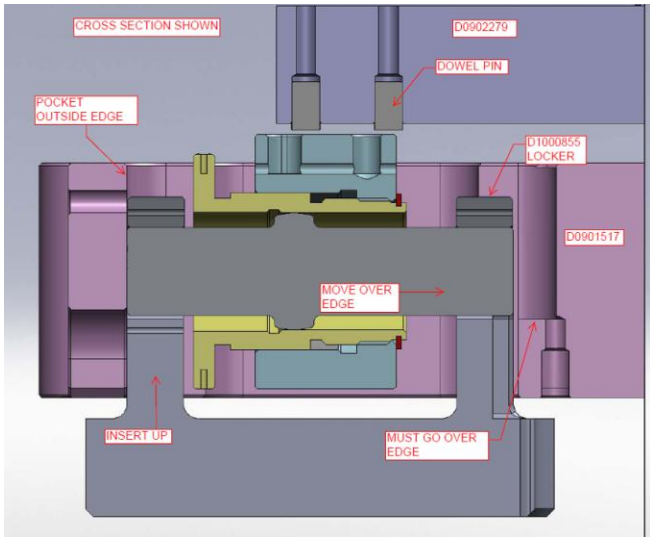


Figure 40: Cross Section of D1000855 Stage 1-2 Locker Assembly Installation 1/2

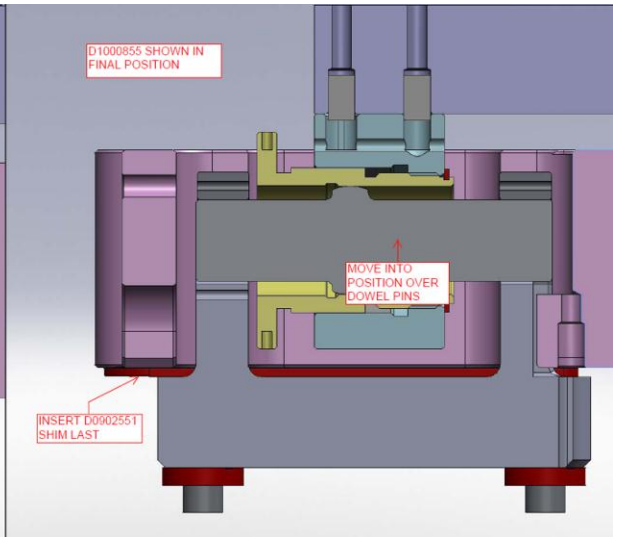


Figure 41: Cross Section of D1000855 Stage 1-2 Locker Assembly Installation 2/2

- Insert upwards D1000855 Stage 1-2 Lockers Assembly along the pocket on the outside edge of D0901517 Cut Out Optical Table as shown on Figure 40 & Figure 40.

Note: Insert it until it can't go up any further. This means that the top of D1000908 Housing Locker Sleeve is in contact with the dowel pins already installed in D0902279 Stage 1 Base Plate (see Figure 40).

- Move D1000855 Stage 1-2 Locker Assembly horizontally, over the edge (lip) of D0901517 until it can't go any further. D1000908 Housing Locker Sleeve will now be positioned relatively to the dowel pins that extend .09" from D0901517 bottom surface.

  Hardware:
  (4) 3/8-16 x 1.375" SHCS – McMaster 92196A627
  (4) 3/8 Vented Washer - UCC-WFV-38

- Once D1000908 is in position insert screws from the top through D0902279 into D10009080 to lift and secure D1000855 Stage 1-2 Locker Assembly to the bottom of D0902279. Snug and **torque to 236 in lbs (19.7 ft lbs).**
- Measure the gap above D1000855 Locker and apply the equivalent shim thickness of D0902551 Stage 1-2 Locker Base Shim Spacer.

Note: There are 20 of them and range from a thickness of .110" to .130". **Before measuring the gap & adding the shims, make sure D1000855 Stage 1-2 Locker is in locked position!**

Hardware:
(4) 3/8-16 x 2.75" SHCS – MSC 05682273
(4) Washer Adjustable Feet – D047942

- Make sure D1000855 Locker is locked (D1000875 Stage 1-2 Locker Sleeve is all the way towards the outside of the BSC-ISI).
- Insert screws from below through D1000873 Stage 1-2 Locker Post and into D0901517 Cut Out Optical Table and leave them loose to help with alignment.
- Fill the gap between D1000855 Locker and D0901517 Cut Out Optical Table with the biggest shim thickness of D0902551 Stage 1-2 Locker Base Shim Spacer that will fit in there.

Note: There are 20 of them and range from a thickness of .110" to .130". **Before measuring the gap & adding the shims, make sure D1000855 Stage 1-2 Locker is in locked position!**

- Once you've determined this thickness, slide (2) D0902551 Stage 1-2 Locker Base Shim Spacers 0.001" thinner than the thickness determined in the previous step.

Note: Make sure the bottom part of the Locker is not crooked by moving it around in every direction.

- Use shims as shown on Figure 42 to make sure that the bottom part of the Locker and the top part are parallel to each other.
- Tighten bolts while rotating D1000875 Stage 1-2 Locker Sleeve, to align Locker horizontally.
- Make sure D1000875 moves freely when the bolts are tight.

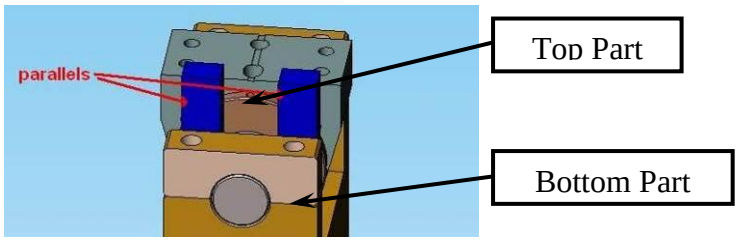


Figure 42: Using Shims to make sure the Bottom Part of the Locker is parallel to the Top Part

- **Snug and torque them to 236 in lbs (19.7 ft lbs).**
- Repeat these steps for the (2) other D1000855 Stage 1-2 Locker Assemblies.

1.35. Attach D1000854 Stage 0-1 Locker Assemblies the bottom of D0902279 Stage 1 Base Plate & the top of D0900895 Top Part of Stage 0 as shown Figure 43 & Figure 43.

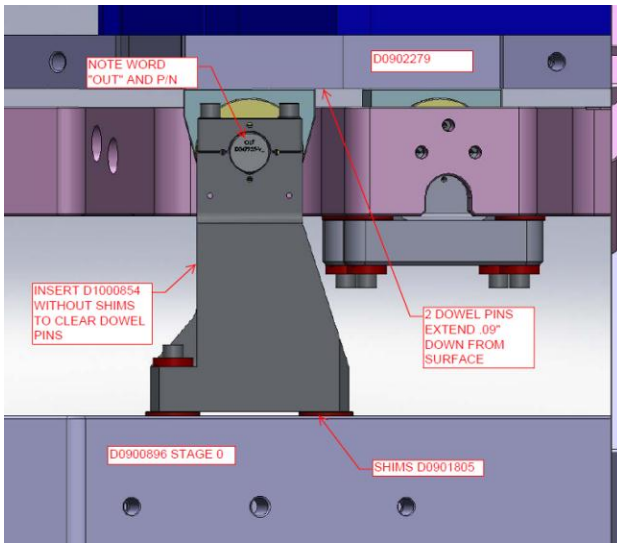


Figure 43: D1000854 Stage 0-1 Locker Assembly Installation 1/2

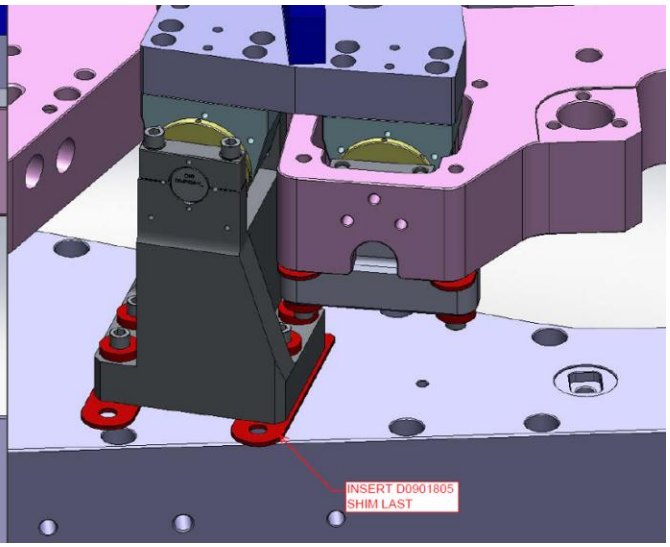


Figure 44: D1000854 Stage 0-1 Locker Assembly Installation 2/2

- Position D1000854 Stage 0-1 Lockers Assembly using the alignment pins already in D0902279 Stage 1 Base Plate. They extend .09" from the bottom surface.
- Insert it by sliding along D0900896 Stage 0.

Note: There is only .03 inches nominal clearance between D1000854 Stage 0-1 Locker Assembly and dowel pins extending down from D0902279.

Hardware:
(4) 3/8-16 x 1.375" SHCS – McMaster 92196A627
(4) 3/8 Vented Washer - UCC-WFV-38

- Once D1000854 is in position, insert screws, snug them and **torque to 236 in lbs (19.7 ft lbs)** to lift and secure to the bottom of D0902279 Stage 1 Base Plate.
- Measure the gap under D1000854 Stage 0-1 Locker Assembly and apply the equivalent shim thickness of D0901805 Stage 0-1 Locker Base Shim Spacer.

Note: There are 20 of them and range from a thickness of .110" to .130". **Before measuring the gap & adding the shims, make sure D1000855 Stage 1-2 Locker is in locked position!**

Hardware:
(4) 3/8-16 x 2.75" SHCS – MSC 05682273
(4) Washer Adjustable Feet – D047942

- Make sure D1000854 Locker is locked (D1000860 Stage 0-1 Locker Sleeve is all the way towards the outside of the BSC-ISI).
- Insert screws from top through D1000861 Stage 0-1 Locker Post into D0900895 Top Part of Stage 0 and leave them loose to help with alignment.

- Fill the gap between D1000854 Locker and D0900895 Top Part of Stage 0 with the biggest shim thickness of D0901805 Stage 0-1 Locker Base Shim Spacer that will fit in there.
- Once you've determined this thickness, slide (2) D0901805 Stage 0-1 Locker Base Shim Spacers 0.001" thinner than the thickness determined in the previous step.

Note: Make sure the bottom part of the Locker is not crooked by moving it around in every direction.

- Use shims as shown on Figure 45to make sure that the bottom part of the Locker and the top part are parallel to each other.
- Tighten bolts while rotating D1000860 Stage 0-1 Locker Sleeve, to align Locker horizontally.
- Make sure D1000860 moves freely when the bolts are tight.

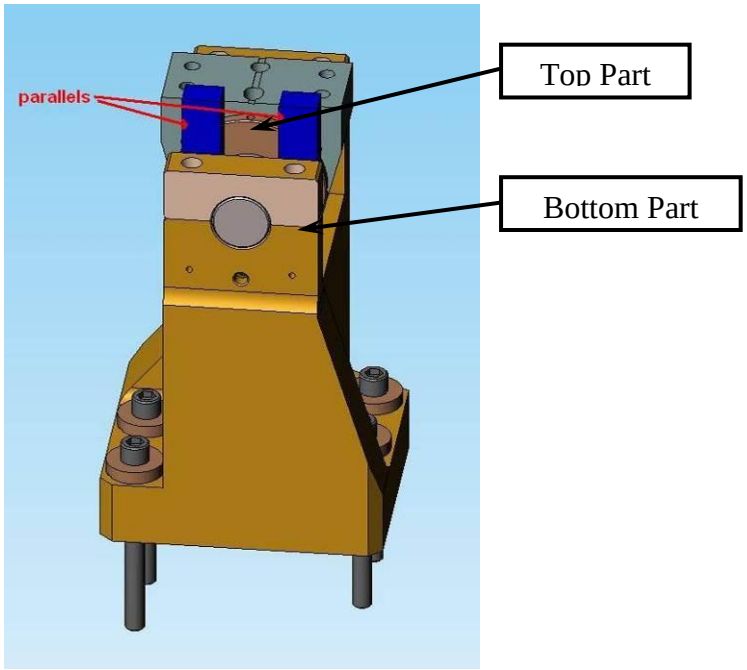


Figure 45: Using Shims to make sure the Bottom Part of the Locker is parallel to the Top Part

- **Snug and torque them to 236 in lbs (19.7 ft lbs).**
- Repeat these steps for the (2) other D1000854 Stage 0-1 Locker Assemblies.

Continue Assembly of Stage 2

Parts required:

Quantity	Part Number	Description	Weight
3	D0901521	Radial Left Wall	16
3	D0901523	Tangential Wall	8
3	D0901522	Radial Right Wall	15
3	D0901524	Larger Lower Hex Wall	10
3	D0901525	Small Lower Hex Wall	3
6	D0901538	Bracket Hex Wall	0.6
1	D0901520	Mid-Plate	245
6	D0902133	Hex Wall Gusset	2
3	D0901526	Large Upper Hex Wall	10
3	D0901530	Adapter Large Hex	3
3	D0901528	Small Upper Hex Wall	5
3	D0901531	Adapter Small Hex	2
3	D0901533	Upper Outer Wall	13

Stage 2 lower half assembly:

1.36. Attach D0901521 Radial Left Walls to the Optical Table

Prep Work for D0901521 Radial Left Walls:

Hardware:
(2) 1/4-20 x 2 DIA Helicoils
(2) 3/8-16 x 1 DIA Helicoils
(2) 3/8-16 x 2 DIA Helicoils
(2) 1/4" x 5/8 dowel pins
(1) 3/8" x 1" dowel pin
(1) 3/8" x 2" THREADED dowel pin

- Install Nitronic 60 Helicoil threaded inserts into D0901521. See Figure 46.
- Press (2) 1/4" x 5/8" dowel pins into D0901521. Pins should sit about 0.25" above the surface.
- Press (1) 3/8" x 1" dowel pins into D0901521. Pins should sit about 0.4" above the surface.
- Press (1) 3/8" x 2" dowel pins into D0901521. Pins should sit about 0.4" above the surface. The threaded side should be facing us on the bottom view on Figure 46.

Note: This last pin will be used to locate the Horizontal GS-13, and will be removed once the GS-13 will be attached to D0901521.

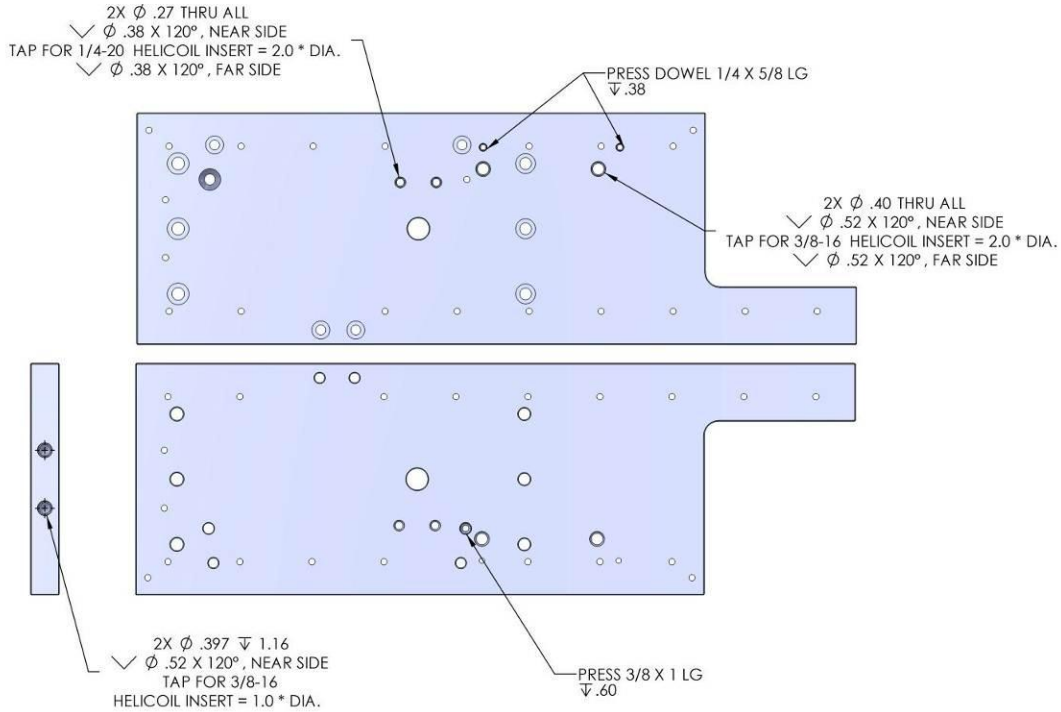


Figure 46: Prep Work for D0901521 Radial Left Wall

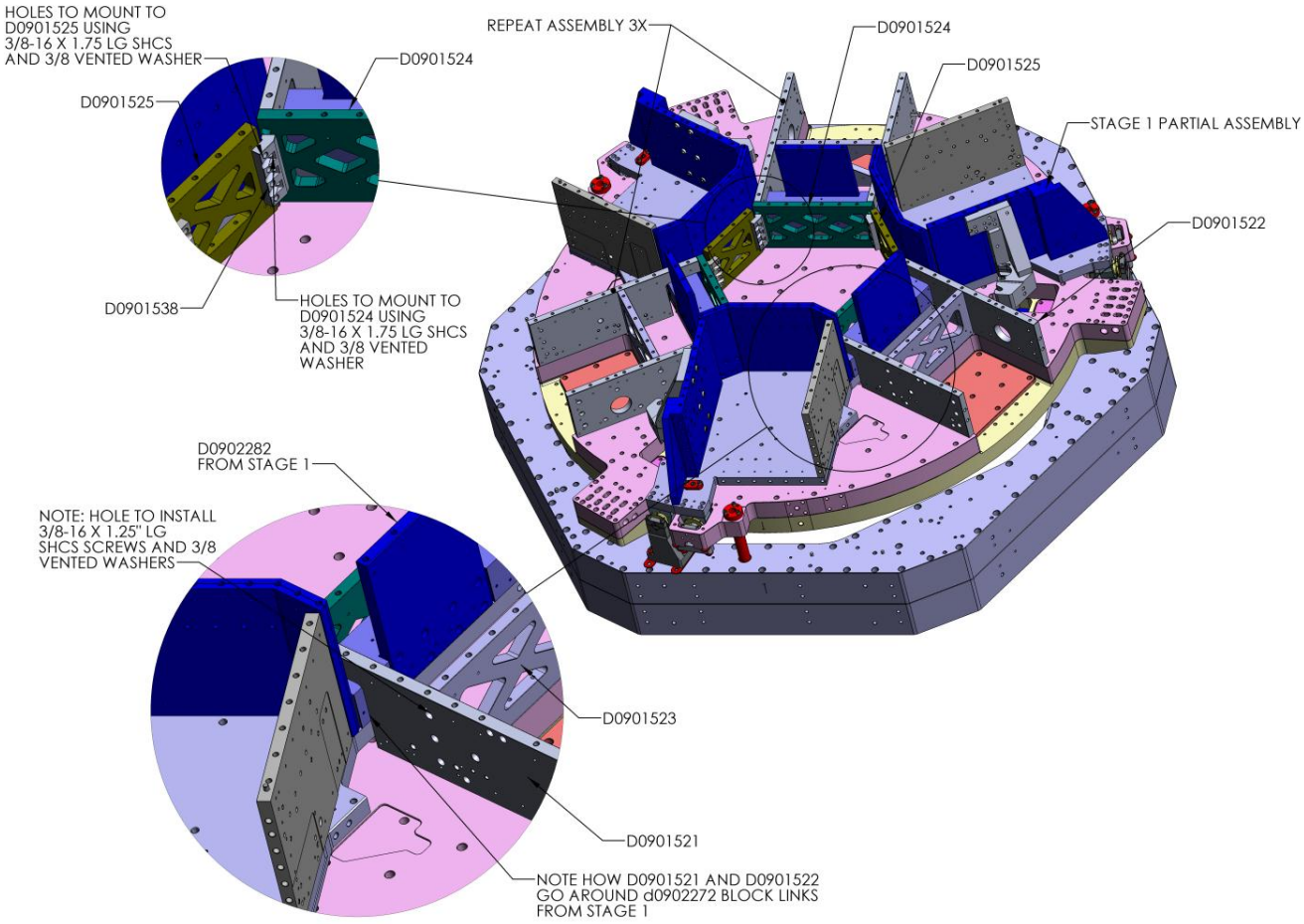


Figure 47: Location of Stage 2 Walls on the Partial Assembly

Hardware:
(7) 3/8-16 x 2" SHCS – MSC 75464701
(7) 3/8 Vented Washers - UCC-WFV-38

- Locate D0901521 Radial Left Wall onto the D0901517 Cut-Out Optical Table with the (2) pins already installed in D0901517 (see Figure 47). Make sure pins seat properly into mating hole and slot.
- Insert all the screws from below (through the Optical Table) into D0901521 Radial Left Wall.
- Snug them and **torque them to 329 in.lbs (27 ft.lbs).**
- Repeat this step for the (2) other D0901521 Radial Left Wall.

1.37. Attach D0901523 Tangential Walls to the Optical Table and to D0901521 Radial Left Wall.

- Locate D0901523 Tangential Wall onto the D0901517 Cut-Out Optical Table with the (2) pins already installed in D0901517 (see Figure 47). Make sure pins seat properly into mating hole and slot.

Hardware:

(3) 3/8-16 x 1.25" SHCS – MSC 75464644 – to connect to D0901521 Radial Left Wall

(6) 3/8-16 x 2" SHCS – MSC 75464701 – to connect to D0901517 Cut-Out Optical Table

(9) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws from below (through D0901517 Cut-Out Optical Table) into D0901523 Tangential Wall. Insert all the screws from the side (through D0901521 Radial Left Wall).
- Snug them and **torque them to 329 in.lbs (27 ft.lbs).**
- Repeat this step for the (2) other D0901523 Tangential Wall.

Note: some of the screw holes are obstructed see Figure 48.

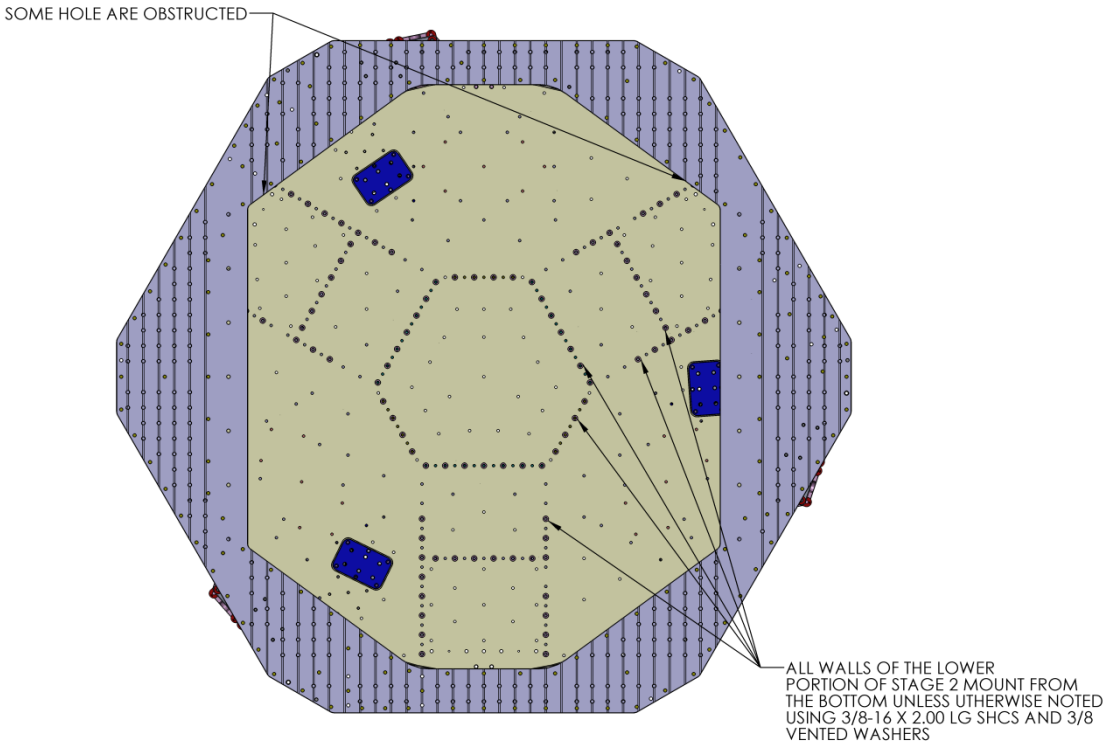


Figure 48: View of the Assembly from below showing the obstructed holes to attach D0901523 Tangential Wall to the Optical Table

1.38. Attach D0901522 Radial Right Walls to D0901523 Tangential Wall & D0901517 Cut-Out Optical Table.

Prep Work for D0901522 Radial Right Walls:

Hardware:
(2) 3/8-16 x 1 DIA Helicoils
(1) 3/8" x 1" dowel pin

- Install Nitronic 60 Helicoil threaded inserts into D0901522. See Figure 49.
- Press (1) 3/8" x 1" dowel pins into D0901521. Pins should sit about 0.4" above the surface.

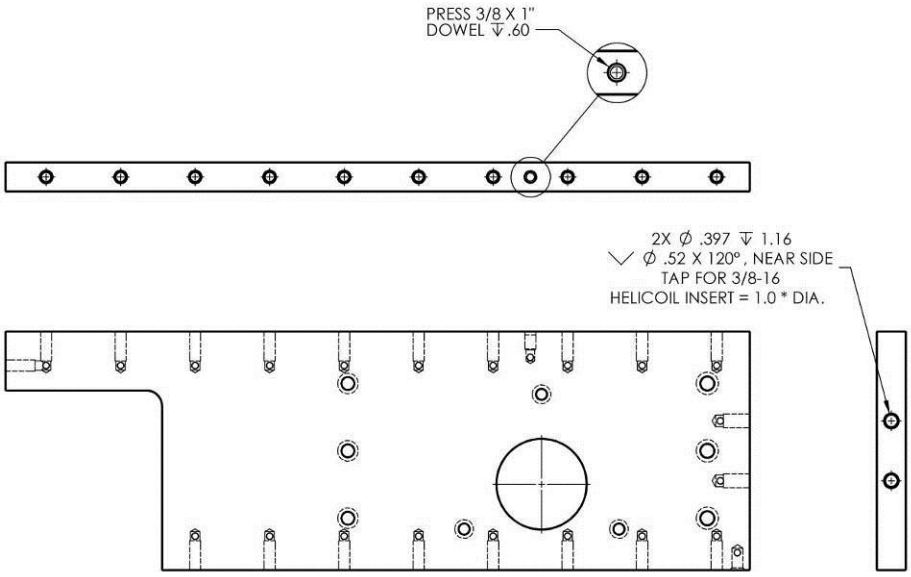


Figure 49: Prep Work for D0901522 Radial Right Wall

- Locate D0901522 Radial Right Wall onto the D0901517 Cut-Out Optical Table with the (2) pins already installed in D0901517 (see Figure 47). Make sure pins seat properly into mating hole and slot.

Hardware:
(3) 3/8-16 x 1.25" SHCS – MSC 75464644 – to connect to D0901523 Tangential Wall
(8) 3/8-16 x 2" SHCS – MSC 75464701 – to connect to D0901517 Cut-Out Optical Table
(11) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws from below (through D0901517 Cut-Out Optical Table) into D0901522 Radial Right Wall. Insert all the screws from the side (through D0901522 Radial Right Wall itself) into D0901523 Tangential Wall.
- Snug them and **torque them to 329 in.lbs (27 ft.lbs).**
- Repeat this step for the (2) other D0901522 Radial Right Wall.

1.39. Attach D0901524 Larger Lower Hex Walls.

- Locate D0901524 Larger Lower Hex Wall onto the D0901517 Cut-Out Optical Table with the (2) pins already installed in D0901517 (see Figure 47). Make sure pins seat properly into mating hole and slot.

Hardware:

(2) 3/8-16 x 1.25" SHCS – MSC 75464644 – to connect to D0901522 Radial Right Wall & to D0901523 Radial Left Wall

(7) 3/8-16 x 2" SHCS – MSC 75464701 – to connect to D0901517 Cut-Out Optical Table

(9) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws from below (through D0901517 Cut-Out Optical Table) into D0901524 Larger Lower Hex Wall. Insert all the screws from the side (through D0901522 Radial Right Wall & D0901523 Radial Left Wall).
- Snug them and **torque them to 329 in.lbs (27 ft.lbs).**
- Repeat this step for the (2) other D0901524 Larger Lower Hex Wall.

1.40. Attach D0901525 Small Lower Hex Walls to D0901517 Cut-Out Optical Table.

Hardware:
(4) 3/8-16 x 2" SHCS – MSC 75464701
(4) 3/8 Vented Washers - UCC-WFV-38

- Locate D0901525 Small Lower Hex Wall onto the D0901517 Cut-Out Optical Table with the (2) pins already installed in D0901517 (see Figure 47). Make sure pins seat properly into mating hole and slot.
- Insert all the screws from below (through D0901517 Cut-Out Optical Table) into D0901525 Small Lower Hex Wall.
- Snug them and **torque them to 329 in.lbs (27 ft.lbs).**
- Repeat this step for the (2) other D0901525 Small Lower Hex Wall.

1.41. Attach D0901524 Larger Lower Hex Walls & D0901525 Small Lower Hex Walls together using (6) D0901538 Bracket Hex Walls.

Hardware:
(7) 3/8-16 x 1.5" SHCS – MSC 75464669
(7) 3/8 Vented Washers - UCC-WFV-38

- Locate D0901538 Bracket Hex Wall between D0901524 Larger Lower Hex Wall & D0901525 Small Lower Hex Wall as shown on Figure 47.
- Insert all the screws through D0901538 Bracket Hex Wall itself into D0901524 Larger Lower Hex Walls & D0901525 Small Lower Hex Walls.
- Leave D0901538 Bracket Hex Wall loosely attached to the assembly.
- Repeat this step for the (5) other D0901538 Bracket Hex Wall.
- Once all the (6) D0901538 Bracket Hex Walls are loosely attached to the assembly, snug them all and **torque them to 329 in.lbs (27 ft.lbs).**

1.42. Add D0901520 Stage 2 Mid Plate.

Note: side with vent slots facing down as shown on Figure 50 & Figure 51.

Prep Work for D0901520 Stage 2 Mid Plate:

Hardware:
(9) 1/4-20 x 2 DIA Helicoils
(15) 3/8-16 x 2 DIA Helicoils
(6) 1/4" x 5/8 dowel pins
(30) 3/8" x 1" dowel pin
(3) 3/8" x 1" THREADED dowel pin

- Install Nitronic 60 Helicoil threaded inserts into D0901521. See Figure 46.
- Press (1) 1/4" x 5/8" dowel pins into D0901521. Pins should sit about 0.25" above the surface.
- Press (1) 3/8" x 1" dowel pins into D0901521. Pins should sit about 0.4" above the surface.
- Press (1) 3/8" x 1" THREADED dowel pins into D0901521 (see Figure 50 for the exact location circled in red). Pins should sit about 0.4" above the surface.
- Press (1) 3/8" x 2" dowel pins into D0901521. Pins should sit about 0.4" above the surface.

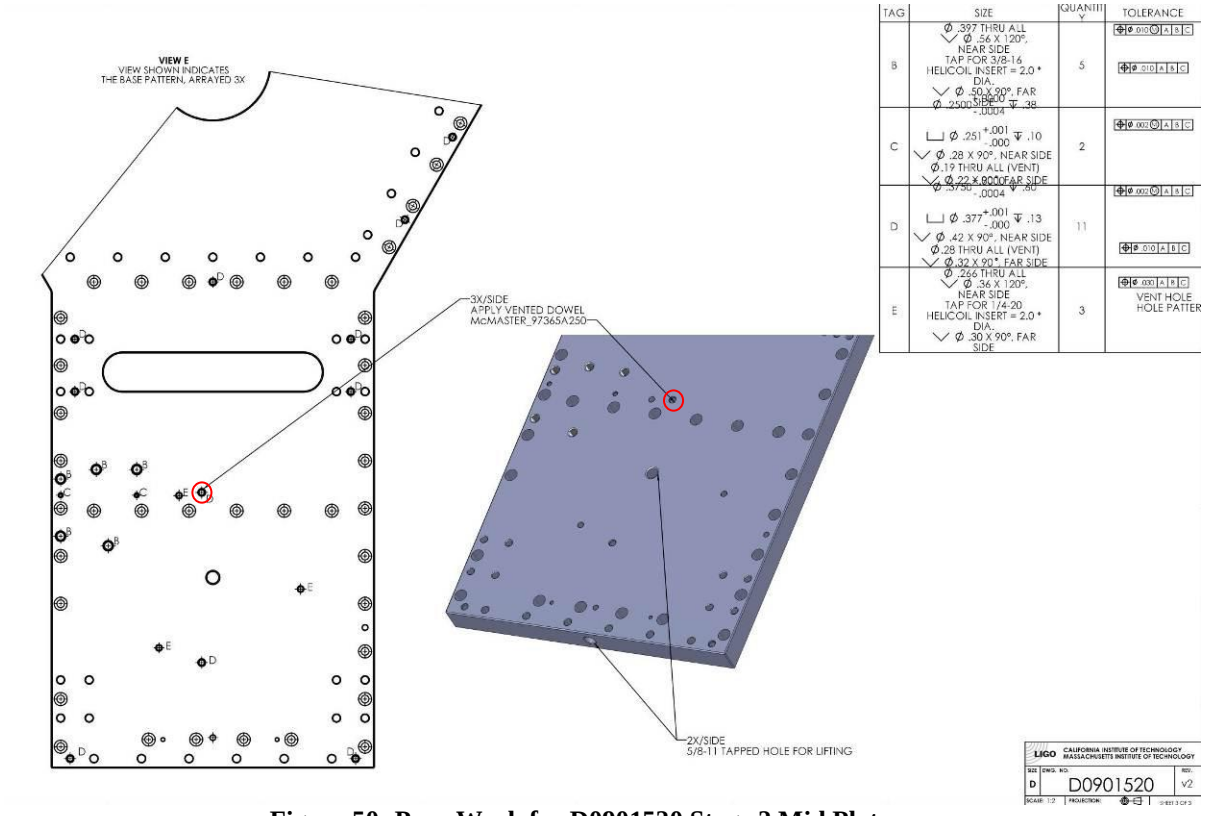


Figure 50: Prep Work for D0901520 Stage 2 Mid Plate

- Lift D0901520 Stage 2 Mid Plate using (3) 5/8-11 Tapped Lifting holes.
- Position D0901520 over the Assembly as shown on Figure 51 (D0902282 Stage 1 Inner Walls must go through the (3) pockets of D0901520).

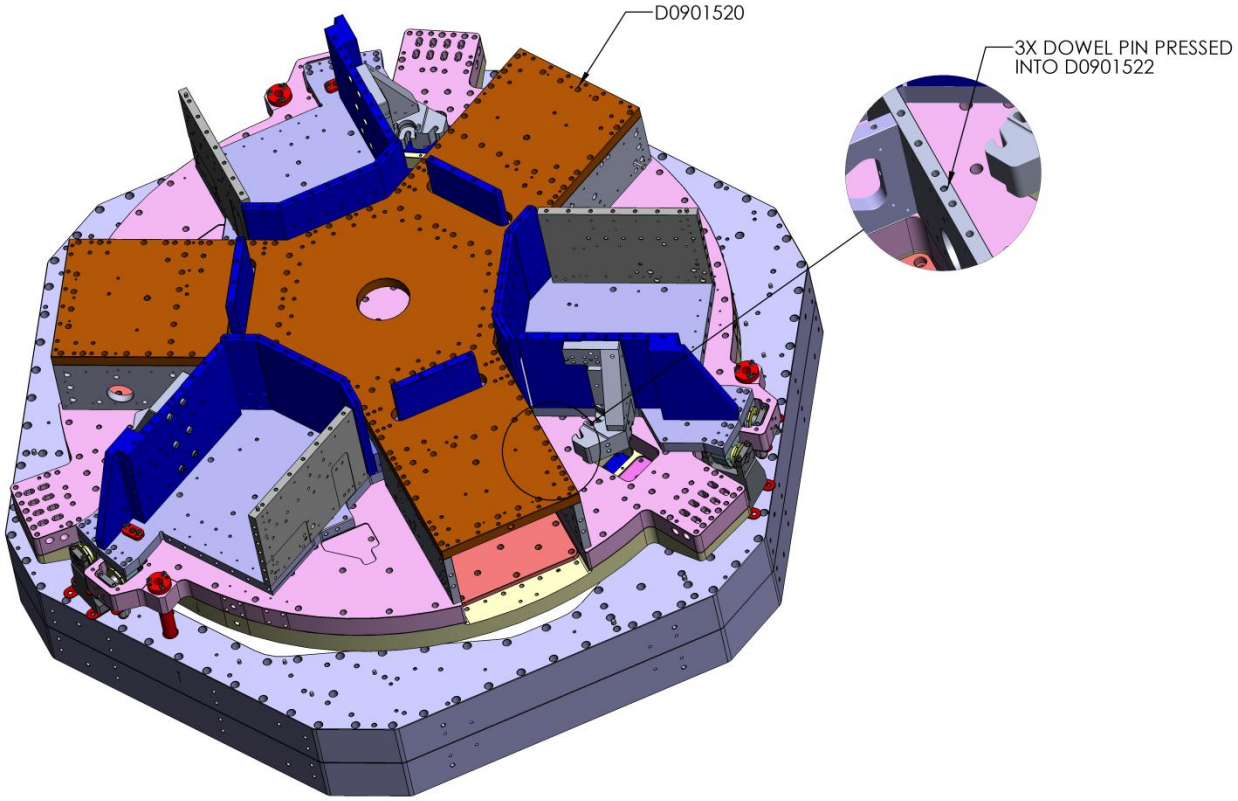


Figure 51: D0901520 Stage 2 Mid plate on the Assembly

Note: D0901520 Stage 2 Mid Plate is located with (3) 3/8" x 1" dowel pins already pressed in D0901522 Radial Right Wall.

Note: **When fastening any of the Large Plates (D0900894, D0900895, D0901516, D0901517, D0901518, D0901519, D0901520, D0902273, D0902279 & D0902503), after torqueing all the bolts once, go around a second time, checking that all of them are torqued to specs. Repeat these steps until all of the bolts are fully torqued.**

Hardware:
(105) 3/8-16 x 1.25" SHCS - MSC 75464644
(105) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws from the top into D0901521 & D0901522 Radial Walls, D0901523 Tangential Walls and into D0901526 & D0901528 Hex Walls.
- Snug all the screws and **torque them to 329 in.lbs (27 ft.lbs).**

1.43. Attach (6) D0902133 Hex Wall Gussets to D0901520 Stage 2 Mid Plate.

- Locate (6) D0902133 Hex Wall Gussets on D0901520 Stage 2 Mid Plate with the (2) pins already installed in D091520 (see Figure 52). Make sure pins seat properly into mating hole and slot.

  Hardware:
  (2) 3/8-16 x 1.25" SHCS - MSC 75464644
  (2) 3/8-16 x 2.25" SHCS – MSC 05682224 **Not HK: Torque Value is: 236 in.lbs (19.7 ft).**
  (2) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws from the top through D0902133 Hex Wall Gussets itself into D0901520 Stage 2 Mid Plate but leave them loose.
- Repeat this step for the (5) other D0902133 Hex Wall Gussets.

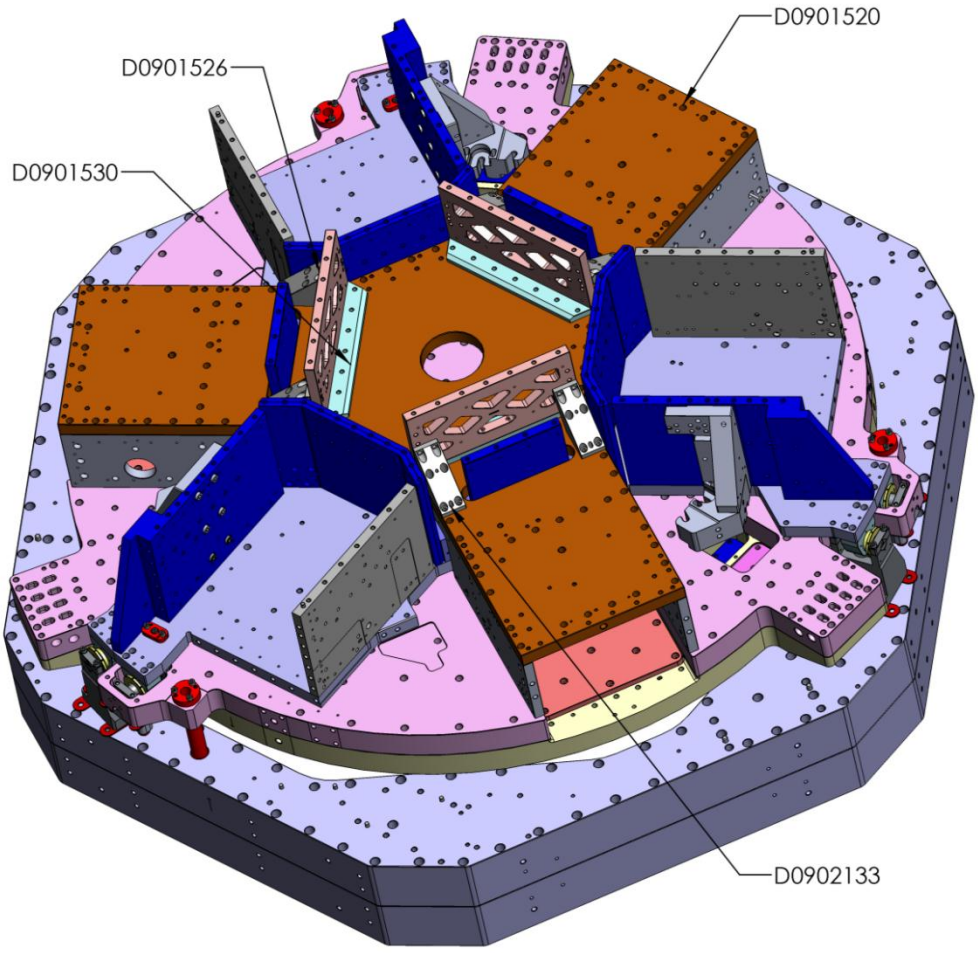


Figure 52: Assembly with D0902133 Hex Wall Gussets on

1.44. Attach D0901526 Large Upper Hex Wall to D0901530 Adapter Large Hex.

Prep Work for D0901530 Adapter Large Hex:

Hardware:
(2) 3/8" x 1" dowel pins

- Press (2) 3/8" x 1" dowel pins into D0901530 as shown on Figure 53. Pins should sit about 0.4" above the surface.

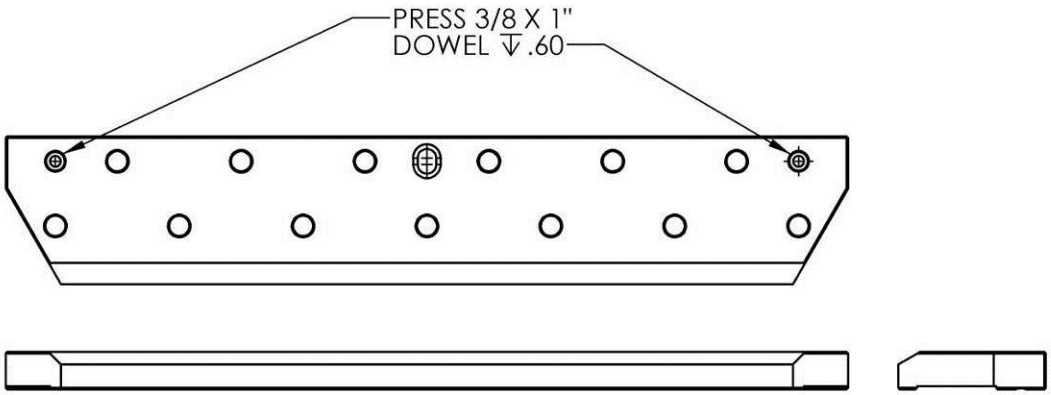


Figure 53: Prep Work for D0901530 Adapter Large Hex

- Locate D0901526 Large Upper Hex Wall on D0901530 Adapter Large Hex with the (2) pins already installed in D091530 (see Figure 53). Make sure pins seat properly into mating hole and slot.

Hardware:
(6) 3/8-16 x 1" SHCS – MSC 75464628
(6) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws through D0901530 Adapter Large Hex into D0901526 Large Upper Hex Wall.
- Snug them and **torque them to 329 in.lbs (27 ft.lbs).**

1.45. Attach the Sub-Assembly D0901526 + D0901530 onto D0901520 Stage 2 Mid Plate & D0902133 Hex Wall Gusset.

- Locate the Sub-Assembly D0901526 + D0901530 onto D0901520 Stage 2 Mid Plate with the (2) pins already installed in D091520 (see Figure 52). Make sure pins seat properly into mating hole and slot.

  Hardware:
  (4) 3/8-16 x 1.25" SHCS – MSC 75464644 – to D0902133 Hex Wall Gussets
  (6) 3/8-16 x 1.5" SHCS – MSC_75464669 – to D0901520 Stage 2 Mid Plate
  (10) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws through D0901530 Adapter Large Hex into D0901520 Stage 2 Mid Plate. Leave them loose.
- Insert all the screws through (2) D0902133 Hex Wall Gussets into D0901526 Large Upper Hex Wall. Leave them loose.
- Snug all the screws making sure there is no gap between D0901530 Adapter Large Hex & D0901520 Stage 2 Mid Plate and between (2) D0902133 Hex Wall Gussets & D0901526 Large Upper Hex Wall.
- **Torque them to 329 in.lbs (27 ft.lbs).**

Note: Check for good contact between D0901530 Adapter Large Hex & D0901520 Stage 2 Mid Plate and between (2) D0902133 Hex Wall Gussets & D0901526 Large Upper Hex Wall, by attempting to slide a .001" thick gauge between them. If the gauge fits in between, untorque the bolts and redo step 1.47 all over.

1.46. Attach D0901528 Small Upper Hex Wall to D0901531 Adapter Small Hex

Prep Work for D0901531 Adapter Small Hex:

Hardware:
(2) 3/8" x 1" dowel pins

- Press (2) 3/8" x 1" dowel pins into D0901531 as shown on Figure 53. Pins should sit about 0.4" above the surface.

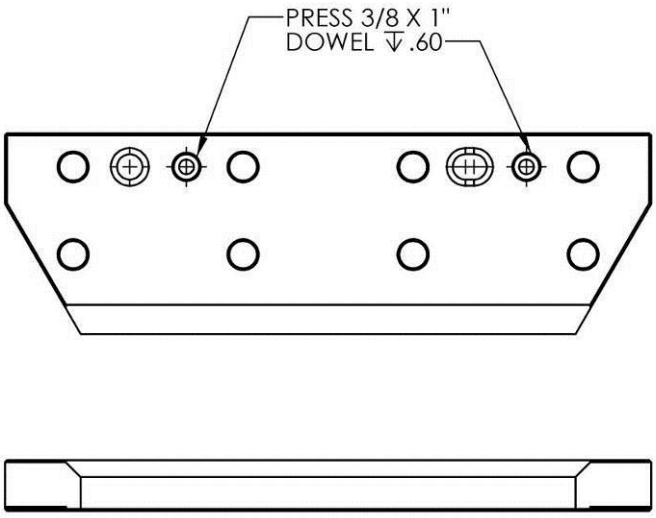


Figure 54: Prep Work for D0901531 Adapter Small Hex

- Locate D0901528 Small Upper Hex Wall on D0901531 Adapter Small Hex with the (2) pins already installed in D091531 (see Figure 54). Make sure pins seat properly into mating hole and slot.

  Hardware:
  (4) 3/8-16 x 1" SHCS – MSC 75464628
  (4) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws through D0901531 Adapter Small Hex into D0901528 Small Upper Hex Wall.
- Snug them and **torque them to 329 in.lbs (27 ft.lbs).**

1.47. Attach the Sub-Assembly D0901528 + D0901531 onto D0901520 Stage 2 Mid Plate.

- Locate the Sub-Assembly D0901528 + D0901531 onto D0901520 Stage 2 Mid Plate with the (2) pins already installed in D091520 (see Figure 52). Make sure pins seat properly into mating hole and slot.

  Hardware:
  (4) 3/8-16 x 1.5" SHCS – MSC_75464669
  (4) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws through D0901531 Adapter Small Hex into D0901520 Stage 2 Mid Plate from the top.
- Snug all the screws making sure there is no gap between D0901531 Adapter Small Hex & D0901520 Stage 2 Mid Plate.
- **Torque them to 329 in.lbs (27 ft.lbs).**

Note: Check for good contact between D0901531 Adapter Small Hex & D0901520 Stage 2 Mid Plate, by attempting to slide a .001" thick gauge between them. If the gauge fits in between, untorque the bolts and redo step 1.49 all over.

1.48. Attach D0901526 & D0901528 Upper Hex Walls using (6) D0901538 Brackets Hex Walls.

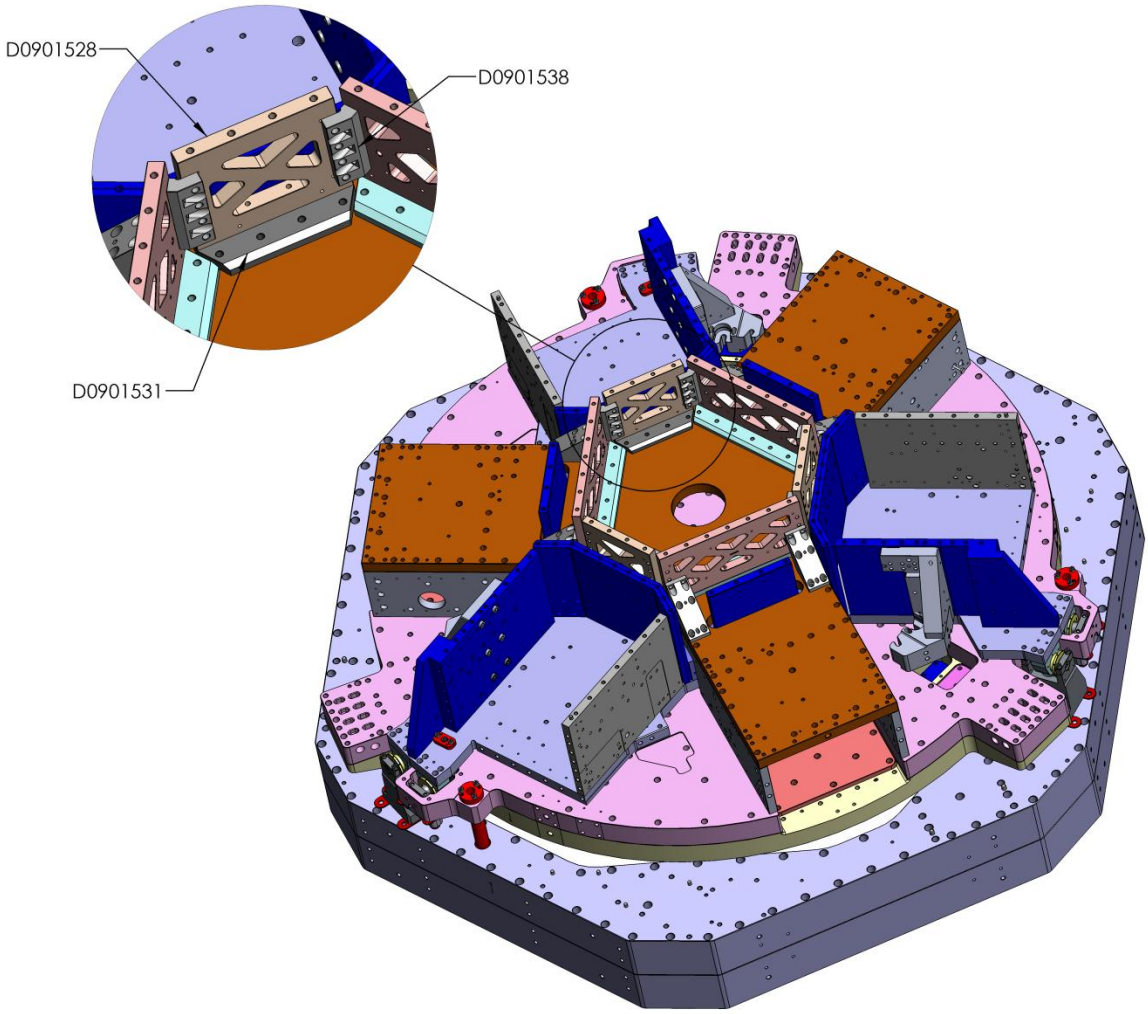


Figure 55: Stage 2 Partially assembled

Hardware:
(7) 3/8-16 x 1.5" SHCS – MSC 75464669
(7) 3/8 Vented Washers - UCC-WFV-38

- Locate D0901538 Bracket Hex Wall between D0901526 Larger Upper Hex Wall & D0901528 Small Upper Hex Wall as shown on Figure 55.
- Insert all the screws through D0901538 Bracket Hex Wall itself into D0901526 Upper Lower Hex Walls & D0901528 Small Upper Hex Walls.
- Leave D0901538 Bracket Hex Wall loosely attached to the assembly.

- Repeat this step for the (5) other D0901538 Bracket Hex Walls.
- Once all the (6) D0901538 Bracket Hex Walls are loosely attached to the assembly, snug them all and **torque them to 329 in.lbs (27 ft.lbs).**

1.49. Pre assemble D1000053 Upper Outer Wall Assembly.

Prep Work for D0901533 Upper Outer Wall:

Hardware:
(8) 3/8-16 x 1 DIA Helicoils
(1) 3/8" x 1" dowel pin
(2) 1/2" x 4" dowel pins

- Install Nitronic 60 Helicoil threaded inserts into D0901533. See Figure 56.
- Press (1) 3/8" x 1" dowel pins into D0901533 as shown on Figure 56. Pins should sit about 0.4" above the surface.
- Press (2) 1/2" x 4" dowel pins into D0901533 as shown on Figure 56. Pins should be flush on the back of D0901533 as shown on Figure 56 & Figure 57.

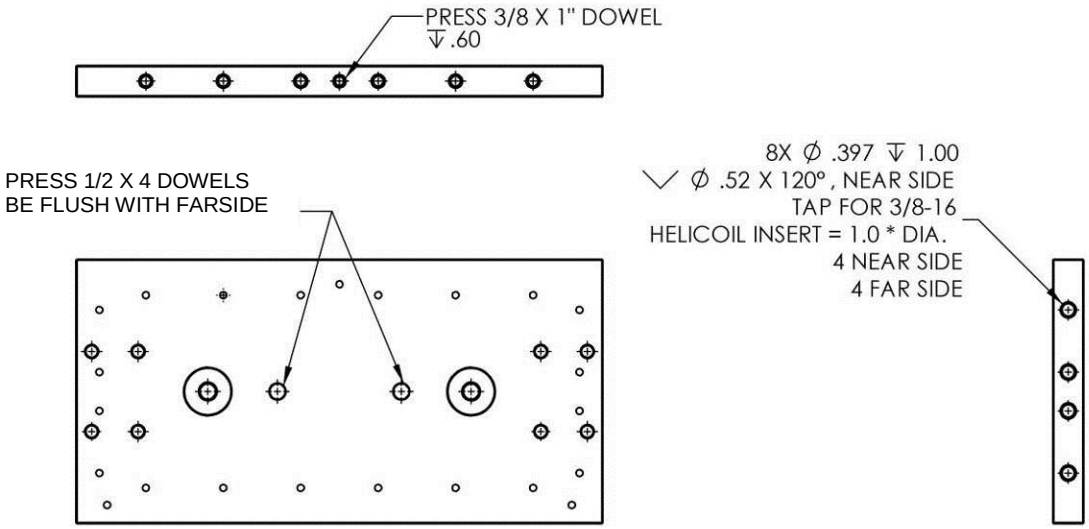
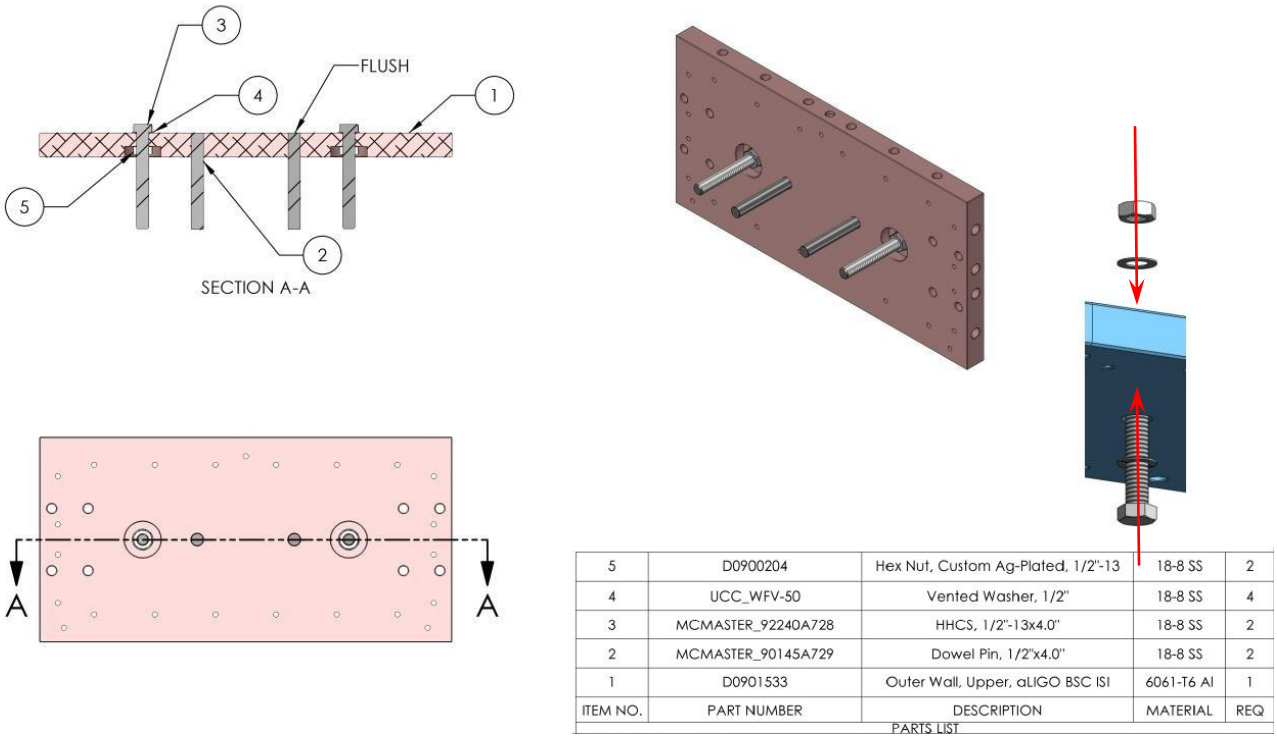


Figure 56: Prep Work for D0901533 Upper Outer Wall

Hardware:
(2) 1/2-13 x 4" full thread HHCS – MSC 67337204
(2) 1/2-13 Hex Nut, Custom Ag-Plated – D0900204
(4) 1/2" Vented Washers – UCC WFV-50

- Insert hex head cap screws, with washer on either side.
- Tighten to Wall, using D0900204 Silver Plated Hex Nuts on each screw, as shown in Figure 57.



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ
5	D0900204	Hex Nut, Custom Ag-Plated, 1/2"-13	18-8 SS	2
4	UCC_WFV-50	Vented Washer, 1/2"	18-8 SS	4
3	MCMASTER_92240A728	HHCS, 1/2"-13x4.0"	18-8 SS	2
2	MCMASTER_90145A729	Dowel Pin, 1/2"x4.0"	18-8 SS	2
1	D0901533	Outer Wall, Upper, aLIGO BSC ISI	6061-T6 Al	1

PARTS LIST

Figure 57: Assembly Drawing of D1000053 Upper Outer Wall Assembly

1.50. Attach D1000053 Upper Outer Wall Assemblies to the Partial BSC-ISI Assembly

- Locate D1000053 Upper Outer Wall Assembly on D0901520 Stag2 Mid Plate with the (2) pins already installed in D091520 (see Figure 58). Make sure pins seat properly into mating hole and slot.

Hardware:
(6) 3/8-16 x 1.25" SHCS – MSC 75464628
(6) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws through D0901520 Stage 2 Mid Plane into D0901533 Upper Outer Wall.
- Snug them and **torque them to 329 in.lbs (27 ft.lbs).**

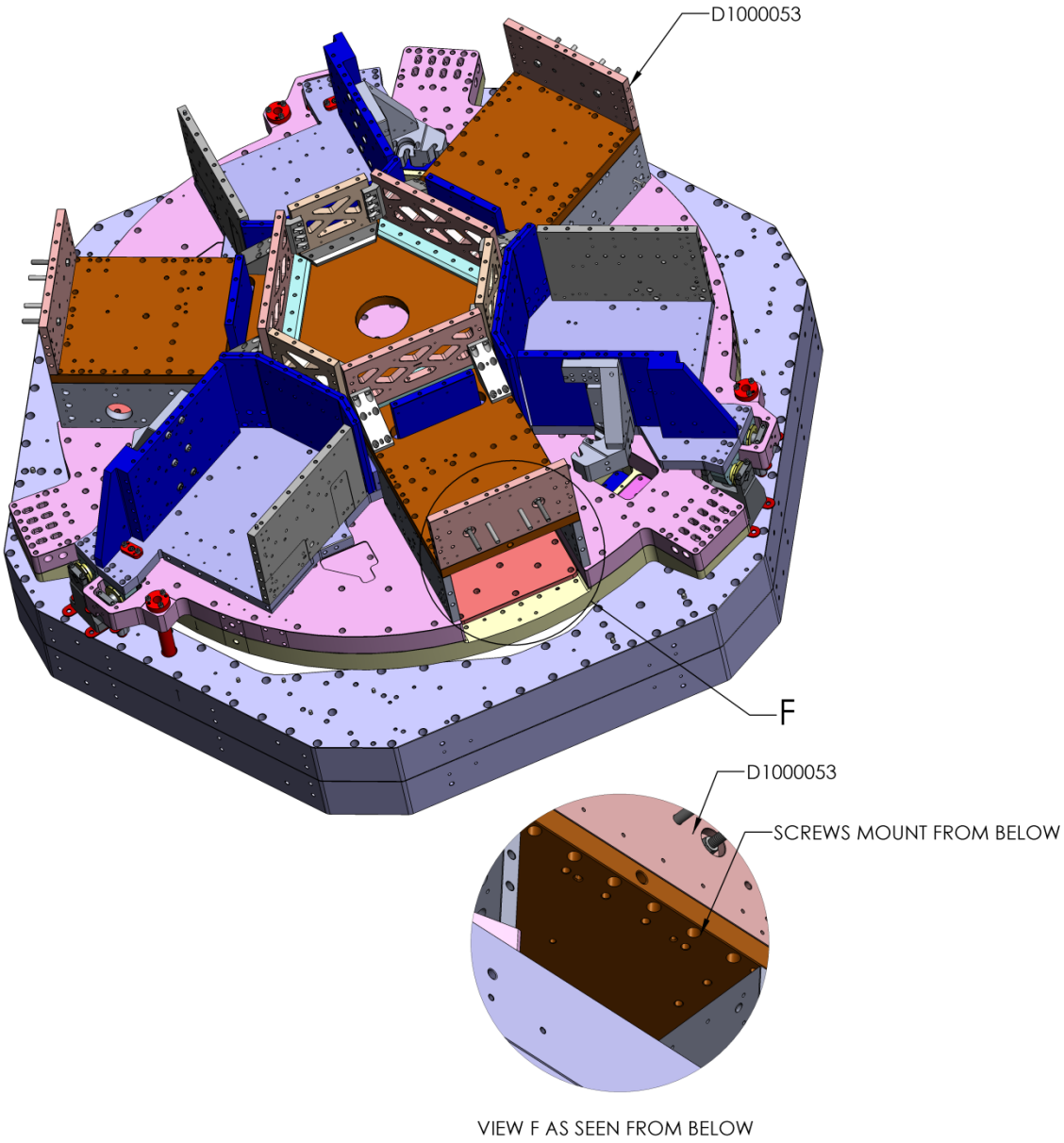


Figure 58: Screws positions to attach the outer upper wall to the mid plate

Install Horizontal GS-13's to Stage 2

Note: To do the following steps, D0900857 GS-13 in pod must be already assembled like described in the following document E1000564-v2.

Quantity	Part Number	Description
3	D0900857	GS-13 Pod Assembly
1	D0902583	Spacer, Horizontal GS-13 Stiffener
1	D1100086	GS-13 Horizontal Stabilizer
1	D1002983	GS-13 Loading Tooling

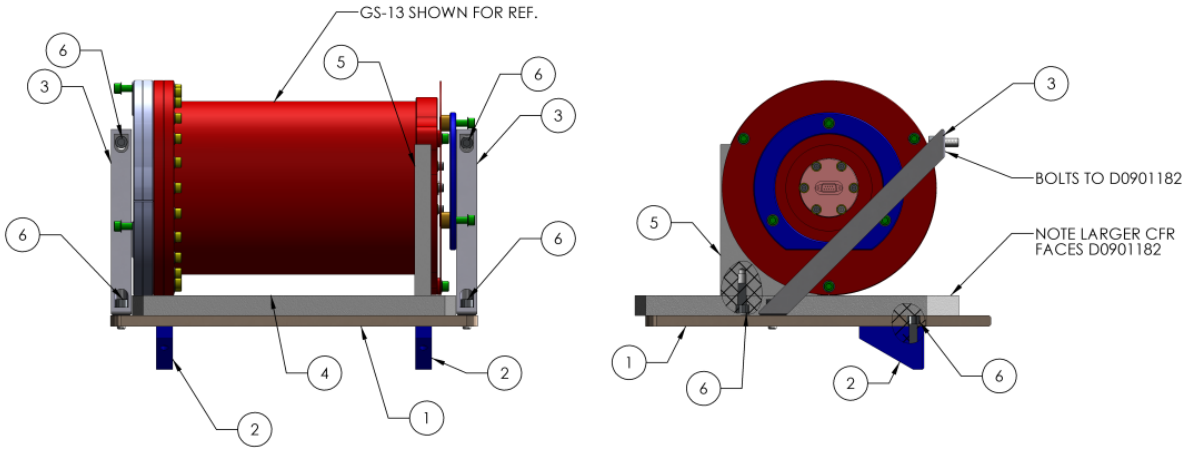
Hardware:
(3) 5/16-24 x 1" SHCS Ag Plated – UCC C-3116-NA
(3) 5/16 Vented Washers – UCC WFV-31

Figure 59: GS-13 with the horizontal stabilizer

D1100086

Note: When installing the horizontal GS-13, item 6 on Figure 59 is a precision washer. There is a selection with different thicknesses (see D0902778 & E1000564). They will be used to adjust the GS-13 to D0901182 BSC ISI. Measure both the distance between the walls and (using calibers) and the height of the GS-13(using a height gage placed on a granite surface plate) adjust the height of the GS-13 to match within 0.002 inch the width of the walls, match each GS-13 with where it is to be mounted.

1.51. Assemble GS-13 installation tooling.



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	Default/REQ
6	HOLOKROME_78098	SHCS, 3/8"-16x1.0"	18-8 SS	11
5	D1002989	GS-13 LOADING POSITION BRACKET, aLIGO BSC ISI	PTFE (general)	1
4	D1002988	GS-13 LOADING TOOLING PLATE, aLIGO BSC ISI	PTFE (general)	1
3	D0900338	Brace, Horiz GS-13 Shelf, HAM ISI	6061-T6 Al	2
2	D1002985	GS-13 LOADING BRACKET, aLIGO BSC ISI	6061-T6 Al	2
1	D1002984	GS-13 LOADING SHELF	6061-T6 Al	1

Figure 60: Special tooling for horizontal GS-13 installation

Hardware:

(2) 3/8-16 x 1" SHCS – MSC 75464628
(2) 3/8 Vented Washers – UCC WFV-38

- Install GS-13 Installation Tooling on Stage 2 as shown on Figure 60 & Figure 61.
- Insert screws through D0900338 Brace for the Horizintal GS-13 Shelf into D0901521 & D0901522 Radial Walls.
- Snug and **torque to 329 in.lbs (27 ft.lbs).**

1.52. Place GS-13 on tooling as shown Figure 60, Figure 61 & Figure 62

Note: Treat the GS-13 with great care to prevent damage, as the seismometer is unlocked.

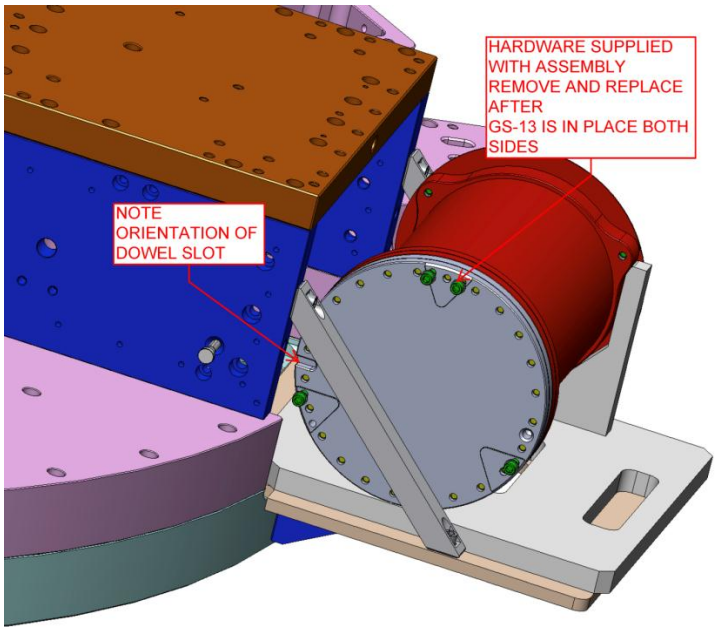


Figure 61: Horizontal GS-13 install-alignment marks should go on the bottom for accurate positioning

Note: The ears of the GS-13 are used as a stop preventing the GS-13 from rotating during installation.

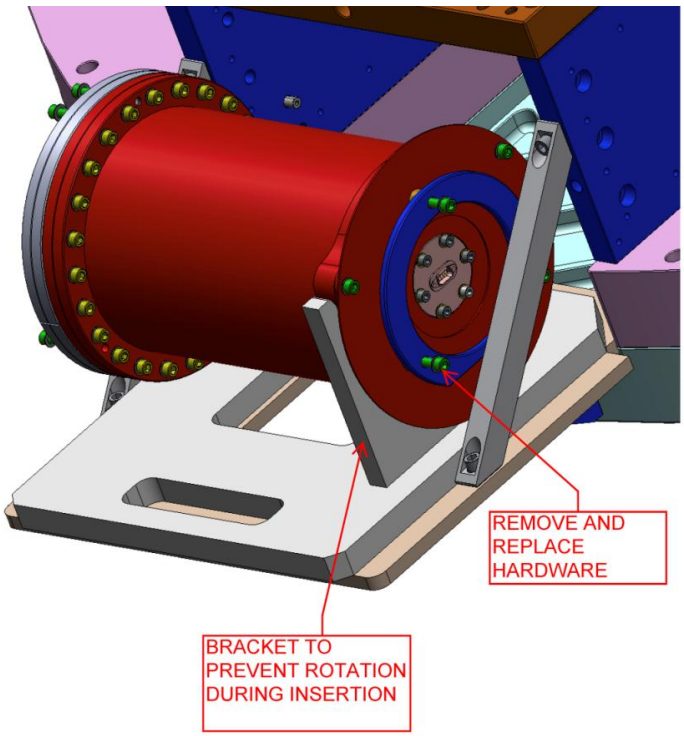


Figure 62: Horizontal GS-13 installation

1.53. Secure the GS-13 manually against D1002989 GS-13 Loading Position Bracket (see Figure 62), once it is secure, slide D1002988 GS-13 Loading Tool Plate holding the GS-13 in place (see Figure 63).

Hardware:

(1) 10-32 x 1.5" Thumb Screws – McMaster 91746A378

- Insert the Thumb Screw in the thread dowel pin already inserted in D0901521 Radial Left Wall.

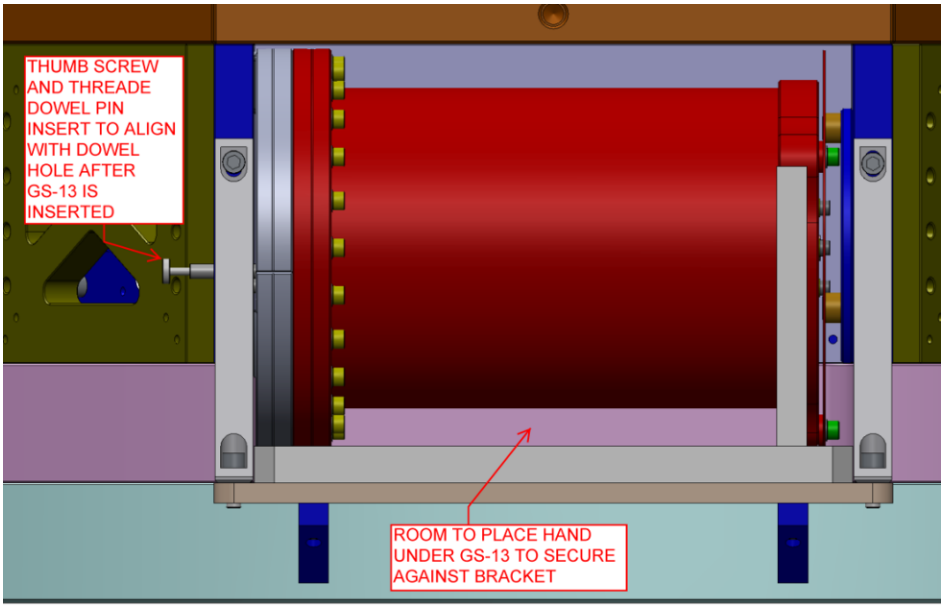


Figure 63: Horizontal GS-13 installation (2)

1.54. Insert the GS-13.

- Gently insert the GS-13 until the dowel slot mentioned in Figure 61 engages the dowel pin already pressed in D0901521 Radial Left Wall.
- Once it is in position, push in the sub assembly composed of the thumb screw & the 3/8" threaded dowel. This will engage the dowel pin in the GS-13. The GS-13 is now in proper position.
- Reattach the screws removed in step 1.54.
- Remove thumb screw & dowel, and Installation Tooling.
- Repeat this step for the (2) other Horizontal GS-13.

-

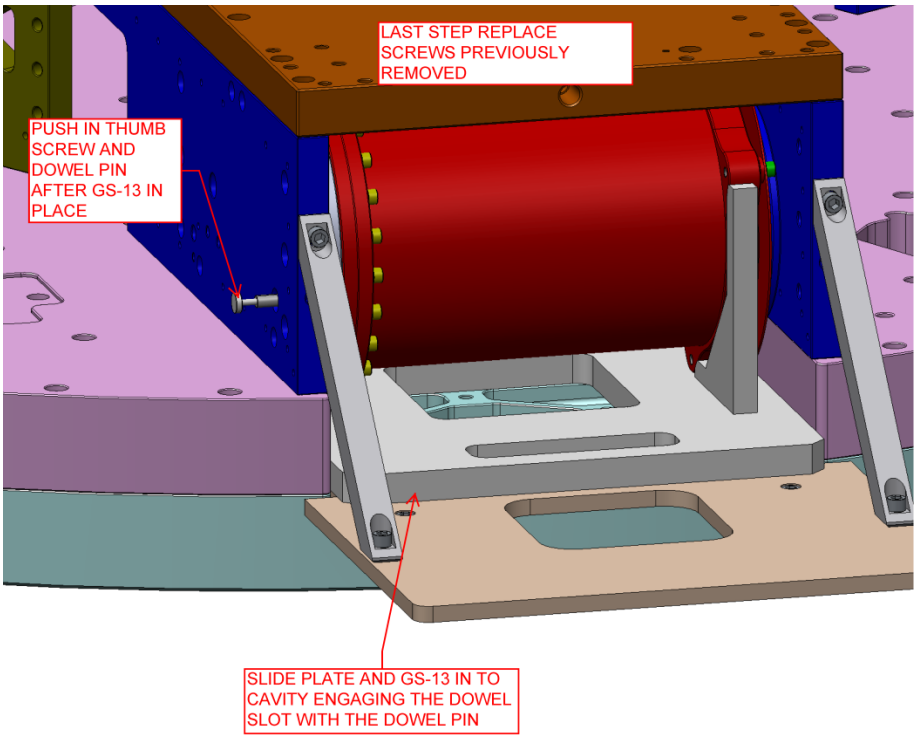


Figure 64: Last steps of the Horizontal GS-13 Installation

Close Stage 2 GS-13 ends

Parts required

Quantity	Part Number	Description	Weight
3	D0901536	Bracket, Lower Outer Wall, Top	
3	D0901535	Bracket, Lower Outer Wall, Bottom	
6	D0901537	Bracket, Lower Outer Wall, Side	
3	D0901532	Lower Outer Wall (= Lower Door)	

1.55. Install D0901536 Bracket, Lower Outer Wall, Top.

Prep Work for D0901536 Bracket, Lower Outer Wall, Top:

Hardware:
(9) 3/8-16 x 2 DIA Helicoils
(2) 1/4" x 5/8" dowel pins

- Install Nitronic 60 Helicoil threaded inserts into D0901536. See Figure 65.
- Press (2) 1/4" x 5/8" dowel pins into D0901536 as shown on Figure 65. Pins should sit about 0.4" above the surface.

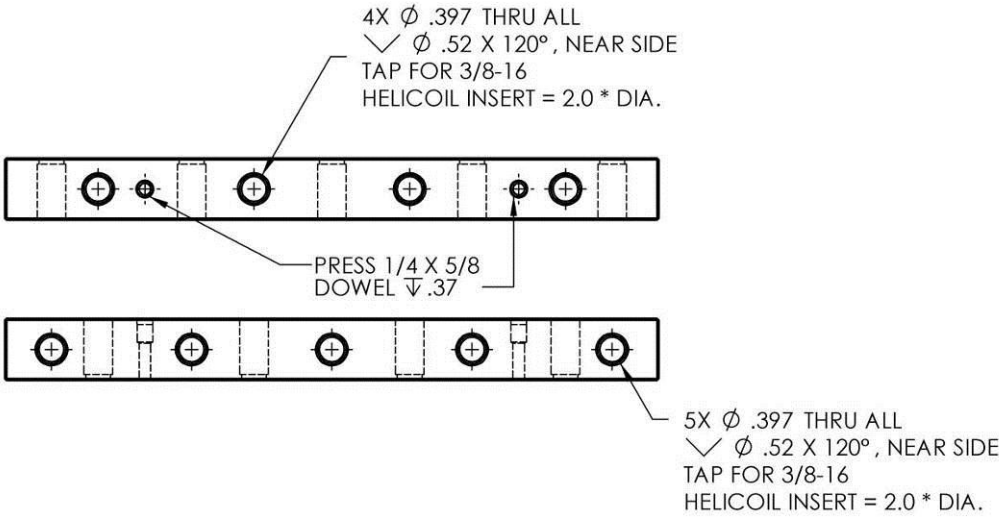


Figure 65: Prep Work for D0901536 Bracket, Lower Outer Wall, Top

Hardware:
(4) 3/8-16 x 1.25" SHCS – MSC 75464644
(4) 3/8 Vented Washers - UCC-WFV-38

- Locate D0901536 Bracket, Lower Outer Wall, Top on D0901520 Stage 2 Mid Plate with the (2) pins already installed in D091520 as shown on Figure 66. Make sure pins seat properly into mating hole and slot.
- Insert all the screws from the top, through D0901520 Stage 2 Mid Plate into D0901536 Bracket, Lower Outer Wall, Top as shown by the black arrows on Figure 66.
- Leave D0901536 Bracket, Lower Outer Wall, Top loosely attached to the assembly.
- Repeat this step for the (2) other D0901536 Bracket, Lower Outer Wall, Top.

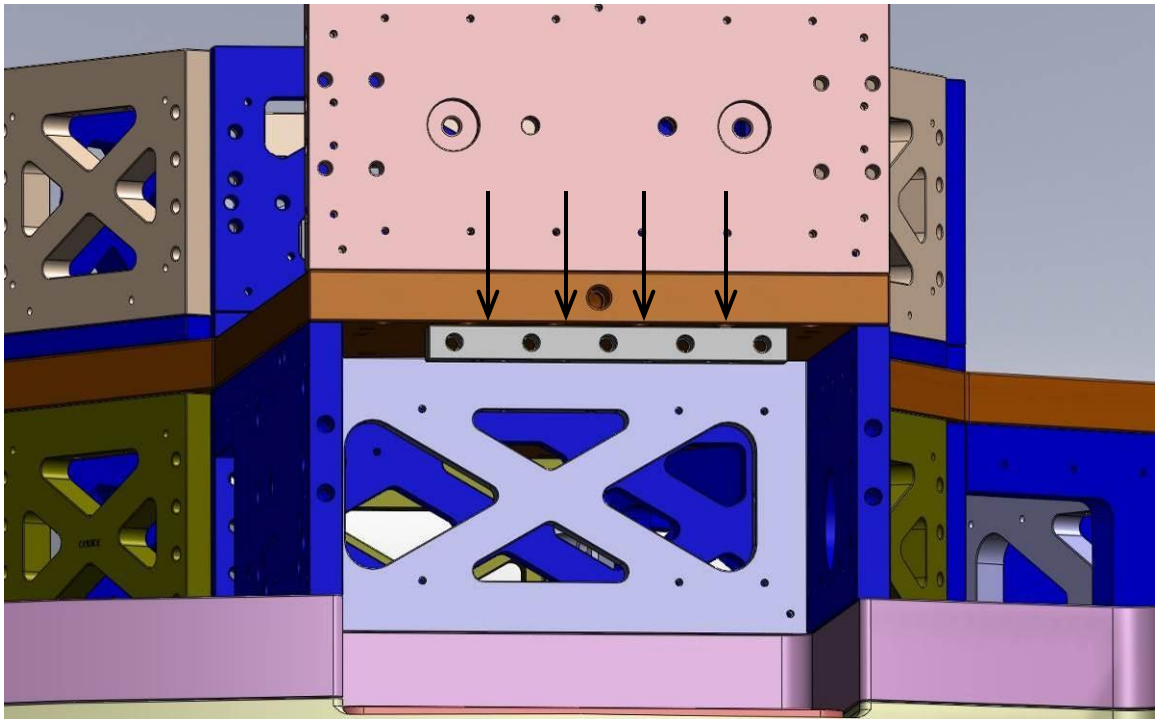


Figure 66: D0901536 Bracket, Lower Outer Wall, Top Installation on D0901520 Stage 2 Mid Plate

1.56. Install D0901535 Bracket, Lower Outer Wall, Bottom.

Prep Work for D0901535 Bracket, Lower Outer Wall, Bottom:

Hardware:
(6) 3/8-16 x 2 DIA Helicoils
(2) 1/4" x 5/8" dowel pins

- Install Nitronic 60 Helicoil threaded inserts into D0901535. See Figure 67.
- Press (2) 1/4" x 5/8" dowel pins into D0901535 as shown on Figure 67. Pins should sit about 0.4" above the surface.

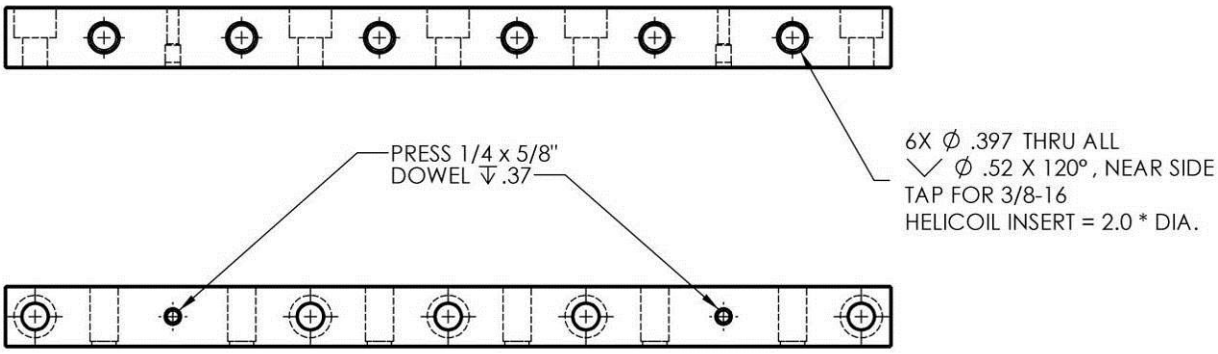


Figure 67: Prep Work for D0901535 Bracket, Lower Outer Wall, Top

Hardware:
(5) 3/8-16 x 1.25" SHCS – MSC 75464669
(5) 3/8 Vented Washers - UCC-WFV-38

- Locate D0901535 Bracket, Lower Outer Wall, Bottom on D0901516 Solid Optical Table with the (2) pins already installed in D091516 as shown on Figure 68. Make sure pins seat properly into mating hole and slot.
- Insert all the screws from the top, through D0901535 itself into D0901516 as shown by the black arrows on Figure 68.
- Snug them and **torque them to 329 in.lbs (27 ft.lbs).**
- Repeat this step for the (2) other D0901535 Bracket, Lower Outer Wall, Bottom.

Note: we torque these screws now contrary to the ones for D0901536 & D0901537, because we won't be able to access them once D0901532 Lower Outer Wall will be in place.

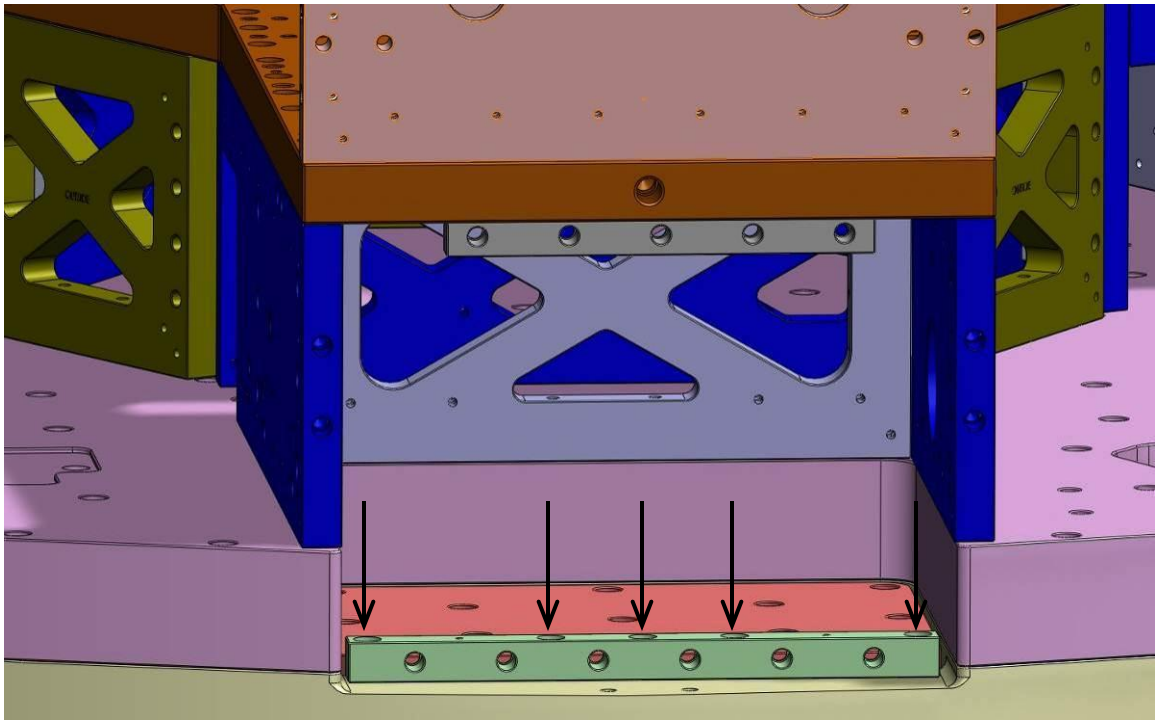


Figure 68: D0901535 Bracket, Lower Outer Wall, Bottom Installation on D0901516 Solid Optical Table

1.57. Install (2) D0901537 Bracket, Lower Outer Wall, Side.

Prep Work for D0901537 Bracket, Lower Outer Wall, Side:

Hardware:
(4) 3/8-16 x 1.5 DIA Helicoils
(3) 3/8-16 x 2 DIA Helicoils

- Install Nitronic 60 Helicoil threaded inserts into D09015357. See Figure 69.

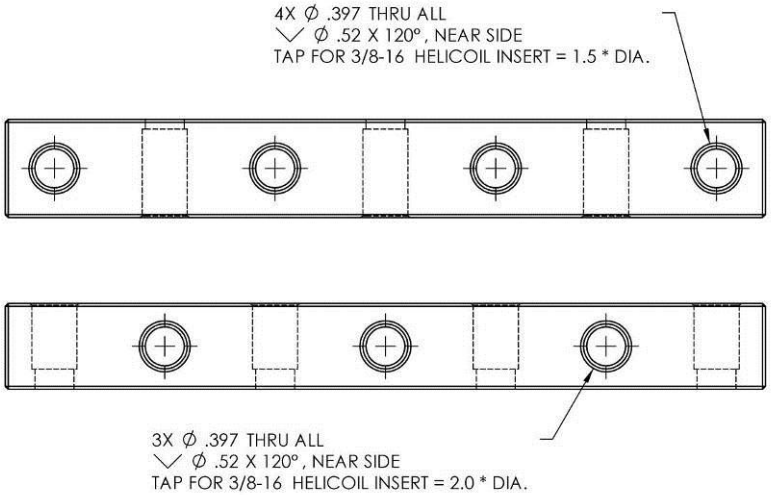


Figure 69: Prep Work for D0901537 Bracket, Lower Outer Wall, Side

Hardware:
(6) 3/8-16 x 1.25" SHCS – MSC 75464669
(6) 3/8 Vented Washers - UCC-WFV-38

- Locate (2) D0901535 Bracket, Lower Outer Wall, Side on D0901521 & D0901522 Radial Walls as shown on Figure 70.
- Insert all the screws from the outside in, through D0901521 & D0901522 Radial Walls into D0901537 as shown by the black arrows on Figure 70.
- Leave D0901537 Bracket, Lower Outer Wall, Side loosely attached to the assembly.
- Repeat this step for the (4) other D0901537 Bracket, Lower Outer Wall, Side.

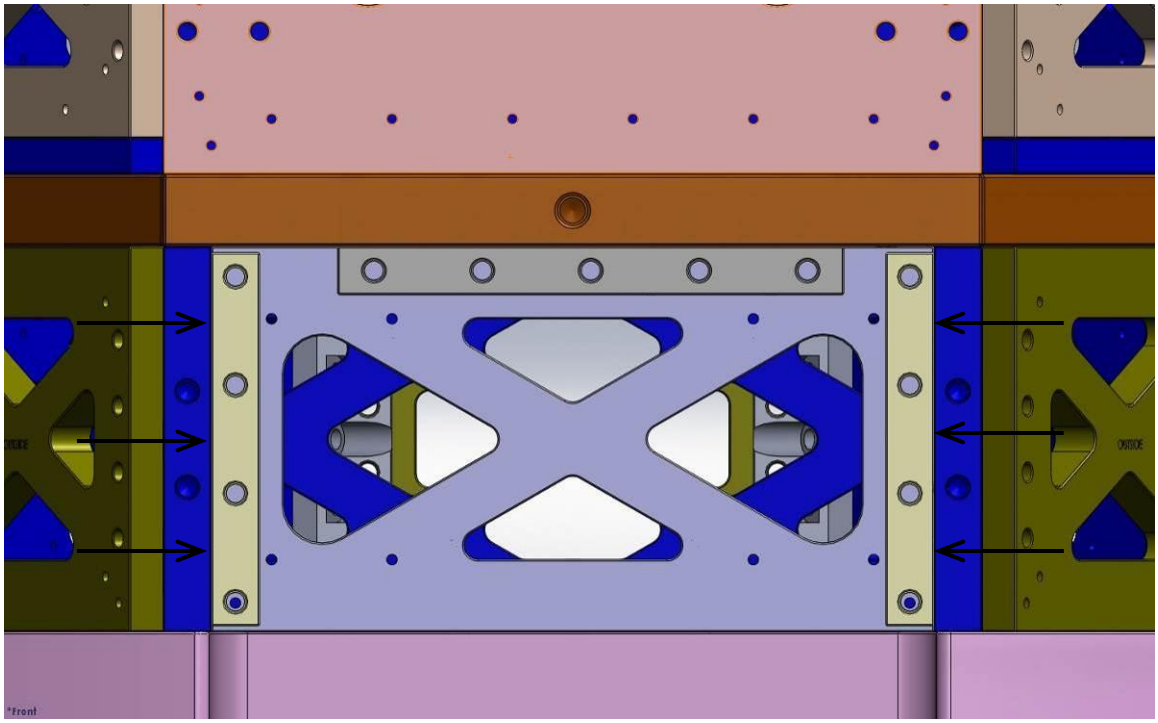


Figure 70: (2) D0901537 Brackets, Lower Outer Wall, Bottom Installation on D0901521 & D0901522 Radial Walls

1.58. Pre assemble D1000052 Lower Outer Wall Assembly.

Prep Work for D0901532 Lower Outer Wall:

Hardware:
(4) 1/2" x 4" dowel pins

- Press (4) 1/2" x 4" dowel pins into D0901532 as shown on Figure 71. Pins should be flush on the back of D0901532 as shown on Figure 71 & Figure 72.

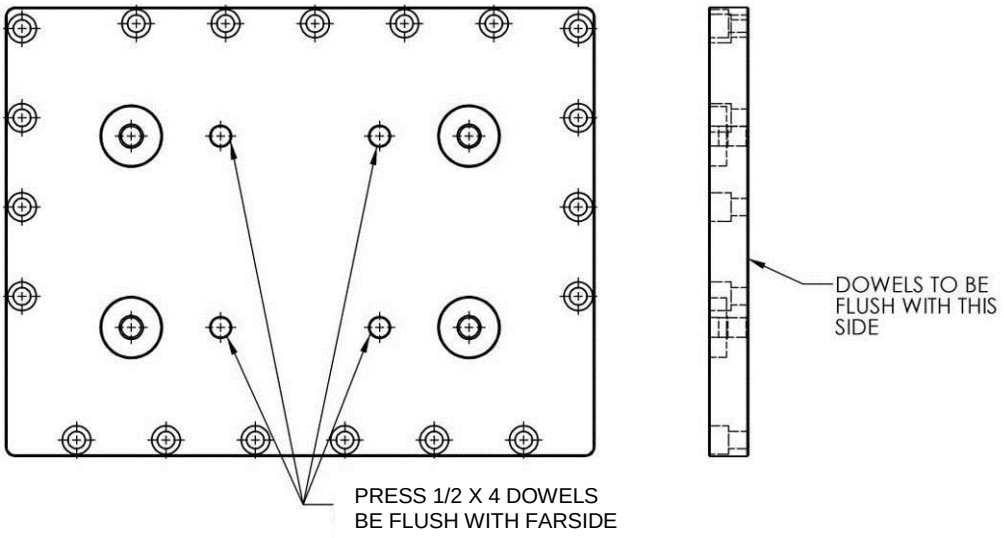
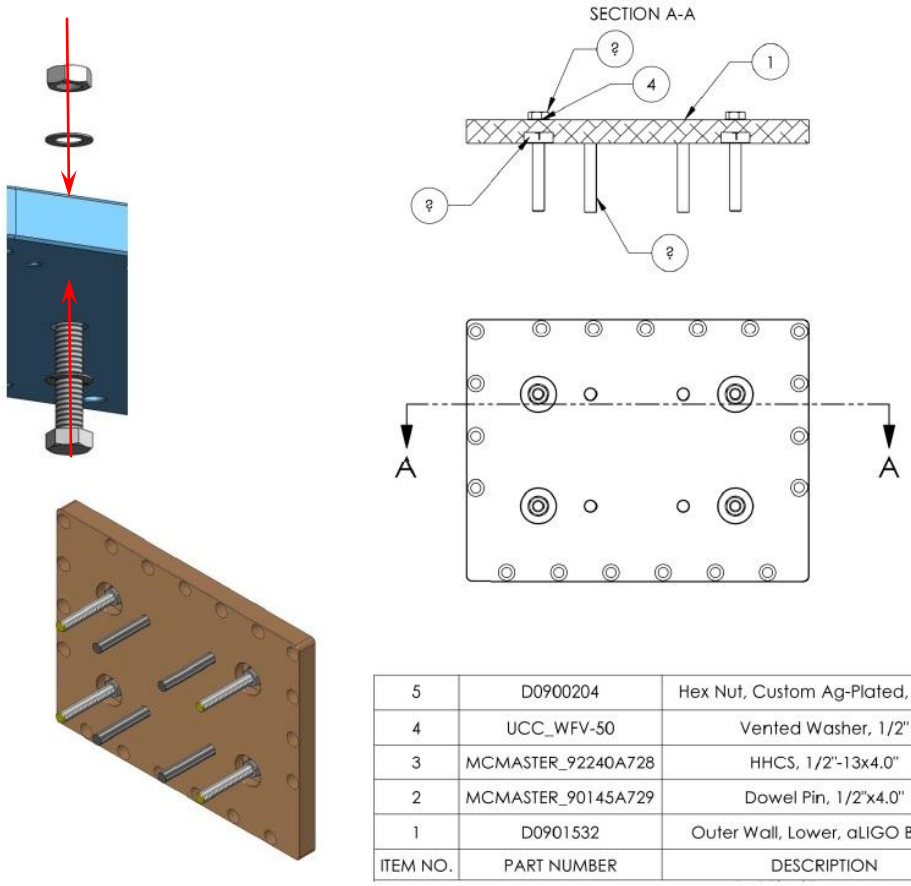


Figure 71: Prep Work for D0901532 Lower Outer Wall

Hardware:
(4) 1/2-13 x 4" full thread HHCS – MSC 67337204
(4) 1/2-13 Hex Nut, Custom Ag-Plated – D0900204
(8) 1/2" Vented Washers – UCC WFV-50

- Insert hex head cap screws, with washer on either side.
- Tighten to Wall, using D0900204 Silver Plated Hex Nuts on each screw, as shown in Figure 72.



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ
5	D0900204	Hex Nut, Custom Ag-Plated, 1/2"-13	18-8 SS	4
4	UCC_WFV-50	Vented Washer, 1/2"	18-8 SS	8
3	MCMASTER_92240A728	HHCS, 1/2"-13x4.0"	18-8 SS	4
2	MCMASTER_90145A729	Dowel Pin, 1/2"x4.0"	18-8 SS	4
1	D0901532	Outer Wall, Lower, aLIGO BSC ISI	6061-T6 Al	1

Figure 72: Assembly Drawing of D1000052 Lower Outer Wall Assembly

1.59. Attach D1000052 Lower Outer Wall Assemblies to the Partial BSC-ISI Assembly

- Locate D1000052 Lower Outer Wall Assembly against onto the previously installed D0901535, D0901536 & D0901537 Brackets.

Hardware:

(11) 3/8" x 1.25" SHCS – MSC 75464628 – into D0901535 & D0901536 Brackets (Bottom & Top)

(8) 3/8" x 1" SHCS – MSC 75464628 – into D0901537 Brackets (Side)

(19) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws through D1000052 Lower Outer Wall Assembly into D0901535, D0901536 & D0901537 Brackets.
- Snug and **torque to 329 in.lbs (27 ft.lbs)** all the screws from the top, that attach D0901536 Bracket, Lower Outer Wall, Top onto D0901520 Stage 2 Mid Plate as shown by the black arrows on Figure 66& Figure 73.
- Snug and **torque to 329 in.lbs (27 ft.lbs)** all the screws from the outside in, that attach (2) D0901537 Brackets, Lower Outer Wall, Side onto D0901521 & D0901522 Radial Walls as shown by the black arrows on Figure 70 & Figure 73.

- Once all these Brackets are torqued to spec, snug all the screws attaching D1000052 Lower Outer Wall Assembly to these Brackets (circled in red on Figure 73) and **torque them to 329 in.lbs (27 ft.lbs).**
- Repeat this step for the (2) other D1000052 Lower Outer Wall Assemblies.

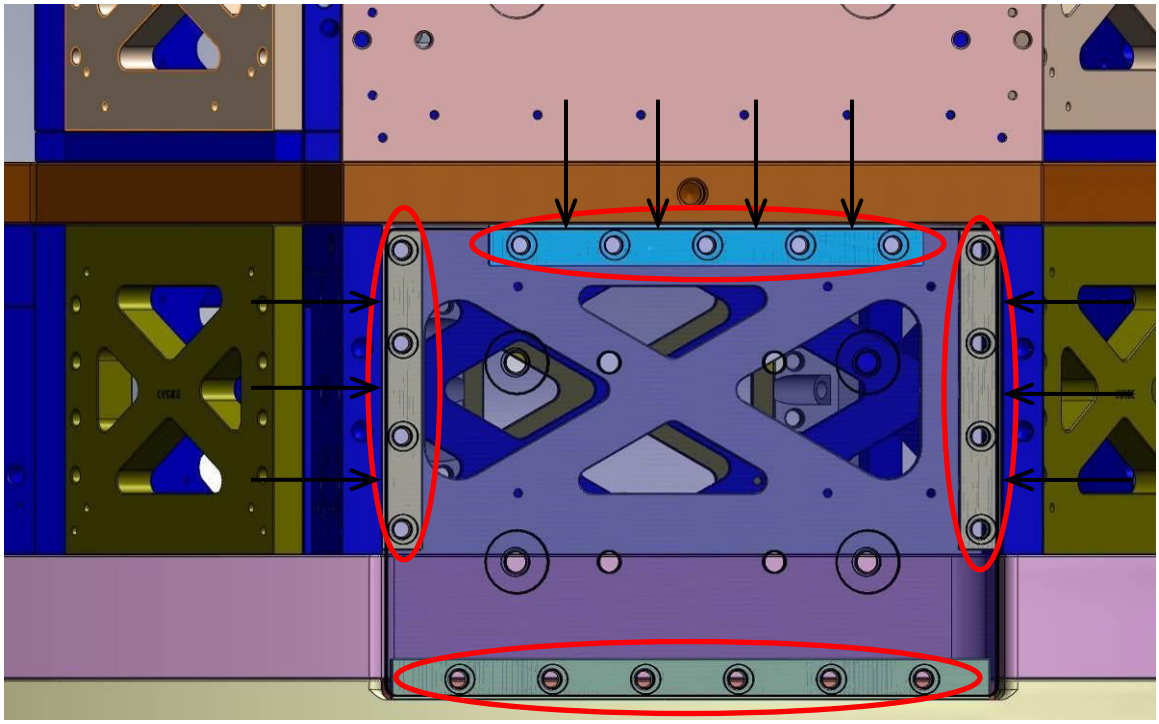


Figure 73 D0901535, D0901536, D0901537 Brackets are visible behind the D0901532 door set as transparent

Install D0902273 Stage 1 Close Out Plate & D0902503 Stage 1 Close Out Plate Cover on Assembly

Parts required

Quantity	Part Number	Description	Weight
1	D0902273	Stage 1 Close Out Plate	286 lbs.
1	D0902503	Stage 1 Close Out Plate Cover	88 lbs.

Prep Work for D0902273 Stage 1 Close Out Plate:

Hardware:
(6) 1/4-20 x 2 DIA Helicoils
(24) 3/8-16 x 2 DIA Helicoils
(3) 3/8" x 1" dowel pins

- Install Nitronic 60 Helicoil threaded inserts into D0902273. See Figure 74.
- Press (3) 3/8" x 1" dowel pins into D0902273 as shown on Figure 74. Pins should sit about 0.4" above the surface.

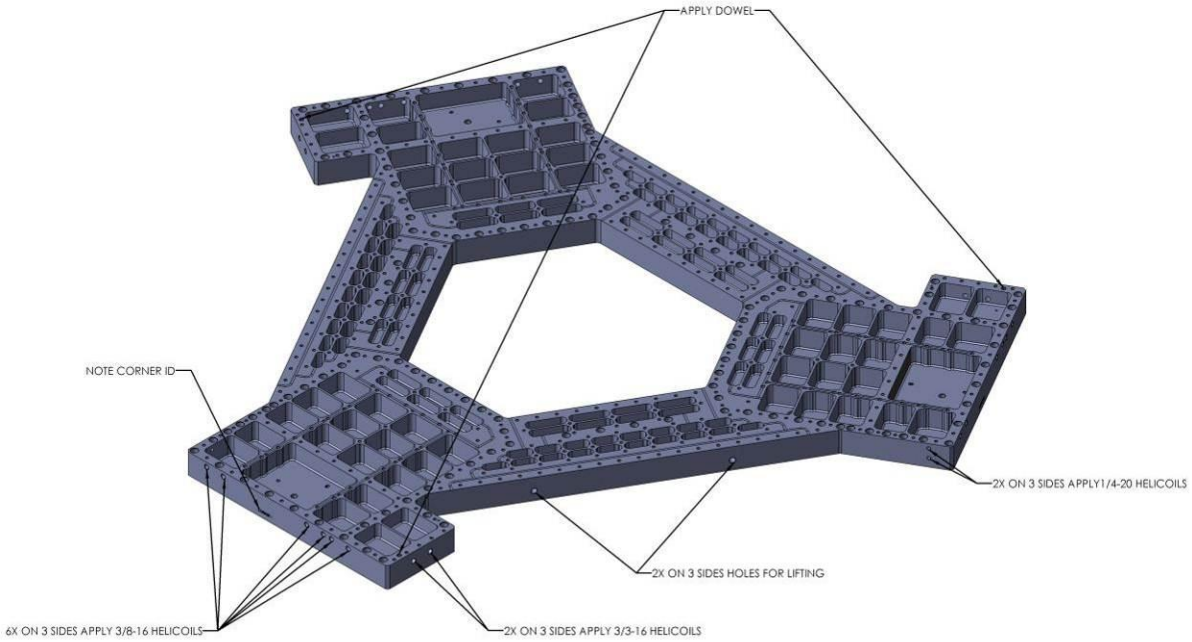


Figure 74: Prep Work for D0902273 Stage 1 Close Out Plate

- Lift D0902273 Stage 1 Close Out Plate using (3) 1/2-13 Tapped Lifting holes shown on Figure 74.

Note: **THERE IS AN ORIENTATION FOR THE D0902273 STAGE 1 CLOSE OUT PLATE: on its side there is engraved stamps specifying the corner's number.**

- Position D0902273 (pocketed surface facing up) over the Assembly as shown on Figure 75. D0902273 Stage 1 Close Out Plate is located with (3) 3/8" x 1" dowel pins already pressed in D0902278 L4C Wall.

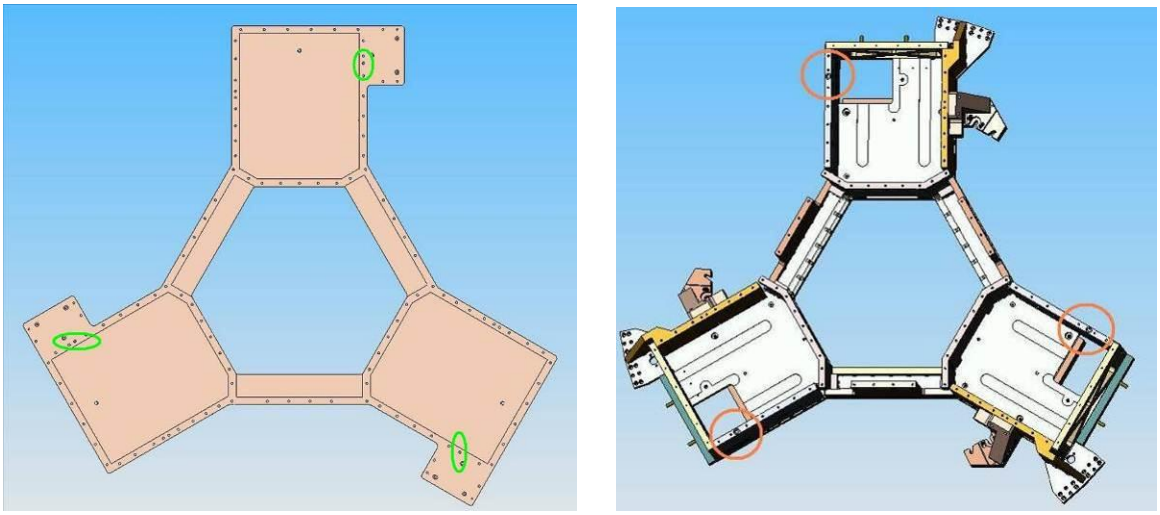


Figure 75: Location of (3) 3/8" slots on D0902273 Stage 1 Close Out Plate (on the left screen capture) & (3) 3/8" x 1" dowel pins on D0902278 L4C Walls (on the right screen capture)

Note: **When fastening any of the Large Plates (D0900894, D0900895, D0901516, D0901517, D0901518, D0901519, D0901520, D0902273, D0902279 & D0902503), after torqueing all the bolts once, go around a second time, checking that all of them are torqued to specs. Repeat these steps until all of the bolts are fully torqued.**

Hardware:
(120) 3/8-16 x 1.25" SHCS - MSC 75464644
(120) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws from the top through D0902273 Stage 1 Close Out Plate into D0902271 Angled Hex Walls, D0902274 Flexure Walls, D0902278 L4C Walls & D0902282 Hex Inner Walls.
- Snug all the screws and **torque them to 329 in.lbs (27 ft.lbs).**

Install D0902503 Close Out Plate Cover over Stage 1

Prep Work for D0902503 Stage 1 Close Out Plate Cover:

Hardware:
(6) 3/8-16 x 1 DIA Helicoils

- Install Nitronic 60 Helicoil threaded inserts into D0902503. See Figure 76.

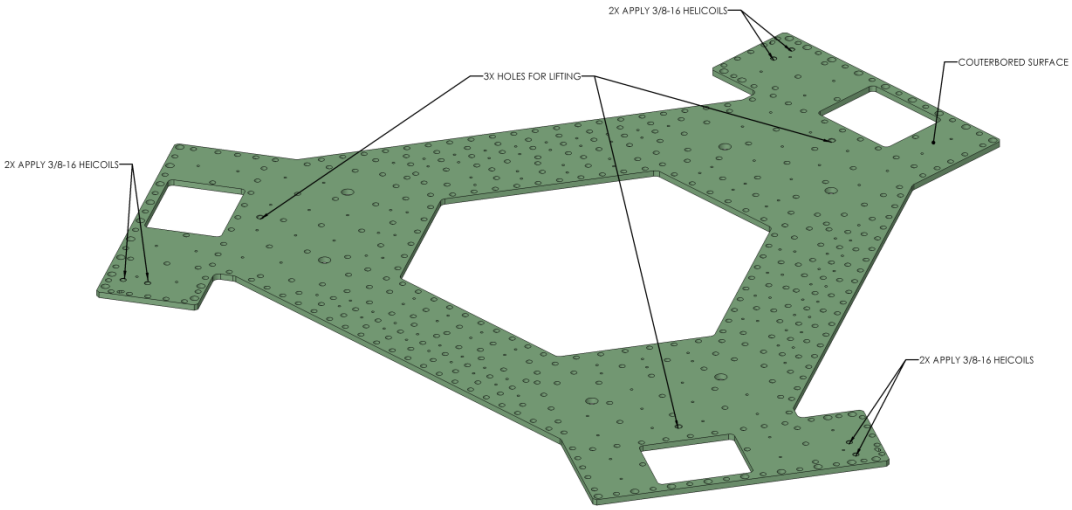


Figure 76: Prep Work for D0902503 Stage 1 Close Out Plate Cover

- Lift D0902503 Stage 1 Close Out Plate Cover using (3) 1/2-13 Tapped Lifting holes shown on Figure 76.
- Position D0902503 (counter bored surface facing up) over D0902273 as shown on Figure 77. D0902503 Stage 1 Close Out Plate Cover is located with (3) 3/8" x 1" dowel pins already pressed in D0902273 Stage 1 Close Out Plate.

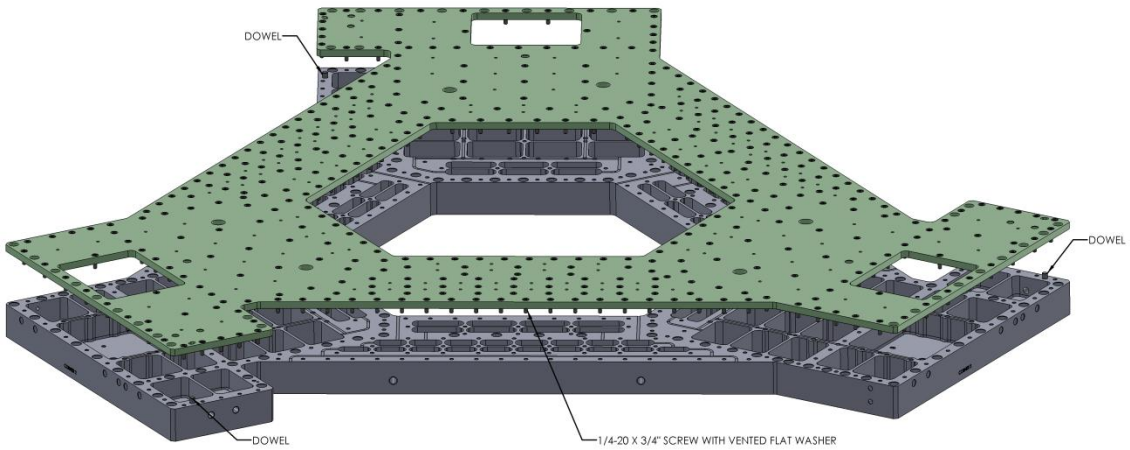


Figure 77: Positioning of D0902503 Stage 1 Close Out Plate Cover over D0902273 Stage 1 Close Out Plate

Note: **When fastening any of the Large Plates (D0900894, D0900895, D0901516, D0901517, D0901518, D0901519, D0901520, D0902273, D0902279 & D0902503), after torqueing all the bolts once, go around a second time, checking that all of them are torqued to specs. Repeat these steps until all of the bolts are fully torqued.**

Hardware:
(405) 1/4-20 x 0.75" SHCS – MSC 75464362
(405) 1/4 Vented Washers - UCC-WFV-25

- Insert all the screws from the top through D0902503 Stage 1 Close Out Plate Cover into D0902273 Stage 1 Close Out Plate.
- Snug all the screws and **torque them to 100 in.lbs (8.3 ft.lbs).**

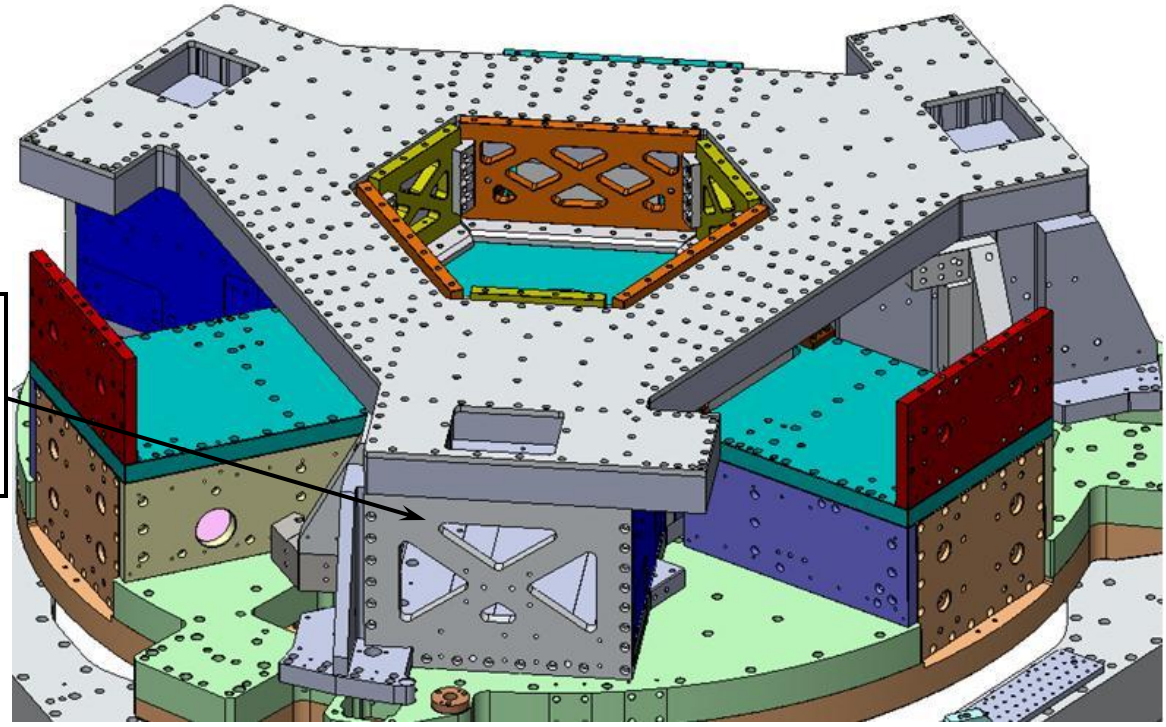


Figure 78: D0902273 & D0902503 assembled on Stage 1

Install D090 2443 Stage 1 Back Ribs

Parts required

Quantity	Part Number	Description	Weight
3	D0902443	Stage 1 Back Rib	

Hardware:
(6) 3/8-16 x 1.25" SHCS – MSC 75464644 – into D0902271 Angled Hex Wall
(6) 3/8-16 x 1.5" SHCS – MSC 75464669 – into D0902273 Stage 1 Close Out Plate
(12) 3/8 Vented Washers - UCC-WFV-38

- Locate D0902443 Stage 1 Back Rib on D0902271 Angled Hex Wall & D0902273 Stage 1 Close Out Plate as shown on Figure 79.
- Insert all the screws from the inside out, through D0902443 Stage 1 Back Rib itself into D0902271 Angled Hex Wall & D0902273 Stage 1 Close Out Plate as shown on Figure 67.
- Snug all the screws and **torque them to 329 in.lbs (27 ft.lbs).**
- Repeat this step for the (2) other D0902443 Stage 1 Back Ribs.

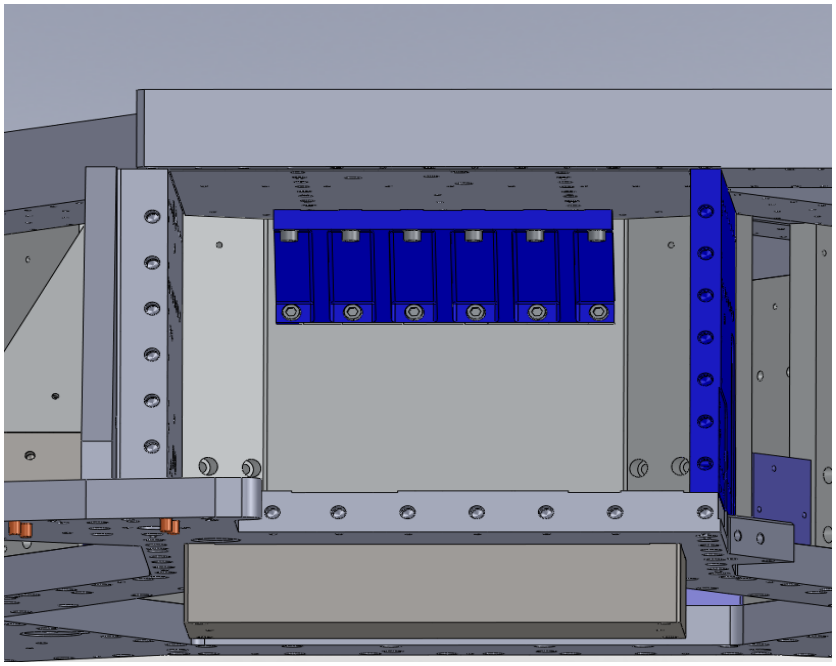


Figure 79: D0902443 Stage 1 Back Rib

Note: At this point, the level of Stage 1 needs to be checked.

Install Trilliums onto Stage 1

Note: To do the following steps, D0900648 Trillium Pod Assembly must be already assembled like described in the following document E1000523-v5.

Parts required

Quantity	Part Number	Description	Weight
3	D0900648	Trillium Pod Assembly	
3	D0902546	Trillium Pod Slider Foot	
3	D0902548	Trillium Pod Slider Pad	

1.60. Assemble (3) D0902547 Trillium Slider Foot

Hardware:
(3) 1/4-20 x 3" SHCS – McMaster 92196A554
(3) 1/4 Vented Washers - UCC-WFV-25

- Attach D0902548 Teflon Pad to D0902546 main part of the foot with screws.
- Snug all the screws and **torque them to 100 in.lbs (8.3 ft.lbs).**
- Repeat this step for the (3) other D0902546 & D0902548.

1.61. Mount (3) D0902547 Trillium Pod Slider Feet on D0900648 Trillium Pod Aseembly.

Hardware:
(2) 1/4-20 x 1.5" Ag-Plated SHCS – UCC C-2024-A
(2) 1/4 Vented Washers - UCC-WFV-25

- Attach D0902547 Trillium Pod Slider to D0900648 Trillium Pod Assembly as shown on Figure 80.

Note: It might be helpful to have the Trillium on an elevated surface, as the slider feet are elevating the pod.

- Snug all the screws and **torque them to 100 in.lbs (8.3 ft.lbs).**
- Repeat this step for the (3) other D0902547 Trillium Pod Sliders.

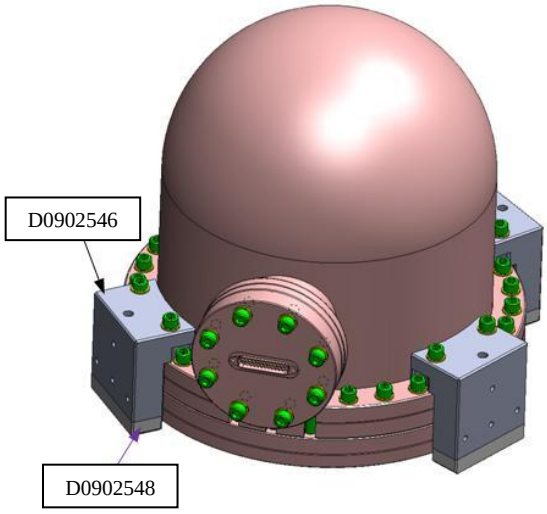


Figure 80: D0900648 Trillium Pod Assembly with (3) D0902547 Trillium Slider Feet on

- Push the fully assembled Trillium pod against the dowel pins installed on D0902279 Stage 1 Base Plate, circled in yellow on Figure 81 & Figure 82. The left pin should slide into the slot of D0900648 Trillium Pod Assembly.

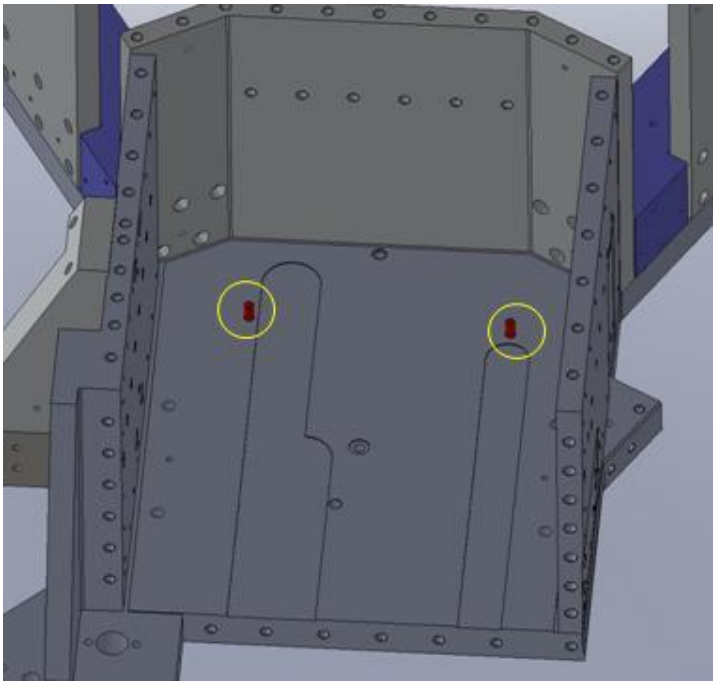


Figure 81: Locations of the (2) dowel pins in D0902279 Stage 1 Base Plate used to locate D0900648 Trillium Pod Assembly (there are no cut-outs)

- Lower the Trillium onto D0902279 Stage 1 Base Plate by gradually unthreading the (6) 1/4-20 x 1.5" Ag-Plated SHCS attaching the slider feet to the Trillium flange.

Note: The 3 feet should be lowered simultaneously. It might be helpful to start releasing the weight on the back feet first, so that the hardest screws to release are easy to

access. Once the Trillium pod has even contact with the base plate, completely detach the slider feet and take them out.

Hardware:
(3) 1/4-20 x 3" SHCS – McMaster 92196A554
(3) 1/4 Vented Washers - UCC-WFV-25
(1) 3/8-16 x 1.5" Shoulder Screw (OD 1/2") - McMaster 90298A716
(1) Trillium Pod Locating Eccentric - D0901819

- Attach D0901819 the Trillium Pod Locating Eccentric loosely with the shoulder screw onto D0902279 Stage 1 Base Plate (see the blue circle on Figure 82). Make sure D0900648 Trillium Pod Assembly is fully pushed against the pins (see yellow circles on Figure 82) by turning D0901819 the Trillium Pod Locating Eccentric with the 1" open-end wrench.

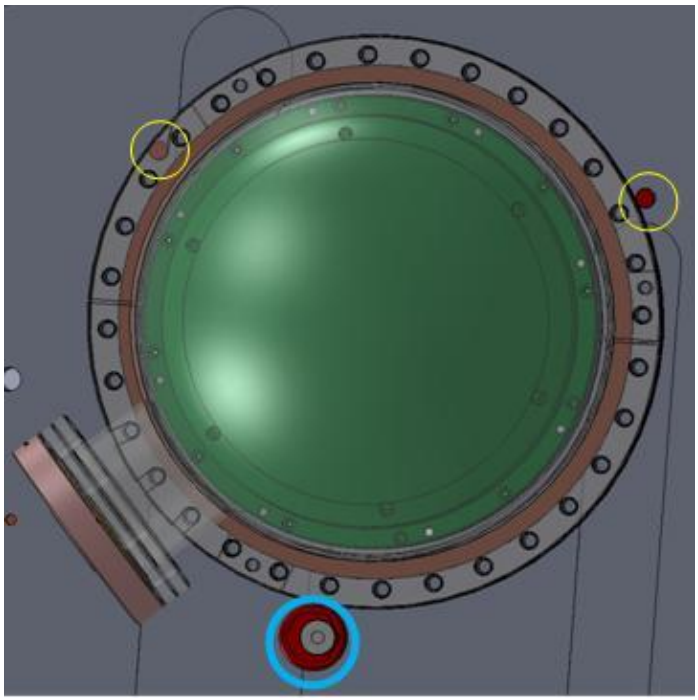


Figure 82 Pins in the base plate circled in yellow & eccentric clamp circled in cyan

- Insert (3) 1/4-20 x 3" SHCS from top, through D0900648 Trillium Pod Assembly itself into D0902279 Stage 1 Base Plate.
- Snug all the screws and **torque them to 75.2 in.lbs (6.3 ft.lbs).**
- Remove D0901819 the Trillium Pod Locating Eccentric & 3/8-16 x 1.5" Shoulder Screw (OD 1/2") from the assembly.
- Repeat this step for the (2) other D0900648 Trillium Pod Assemblies.

Install stage 1 side ribs

Parts required

Quantity	Part Number	Description	Weight
6	D0902441	Stage 1 Side Rib	

Hardware:
(14) 3/8-16 x 1.5" SHCS – MSC 75464669
(14) 3/8 Vented Washers - UCC-WFV-38

- Locate D0902441 Stage 1 Side Rib on D0902274 Flexure Wall, D0902278 L4C Wall & D0902273 Stage 1 Close Out Plate as shown on Figure 83.
- Insert all the screws from the inside out, through D0902441 Stage 1 Side Rib itself into D0902274 Flexure Wall, D0902278 L4C Wall & D0902273 Stage 1 Close Out Plate as shown on Figure 83.
- Snug all the screws and **torque them to 329 in.lbs (27 ft.lbs).**
- Repeat this step for the (2) other corners of Stage 1.

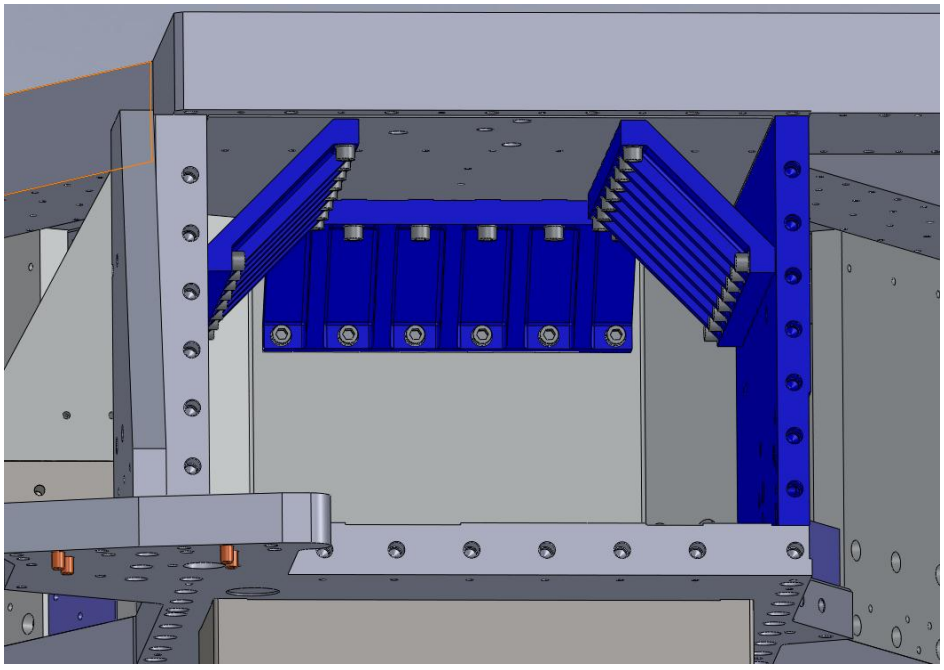


Figure 83: Stage 1 Ribs installed

Install D0901518 & D0901519 Keel Plates on Stage 2

Parts required

Quantity	Part Number	Description	Weight
1	D0901518	Keel Plate Down-Facing	332 lbs.
1	D0901519	Keel Plate Up-Facing	347 lbs.
12	D0901539	Outer Wall Gusset	1.5 lbs.

Prep Work for D0901518 Keel Plate Down-Facing:

Hardware:
(3) 1/2" x 1.25" dowel pins

- Press (3) 1/2" x 1.25" dowel pins into D0901518 as shown on Figure 84. Pins should sit about 0.5" above the surface.

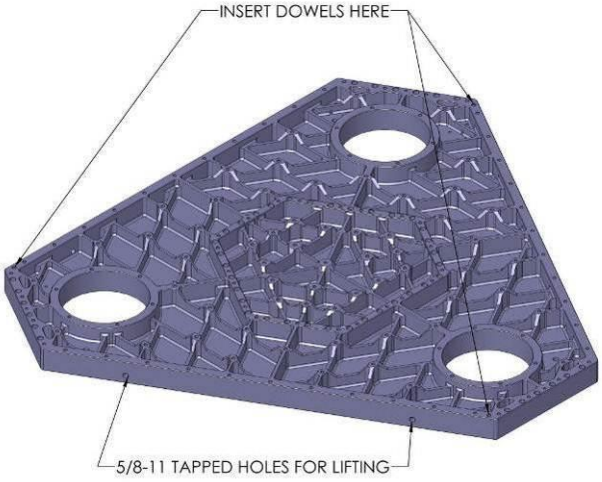


Figure 84: Prep Work for D0901518 Keel Plate Down-Facing

- Lift D0901518 Keel Plate Down-Facing using (3) of the (6) 5/8-11 Tapped Lifting holes shown on Figure 84.
- Position D0901518 (pocketed surface facing up) over D0901526, D0901528 & D0901533 Stage 2 Upper Walls as shown on Figure 85 (contact surface in red). D0901518 Keel Plate Down-Facing is located with (3) 3/8" x 1" dowel pins already pressed in (3) D0901533 Upper Outer Walls (see black circles on Figure 85 for pins locations).

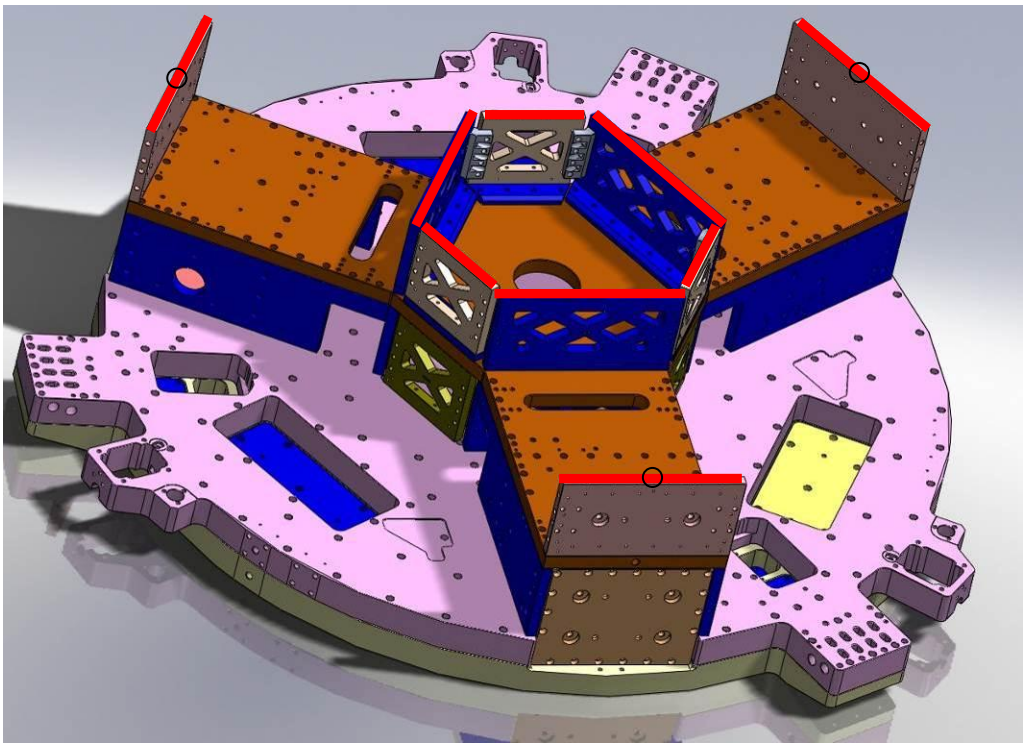


Figure 85: D0901518 Keel Plate Down-Facing contact areas with Stage 2 in red and pins locations circled in black

Note: Start by attaching D0901518 Keel Plate Down-Facing to D0901526 & D0901528 Inner Upper Hex Walls and work your way inside out finishing with D0901533 Upper Outer Walls.

Note: **When fastening any of the Large Plates (D0900894, D0900895, D0901516, D0901517, D0901518, D0901519, D0901520, D0902273, D0902279 & D0902503), after torqueing all the bolts once, go around a second time, checking that all of them are torqued to specs. Repeat these steps until all of the bolts are fully torqued.**

Hardware:
(51) 3/8-16 x 2" SHCS – MSC 75464701
(51) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws from the top through D0901518 Keel Plate Down-Facing into D0901526 D0901528 & D0901533 Stage 2 Upper Walls.
- Snug all the screws and **torque them to 329 in.lbs (27 ft.lbs).**

1.62. Attach (12) D0901539 Outer Wall Gussets to D0901518 Keel Plate Down-Facing, D0901520 Stage 2 Mid Plate & D0901533 Upper Outer Walls

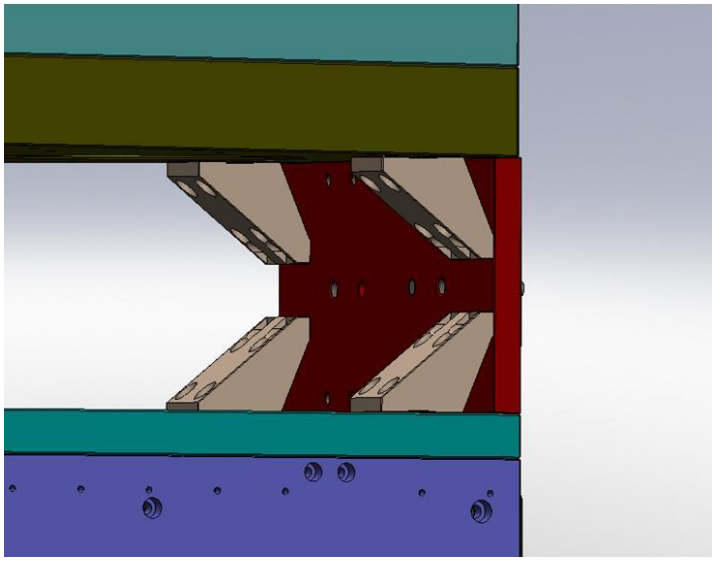


Figure 86 D0901539 Outer Wall Gussets in place

Hardware:

(4) 3/8-16 x 1.25" SHCS – MSC 75464644 – to D0901533 Upper Outer Wall

(2) 3/8-16 x 2.5" SHCS – MSC 75464727 – to D0901520 Stage 2 Mid Plate or to D0901518 Keel Plate Down Facing

(6) 3/8 Vented Washers - UCC-WFV-38

- Locate D0901539 Outer Wall Gusset on D0901518 Keel Plate Down-Facing, & D0901533 Upper Outer Wall or on D0901520 Stage 2 Mid Plate & D0901533 Upper Outer Wall as shown on Figure 86.
- Insert all the screws through D0901539 Outer Wall Gusset itself into D0901520 Stage 2 Mid Plate, D0901518 Keel Plate Down-Facing (3/8-16 x 2.5" SHCS) or D0901533 Upper Outer Wall (3/8-16 x 1.25" SHCS) as shown on Figure 86.
- Snug all the screws and **torque them to 329 in.lbs (27 ft.lbs).**
- Repeat this step for the (2) other corners of Stage 1.

1.63. Install D0901519 Keel Plate Up-Facing.

Prep Work for D0901519 Keel Plate Up-Facing:

Hardware:
(24) 1/4-20 x 2 DIA Helicoils
(18) 5/16-24 x 2 DIA Helicoils
(448) 3/8-16 x 1 DIA Helicoils

- Install Nitronic 60 Helicoil threaded inserts into D0901519. See Figure 87.

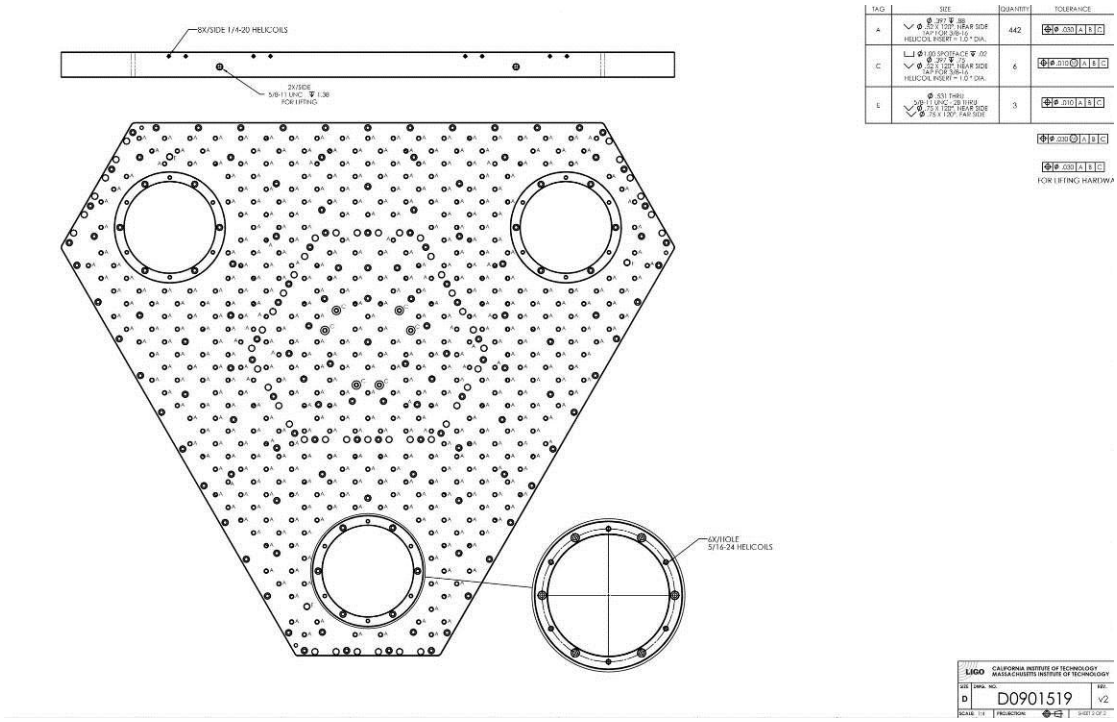


Figure 87: Prep Work for D0901519 Keel Plate Up-Facing

Note: **There is an orientation for D0901519 Keel Plate Up Facing in order to be able to mount correctly the Lifting Fixture (See Figure 88)**

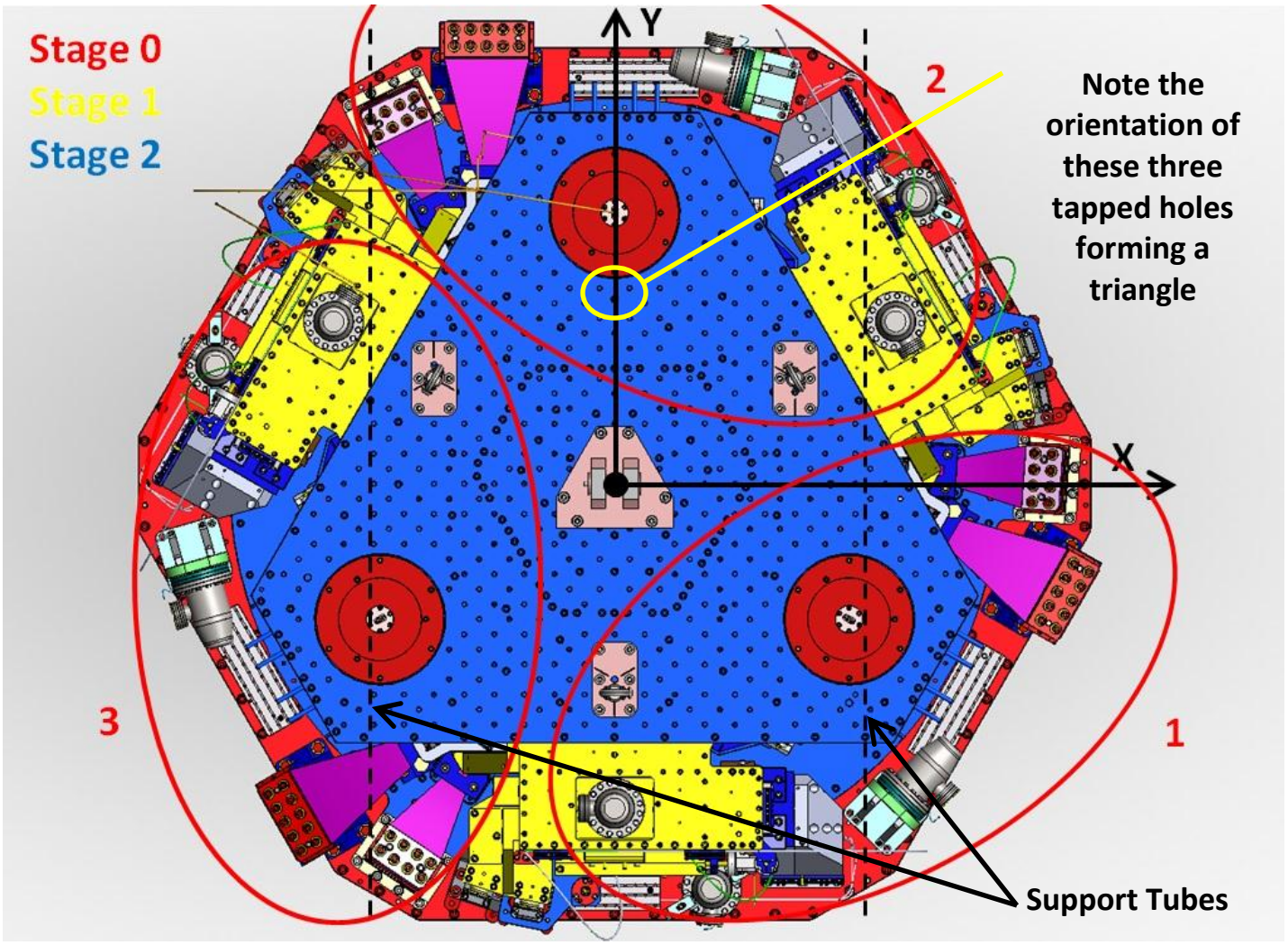


Figure 88: Orientation of D0901519 Keel Plate Facing Up

- Lift D0901519 Keel Plate Up-Facing using (3) 5/8-11 Tapped Lifting holes shown on Figure 87 & Figure 89.

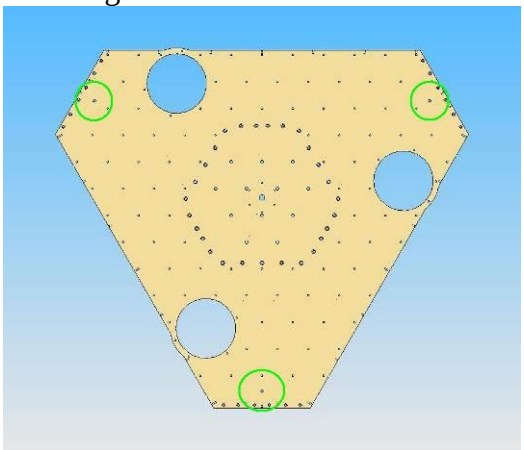


Figure 89: Lifting hook locations on keel plate.

- Position D0901519 (pocketed surface facing down) over D0901518 Keel Plate Down-Facing as shown on Figure 90. D0901519 Keel Plate Up-Facing is located with (3) 1/2" x 1.25" dowel pins already pressed in (3) D0901518 Keel Plate Down-Facing (see Figure 84).

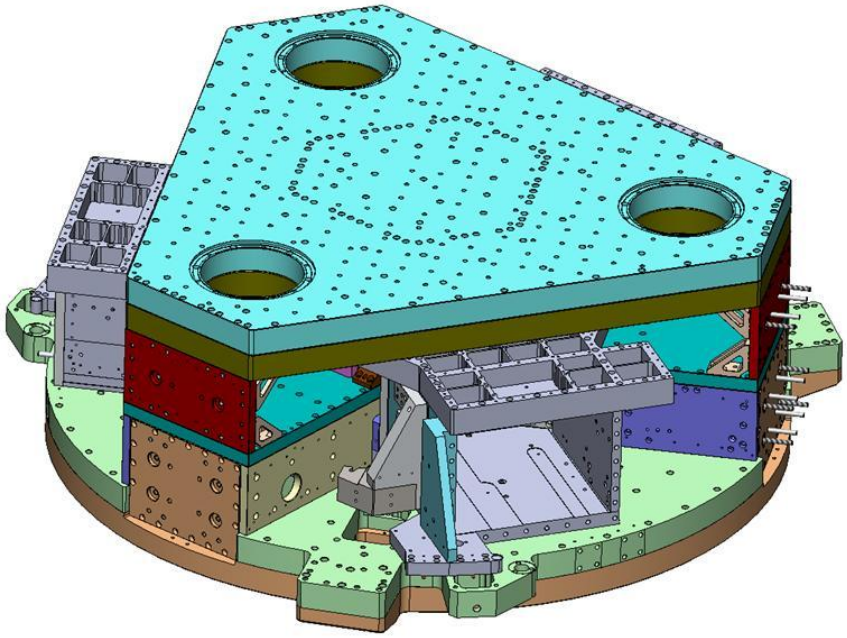


Figure 90: Assembly with D0901518 & D0901519 Keel Plates on

Note: **When fastening any of the Large Plates (D0900894, D0900895, D0901516, D0901517, D0901518, D0901519, D0901520, D0902273, D0902279 & D0902503), after torqueing all the bolts once, go around a second time, checking that all of them are torqued to specs. Repeat these steps until all of the bolts are fully torqued.**

Hardware:
(127) 3/8-16 x 2" SHCS – MSC 75464701
(127) 3/8 Vented Washers - UCC-WFV-38

- Insert all the screws from the top through D0901519 Keel Plate Up-Facing into D0901518 Keel Plate Down-Facing.
- Snug all the screws and **torque them to 329 in.lbs (27 ft.lbs).**

Install keel weights

To make sure that the system is at the correct weight before floating, dummy weights for any missing optics/instruments on Stage 2 will be added as shown on Figure 91.

Quantity	Part Number	Description	Weight
3	D972213	Isolation Stack Leg Element #1	610.7 lbs.
2	D972215	Isolation Stack Leg Element #3	233.5 lbs.

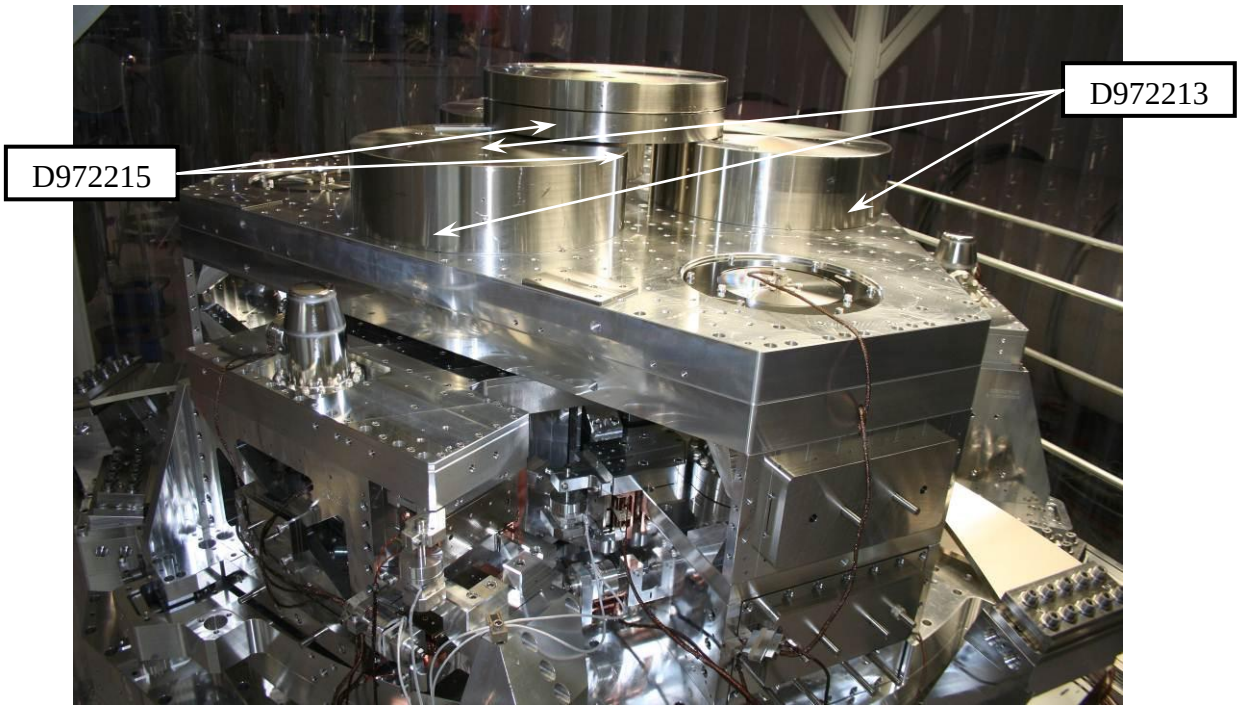


Figure 91: Mass Distribution for the BSC-ISI 1/2

The following Trim Masses (much lighter than the 2 first ones) or even other masses might be used to adjust the leveling of the BSC-ISI as shown on Figure 92:

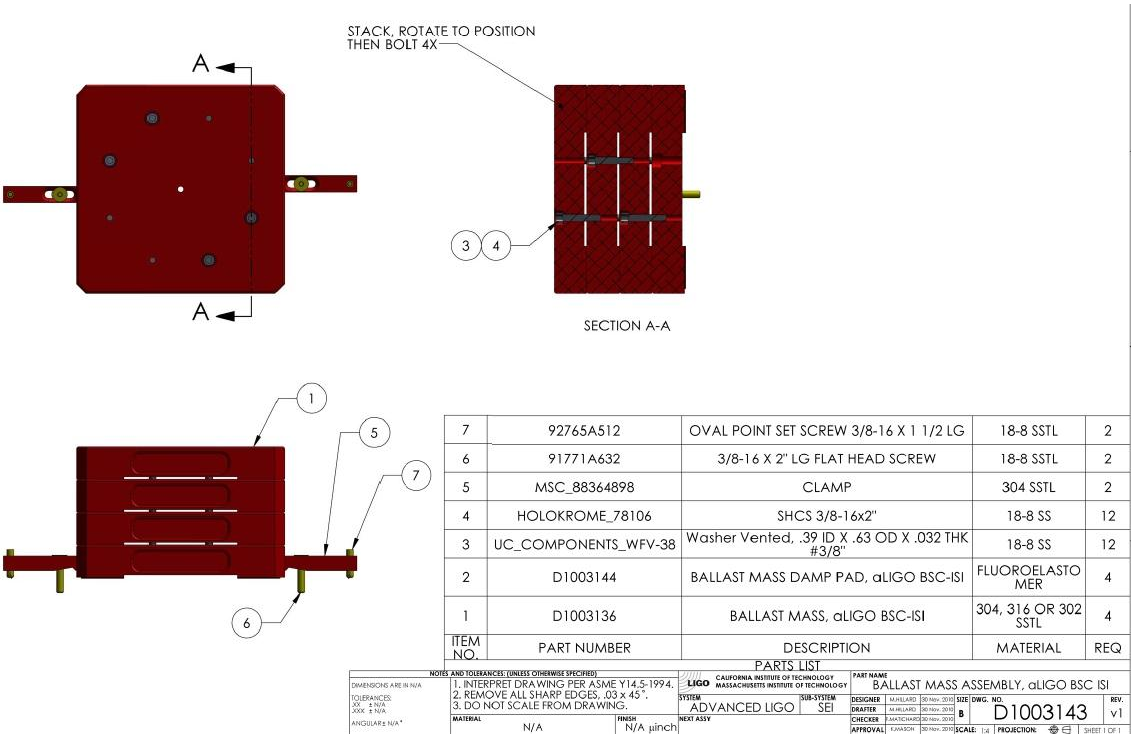
Quantity	Part Number	Description	Weight
	D0902612	BSC Stage 1 Lateral Trim Mass 12 lbs.	12 lbs.
	D0902613	BSC Stage 1 Lateral Trim Mass 15 lbs.	15 lbs.
	D0902614	BSC Stage 1 Front Lower Trim Mass 10 lbs.	10 lbs.
	D0902615	BSC Stage 1 Front Upper Trim Mass 10 lbs.	10 lbs.
…	…	…	…

Figure 92: Mass Distribution for the BSC-ISI 2/2

Quantity	Part Number	Description	Weight
4	D1003136	BSC Ballast Mass.	50 lbs
4	D1003144	BSC Ballast Mass Damp Pad	

Note: For the final balancing the following masses will be used and stacked as shown on Figure 93:

<u>Hardware:</u>
(12) 3/8-16 x 2" SHCS – MSC 75464701
(12) 3/8 Vented Washers - UCC-WFV-38
(2) 3/8-16 x 1.5" Oval Point Set Screw – McMaster 92765A512
(2) 3/8-16 x 2" Flat Head Screw – McMaster 91771A632
(2) Clamp – MSC 88364898



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ
7	92765A512	OVAL POINT SET SCREW 3/8-16 X 1 1/2 LG	18-8 SSTL	2
6	91771A632	3/8-16 X 2" LG FLAT HEAD SCREW	18-8 SSTL	2
5	MSC_88364898	CLAMP	304 SSTL	2
4	HOLOKROME_78106	SHCS 3/8-16x2"	18-8 SS	12
3	UC_COMPONENTS_WFV-38	Washer Vented, .39 ID X .63 OD X .032 THK #3/8"	18-8 SS	12
2	D1003144	BALLAST MASS DAMP PAD, aLIGO BSC-ISI	FLUOROELASTOMER	4
1	D1003136	BALLAST MASS, aLIGO BSC-ISI	304, 316 OR 302 SSTL	4

PARTS LIST

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)
DIMENSIONS ARE IN N/A
TOLERANCES:
XX ± N/A
XXX ± N/A
ANGULAR± N/A°
1. INTERPRET DRAWING PER ASME Y14.5-1994.
2. REMOVE ALL SHARP EDGES, .03 x 45°.
3. DO NOT SCALE FROM DRAWING.
MATERIAL: N/A
FINISH: N/A µinch
NEXT ASSY

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY
PART NAME: BALLAST MASS ASSEMBLY, aLIGO BSC ISI
SYSTEM: ADVANCED LIGO | SUB-SYSTEM: SEI
DESIGNER M.HILLARD 30 Nov. 2010
DRAFTER M.HILLARD 30 Nov. 2010
CHECKER K.MATCHARD 30 Nov. 2010
APPROVAL K.KAWABE 30 Nov. 2010
SIZE: B | DWG. NO.: D1003143 | REV.: v1
SCALE: 1:4 | PROJECTION: | SHEET 1 OF 1

Figure 93: D1003143 BSC-ISI Ballast Mass Assembly

Add any Trim Weights equivalent to any missing instruments

To make sure that the system is at the correct weight before floating, dummy weights for any missing instruments or parts will need to be added. Looking through the checklist below to find parts not yet installed will determine what dummy weights are needed.

Please refer to the latest version of E0900385.

Note that if stage 0-1 locks are hanging from stage 1 that part of that weight actually belongs on stage 0. Don't forget to compensate for this.

Table 1: Weights Compensation Table

		Weight (lbs)		
Part	**Part #**	**Stage 0**	**Stage 1**	**Stage 2**
Actuator Post	**D0901554**	**148.4**	0	0
Actuator Bridge	**D0901183**	**12.1**	0	0
GS-13	**D0900857**	0	0	**464.1**
Trillium	**D0900648**	0	**261.5**	0
L-4C	**D0902624**	**123.2**	**123.2**	0
0-1 Horizontal Actuator				0
0-1 Vertical Actuator				0
1-2 Horizontal Actuator		0		
1-2 Vertical Actuator		0		
0-1 Horizontal Actuator Field Adapter Bracket		0		0
0-1 Horizontal Actuator Coil Adapter Bracket			0	0
1-2 Vertical Actuator Coil Adapter Bracket		0		
1-2 Horizontal Actuator Field Adapter Bracket		0		
1-2 Horizontal Actuator Coil Adapter Bracket		0		
0-1 Locks				0
1-2 Locks		0		

Assemble and Install 1-2 Blade Spring

See blade spring assembly drawing: D0902485.

Parts required

Quantity	Part Number	Description	Weight
3	D0902502	Blade Spring	9 lbs.
3	D0902647	Stage 1-2 Spring Base	1 lbs.
3	D1100564	Blade Spring Clamp Plate	
3	D0902695	Stage 1-2 Spring Clamp Cap	

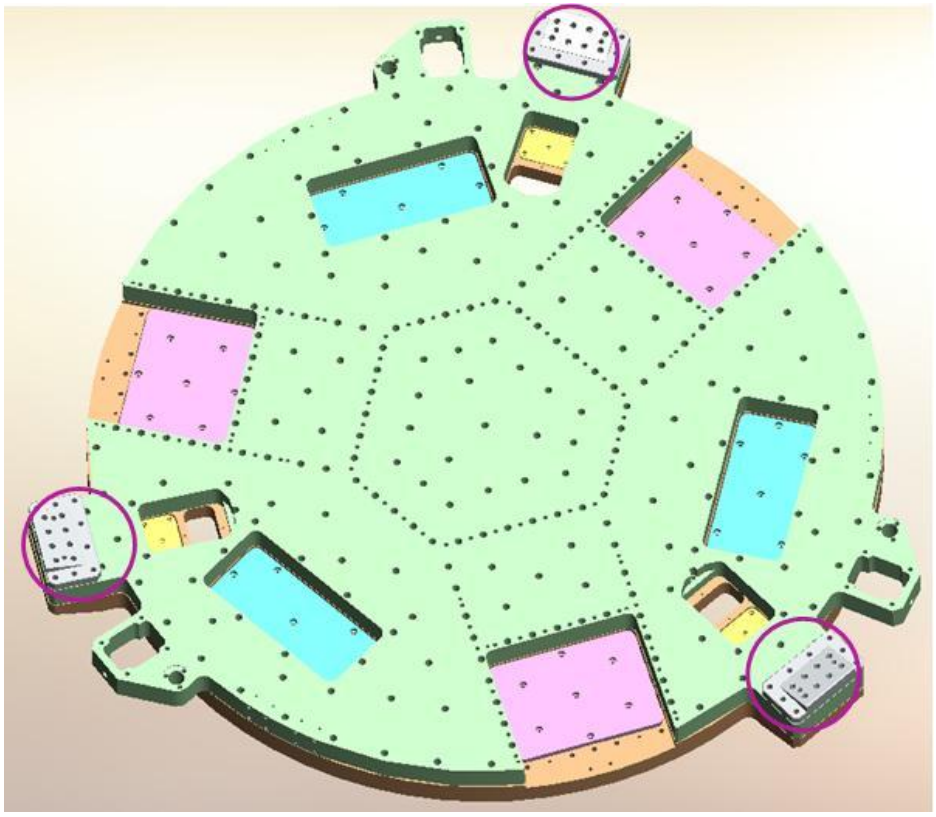
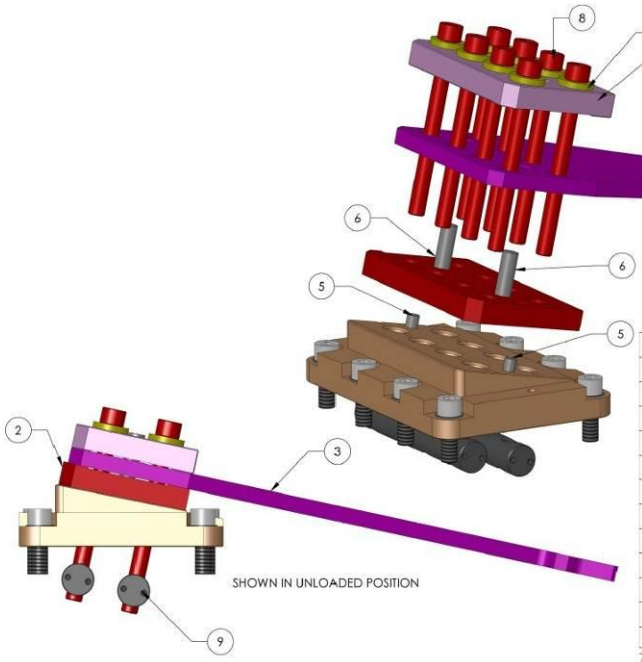


Figure 94: Stage 2 Spring Base Location on D0901517 Cut Out Optical Table

Hardware:
(8) 1/2-13 x 1.5" SHCS – MSC 75464842
(8) 1/2 Vented Washers - UCC-WFV-50
(8) 1/2-13 x 5.5" Eastwood Bolts Ag Plated – D1200675
(8) 1/2 Washers (.53 ID X 1.13 OD X .19 THK) – McMaster 98125A033
(2) 3/8" x 1" dowel pin – MSC 67601724
(2) 1/2" x 2" dowel pins – MSC 67602128

- Press (2) 3/8" x 1.0" Dowel Pins into each D0902647 Stage 1-2 Spring Base as shown on Figure 95.



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ
12	UC_COMPONENTS_WFV-50	Vented Washer, .515 ID X .87 OD X .032 THK #1/2"	18-8 SS	8
11	HOLOKROME_78116	SHCS, 1/2-13 x 1.5"	300 SSTL	8
10	D1002380	Barrel Nut Bar, Stage 1-2, aLIGO BSC ISI	NITRONIC 60	4
9	D0902104	FLEXURE ROD ASSEMBLY, STAGE 1-2, aLIGO BSC ISI	N/A	1
8	D1200675	Custom Bolt from Eastwood, 1/2-13x5.5 SHCS 17-4	17-4 PH SSTL	8
7	MCMASTER_98125A033	Washer, .53 ID X 1.13 OD X .19 THK	18-8 SSTL	8
6	MCMASTER_99010A345	Dowel Pin, 1/2 od x 2 lg. x .5009"-.5011" thck	18-8 SS	2
5	MCMASTER_90145A624	Dowel Pin, 3/8"x1.0"	18-8 SS	2
4	D0902695	Spring Clamp Cap, Stage 1-2, aLIGO BSC ISI	17-4 PH SSTL, H 1150	1
3	D0902502	Blade Spring, Stage 1-2, aLIGO BSC ISI	MARAGING STEEL C300	1
2	D1100564	Stage 1-2 Angled Blade Spacer, aLIGO BSC ISI	304 SSTL	1
1	D0902647	Spring Base, Stage 1-2, aLIGO BSC ISI	6061-T6 Al	1

NOTES AND TOLERANCES (UNLESS OTHERWISE SPECIFIED)
ARE IN INCHES
1. INTERPRET DRAWING PER ASME Y14.5-1994.
2. REMOVE ALL SHARP EDGES, R32 MIN.
LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY
PART NAME
Stage1-2 Blade Spring Flexure Assem

Figure 95: D0902485 Stage 1-2 Blade Assembly Exploded View

- Place D0902647 Stage 1-2 Spring Base on the Optical Table as shown on Figure 94, the position is determined by the (2) dowel pins inserted previously in the Optical Table. Make sure pins seat properly into mating hole and slot.
- Insert and snug (8) 1/2"-13 x 1.5" SHCS.
- **Torque them to 805 in-lbs (67 ft-lbs).**
- Place D1100564 Stage 1-2 Angled Blade Spacer on D0902647 Stage 1-2 Spring Base. Its position is determined by (2) 3/8" x 1" dowel pins. Make sure pins seat properly into mating hole and slot.
- Insert (2) 1/2" x 2" dowel pins in D1100564 Stage 1-2 Angled Blade Spacer as shown on Figure 95.
- Place D0902502 Stage 1-2 Spring Blade on D1100564 Stage 1-2 Angled Blade Spacer. Its location is determined by (2) 1/2" x 2" dowel pins previously inserted in D1100564.
- Place D0902695 Stage 1-2 Spring Clamp Cap on top of D0902502 Stage 1-2 Spring Blade.

Note: Its location is also determined by these (2) 1/2" x 2” dowel pins.

- Insert and snug (8) 1/2”-13 x 5.5” Eastwood Bolts Ag Plated with (8) 1/2" McMaster 98125A033 Washers. Before torqueing, make sure that D0902502 Stage 1-2 Spring Blade & D0902695 Stage 1-2 Spring Clamp Cap are against the (2) 1/2" x 2” dowel pins. If they are a little bit loose, push D0902502 & D0902695 against these pins as shown by the black arrows on Figure 96.

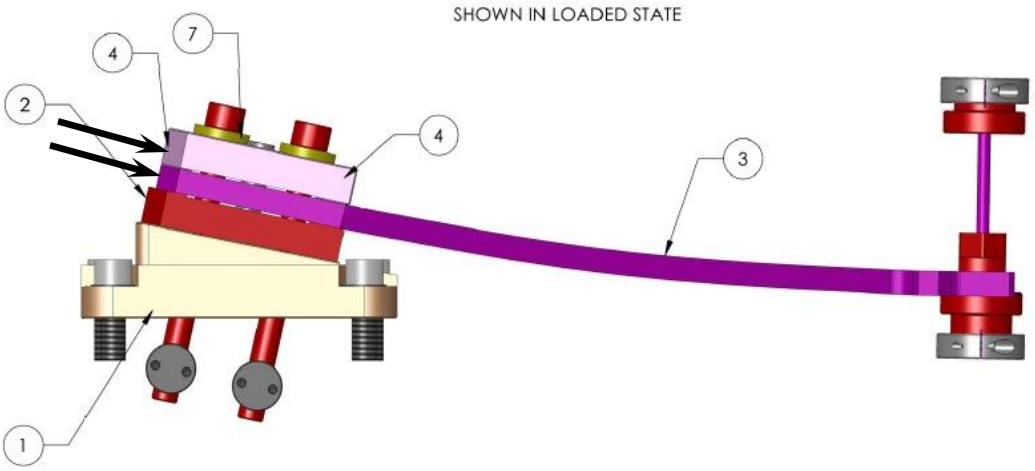


Figure 96: D0902485 Stage 1-2 Blade Assembly Drawing in the Loaded State

- **Torque them to 110 ft-lbs. DO NOT USE METHANOL OR ISOPROPANOL on these bolts, it would change the actual torque value on them!**
- Repeat these steps for the (3) corners of the Optical Table.

Note: To align D0902502 Stage 1-2 Spring Blade on the saddle use an Alignment Rod (specially made tooling).

- Place the Alignment Rod in the “U” of the end of the blade spring and in the flexure rod bracket as shown on Figure 97, Figure 98 & Figure 99. The Rod will fit snugly and will determine if the spring is properly aligned before loading it.

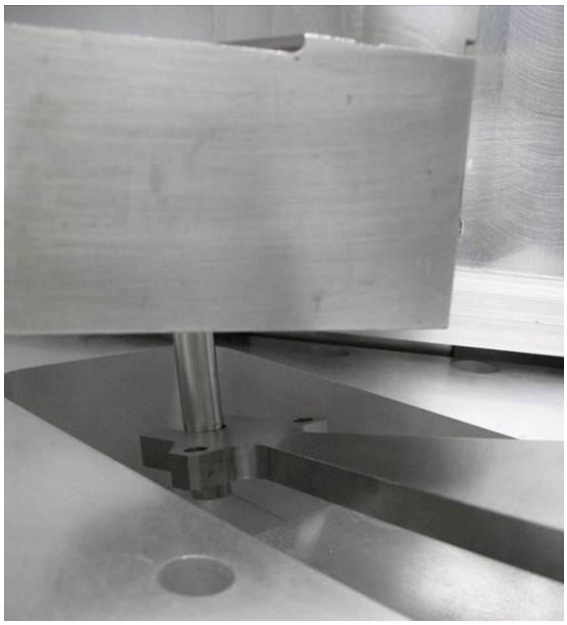


Figure 97: Alignment Rod in end of D0902502 Stage 1-2 Blade Spring and D0902276 Stage 1 Flexure Rod Bracket

Figure 98: Top of Alignment Rod on D0902276 Stage 1 Flexure Rod Bracket (looking down from the top)

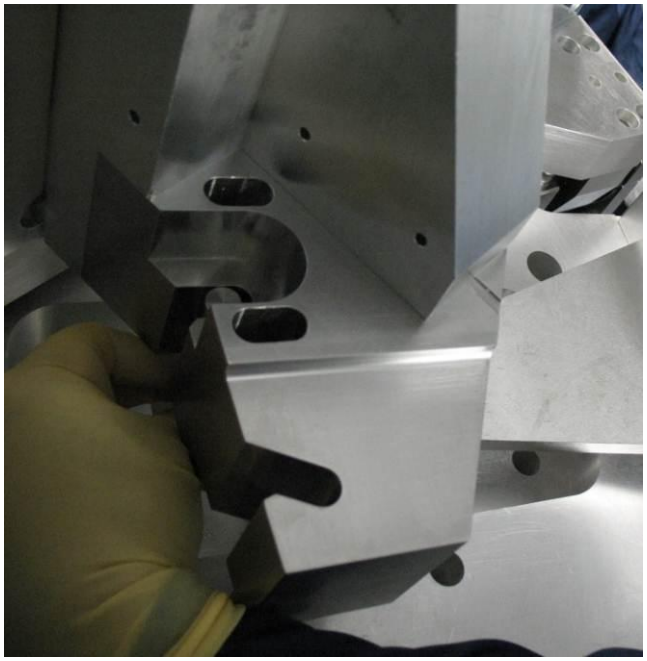


Figure 99: Inserting Alignment Rod for D0902502 Stage 1-2 Spring Blade

Assemble D0902104 Flexure Rod Assembly

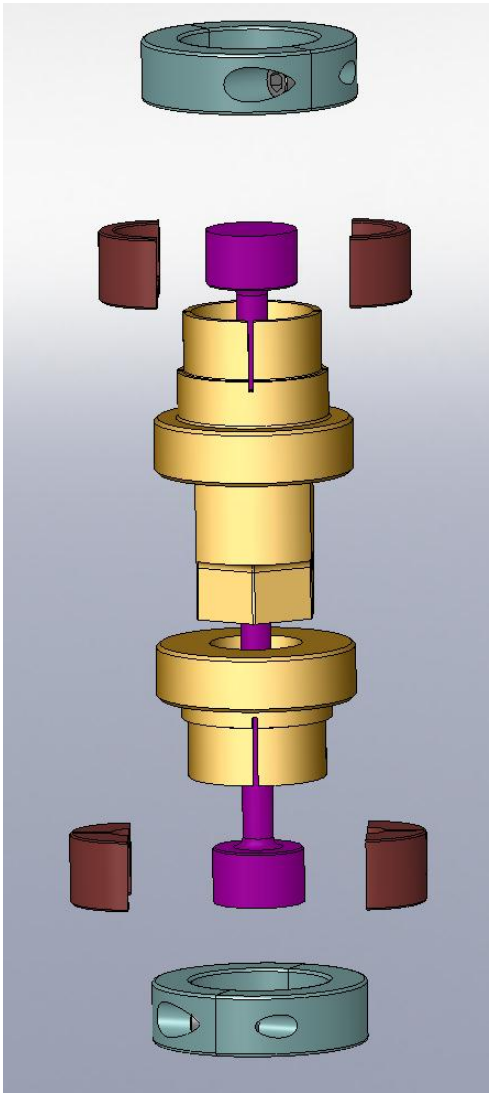
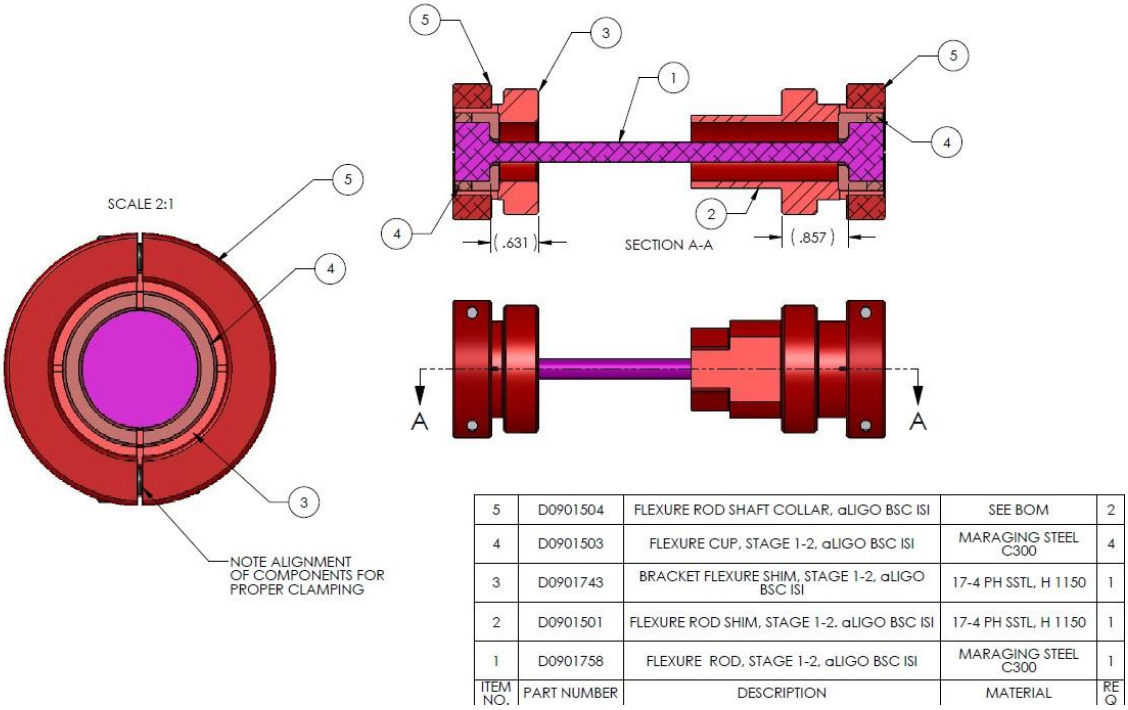


Figure 100: Exploded View of D0902104 Stage 1-2 Flexure Rod Assembly

Quantity	Part Number	Description	Weight
3	D0901501	Stage 1-2 Flexure Rod Shim	
12	D0901503	Stage 1-2 Flexure Cup	
6	D0901504	Flexure Rod Shaft Collar	
3	D0901743	Stage 1-2 Bracket Flexure Shim	
3	D0901758	Stage 1-2 Flexure Rod	

Note: The Flexures are **fragile**! Before starting this section, check that all are still straight (e.g., by rolling them on a surface plate).

- Place D0901758 Stage 1-2 Flexure Rod vertical on a level surface.
- Have (2) D0901503 Stage 1-2 Flexure Cups sit on the bottom head of D0901758.
- Slide D0901743 Stage 1-2 Bracket Flexure Shim in place as shown on Figure 100 & Figure 101.
- Slide D0901501 Stage 1-2 Flexure Rod Shim over and let it go in contact with D0901743.
- Place (2) other D0901503 Stage 1-2 Flexure Cups inside D0901743.
- Slide D0901501 Stage 1-2 Flexure Rod Shim up until D0901503 Stage 1-2 Flexure Cups are in contact with the top of D0901758 Stage 1-2 Flexure Rod.



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ
5	D0901504	FLEXURE ROD SHAFT COLLAR, aLIGO BSC ISI	SEE BOM	2
4	D0901503	FLEXURE CUP, STAGE 1-2, aLIGO BSC ISI	MARAGING STEEL C300	4
3	D0901743	BRACKET FLEXURE SHIM, STAGE 1-2, aLIGO BSC ISI	17-4 PH SSTL, H 1150	1
2	D0901501	FLEXURE ROD SHIM, STAGE 1-2, aLIGO BSC ISI	17-4 PH SSTL, H 1150	1
1	D0901758	FLEXURE ROD, STAGE 1-2, aLIGO BSC ISI	MARAGING STEEL C300	1

Figure 101: D0902104 Stage 1-2 Flexure Rod Assembly

Hardware:
(4) #8-32 x 0.5" Ag-plated SHCS – UCC C-808-NA

- Attach top D0901504 Flexure Rod Shaft Collar.
- Attach bottom D0901504 Flexure Rod Shaft Collar.
- Ensure that the rod heads are in an even position in the cups and **torque screws to 19.8 in.lbs (1.7 ft.lbs).**

Assemble Stage 1-2 Pre-Load Tooling

For assembly of the Loading Tool refer to D0902454, for assembly of the Safety Tool refer to D09002164.

Parts required

Quantity	Part Number	Description	Weight
1	D0902165	Cap	
2	D0902166	Special Screw	
1	D0902167	Post	
2	D0902188	Rod	
1	D0902191	Pre-Load Bracket Saddle	
1	D0902190	Pivoting Nut	
1	D0902488	Blade Spring Preload Bracket	
1	D0902193	Puller Screw	
1	D0902186	Bushing or Centering Washer	
1	D0902187	Connection Block	
1	D0902192	Basket	
1	D0902189	Rod End Spacer	

Prep Work for D0901516 Solid Optical Table:

Hardware:
(2) 5/16" x 1" dowel pins

- Press (2) 5/16" x 1" dowel pins into D0902192 Basket. Pins should sit about 0.4" above the surface (see Figure 102).

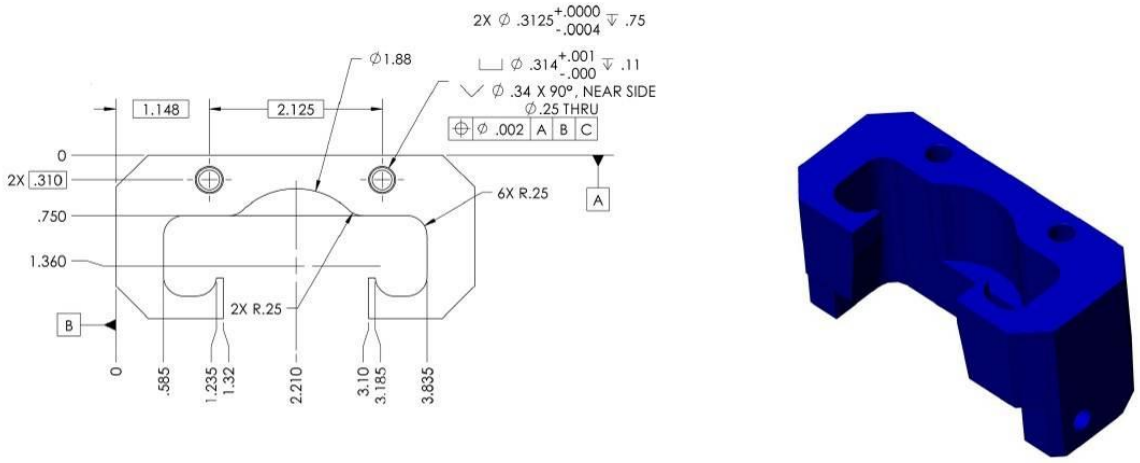
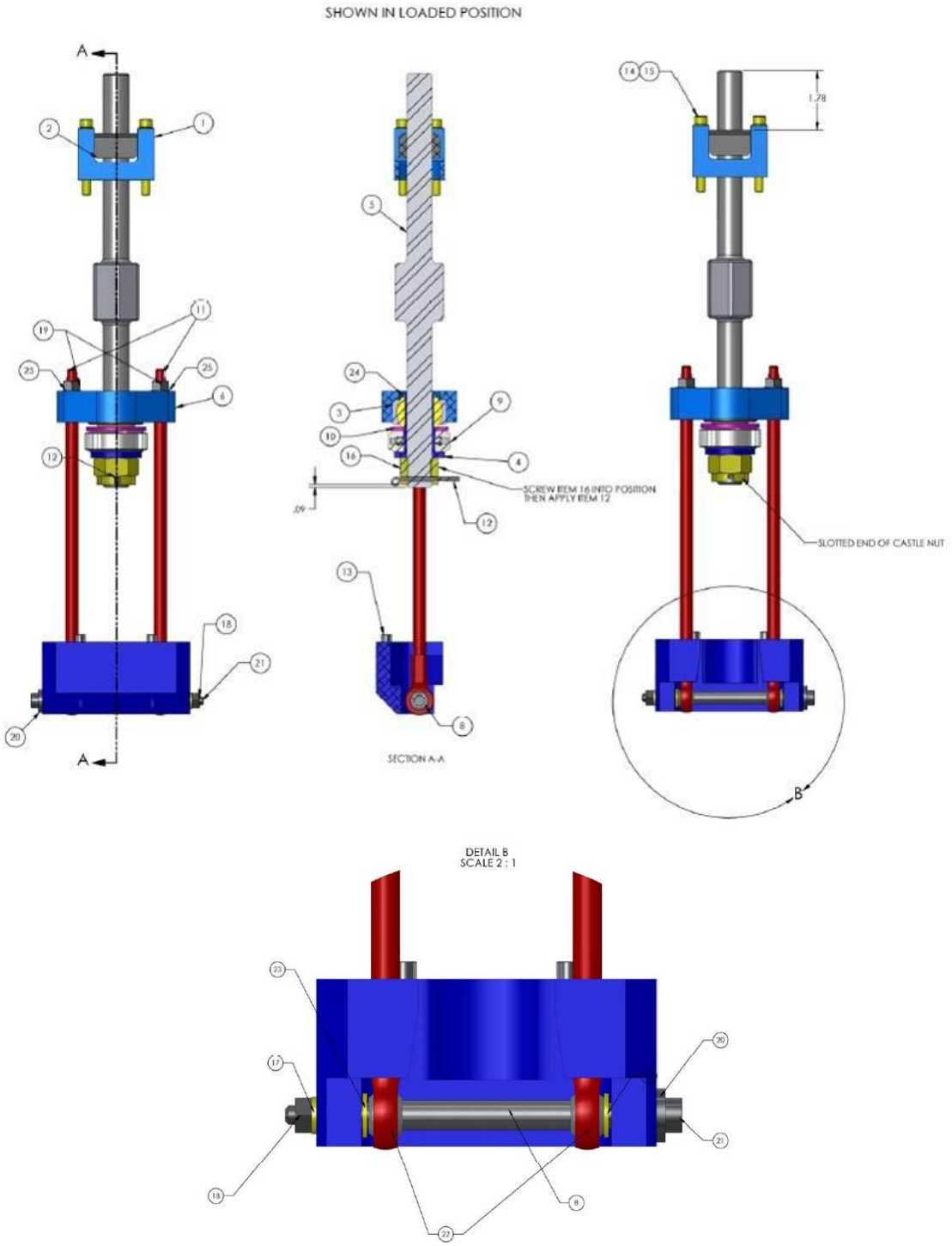
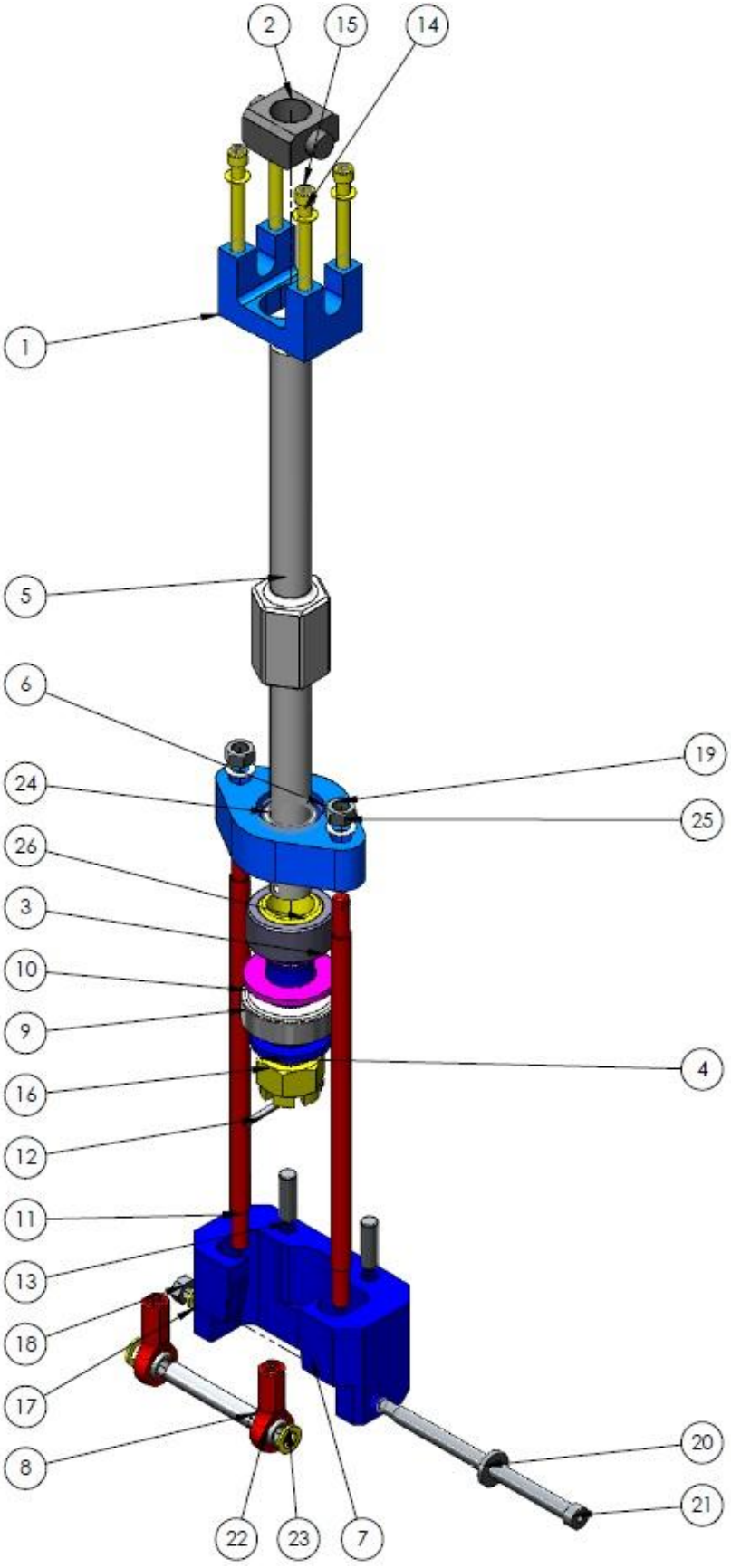


Figure 102: Prep Work for D0902192 Basket


SHOWN IN LOADED POSITION
A
A
SECTION A-A
SCREW ITEM 16 INTO POSITION
THEN APPLY ITEM 12
SLOTTED END OF CASTLE NUT
1.78
B
DETAIL B
SCALE 2 : 1


2
15
14
1
5
6
19
24
25
26
3
10
9
4
16
12
11
13
18
17
8
20
21
22
23
7

25	McMaster_98017A689	Washer .56 od x .32 id x .02-.04 thk	300 SSTL	2
24	McMaster_91590A131	RETAINING RING	15-7 MO SS	1
23	McMaster_98017A690	Washer .57 od x .32 id x .05-.07 thk	300 SSTL	2
22	McMaster_59915K483	Ball Joint Rod End 5/16-24 thd x 5/16 id 7/8 od 1.38 lg	302 SSTL	2
21	McMaster_90298A603	Shoulder Screw 5/16 shoulder 4.5 lg 1/4-20 thd	18-8 SS	1
20	McMaster_98370A017	Washer .68 od x .344 id x .11-.14 thk	18-8 SS	1
19	McMaster_91845A030	Hex Nut 5/16-18	18-8 SS	2
18	McMaster_91845A029	Hex Nut 1/4-20	18-8 SS	1
17	McMASTER_90945A761	WASHER .26 ID X .47 OD X .06-.07 THK (NAS 620-C416)	300 SSTL	1
16	MSC_67484246	CASTLE NUT, 3/4-16	18-8 SSTL	1
15	HOLOKROME_78070	Screw shcs 1/4-20 UNC-3A X 2" lg.	300 SSTL	4
14	UCC WFV-25	Flat Washer, Vented .255 ID, .46 OD, .032 THK	18-8 SSTL	4
13	McMaster_90145A583	Dowel Pin 5/16 x 1" lg	18-8 SS	2
12	McMaster_98401A479	Cotter Pin .125 dia x 1.75 lg	18-8 SS	1
11	D0902188	SPRING PRELOAD TOOL ROD, BLADE PULLER ASSY, STAGE 1-2, aLIGO BSC ISI	304 SSTL	2
10	McMaster_98019A524	Washer 1.75 od x .94 id x .10-.14 thk.	300 SSTL	1
9	Stock Drive Products_S9912Y-TB093184	Thrust Bearing 1.844 od x .938 id x .625 thk	Chrome Stainless Steel	1
8	D0902189	SPRING PRELOAD SPACER, BLADER PULLER ASSY, aLIGO BSC ISI	6061 Alloy	1
7	D0902192	SPRING PRELOAD END BRACKET, BLADE PULLER ASSY, STAGE 1-2, aLIGO BSC ISI	6061-T6 Al	1
6	D0902187	SPRING PRELOAD CONNECTION BLOCK, BLADE PULLER ASSY, STAGE 1-2, aLIGO BSC ISI	304 SSTL	1
5	D0902193	SPRING BLADE PULLER BOLT, BLADE PULLER ASSY, STAGE 1-2, aLIGO BSC ISI	420 SSTL	1
4	D0902186	CENTERING WASHER, BLADE PULLER ASSY, STAGE 1-2, aLIGO BSC ISI	6061-T6 Al	1
3	Aurora_Bearing_AWC-14T	Spherical Bearing 1.625 od x .875 id	N/A	1
2	D0902190	SPRING PRELOAD PIVOT, BLADE PULLER ASSY, aLIGO BSC ISI	NITRONIC 60	1
1	D0902191	SPRING PRELOAD SADDLE, BLADE PULLER ASSY, aLIGO BSC ISI	NITRONIC 60	1
ITEM NO.	**PART NUMBER**	**DESCRIPTION**	**MATERIAL**	**REQ**

PARTS LIST

Figure 103: D0902454 Stage 1-2 Blade Puller Assembly Drawing & Exploded View

- Assemble D0902454 Stage 1-2 Blade Puller Assembly as shown on Figure 103.

1.64. Install D0902488 Pre-Load Bracket on D0902277 Flexure Rod Bracket Gusset

Prep Work for D0902488 Pre-Load Bracket:

Hardware:
(12) 1/4-20 x 2 DIA Helicoils
(2) 1/4" x 5/8 dowel pins

- Install Nitronic 60 Helicoil threaded inserts into D0902488 (see red circles on Figure 104).
- Press (2) 1/4" x 5/8" dowel pins into D0902488. Pins should sit about 0.25" above the surface (see green circles on Figure 104).

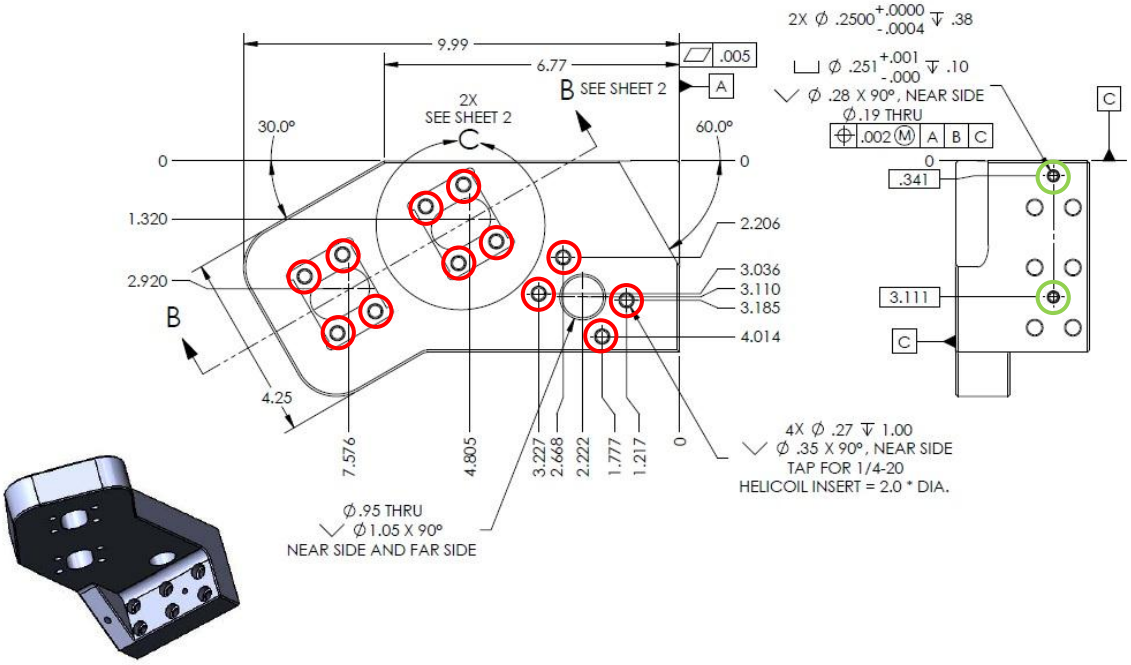


Figure 104: Prep Work for D0902488 Pre-Load Bracket

Hardware:
(6) 5/16-18 x 2" SHCS – MSC_67227231
(6) 5/16 Vented Washers - UCC_WFV-31

- Locate D0902488 Pre-Load Bracket onto the D0902277 Flexure Rod Bracket Gusset with the (2) pins already installed in D0902488 (see Figure 105). Make sure pins seat properly into mating hole and slot.
- Insert all the screws through D0902488 Pre-Load Bracket into D0902277 Flexure Rod Bracket Gusset.
- Snug them and **torque them to 203 in.lbs (16.9 ft.lbs).**

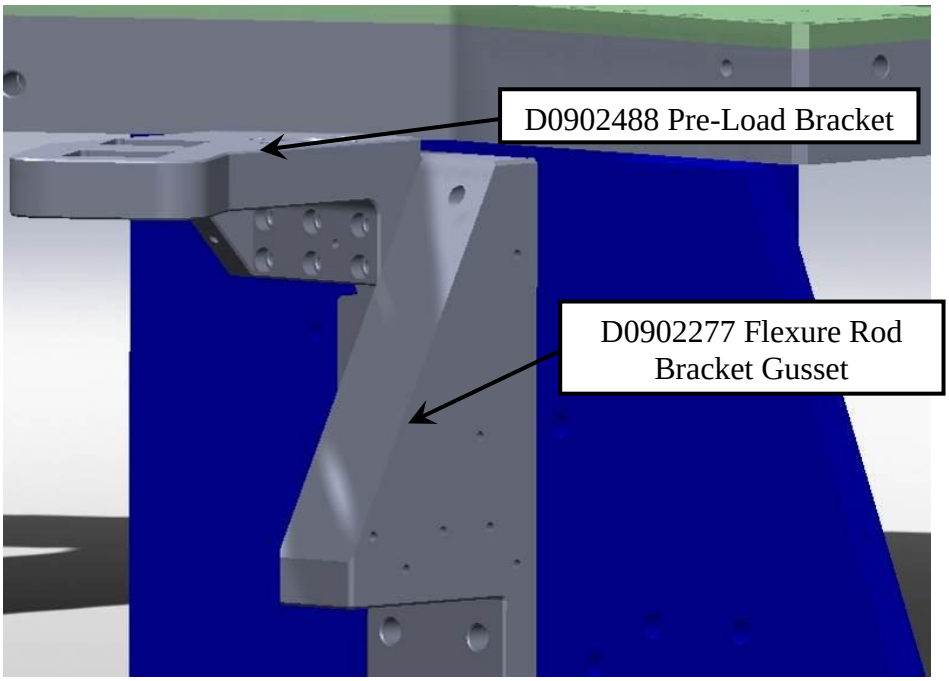


Figure 105: D0902488 Pre-Load Bracket assembled with D0902277 Flexure Rod Bracket Gusset

- Repeat this step for the (2) other D0902488 Pre-Load Bracket.

1.65. Install D0902191 Pre-Load Bracket Saddle on D0902488 Pre-Load Bracket

Hardware:
(4) 1/4-20 x 2" SHCS – MSC 75464487
(4) 1/4 Vented Washers - UCC_WFV-25

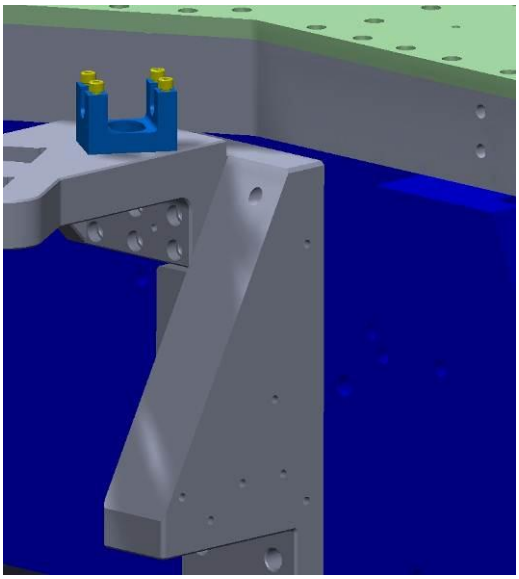


Figure 106: D0902191 Pre-Load Bracket Saddle on D0902488 Pre-Load Bracket

- Insert all screws from top, through D0902191 Pre-Load Bracket Saddle into D0902488 Pre-Load Bracket.
- Snug all the screws and **torque them to 100 in.lbs (8.3 ft.lbs).**
- Repeat this step for the (2) other D0902454 Stage 1-2 Blade Puller Assembly.

1.66. Slide D0902454 Stage 1-2 Blade Puller Assembly Top Parts (see Figure 107) through D0902488 Pre-Load Bracket & D0902191 Pre-Load Bracket Saddle

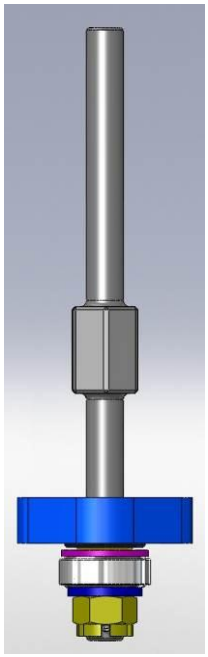


Figure 107: D0902454 Stage 1-2 Blade Puller Assembly Top Parts to slide from below through D0902191 Pre-Load Bracket Saddle

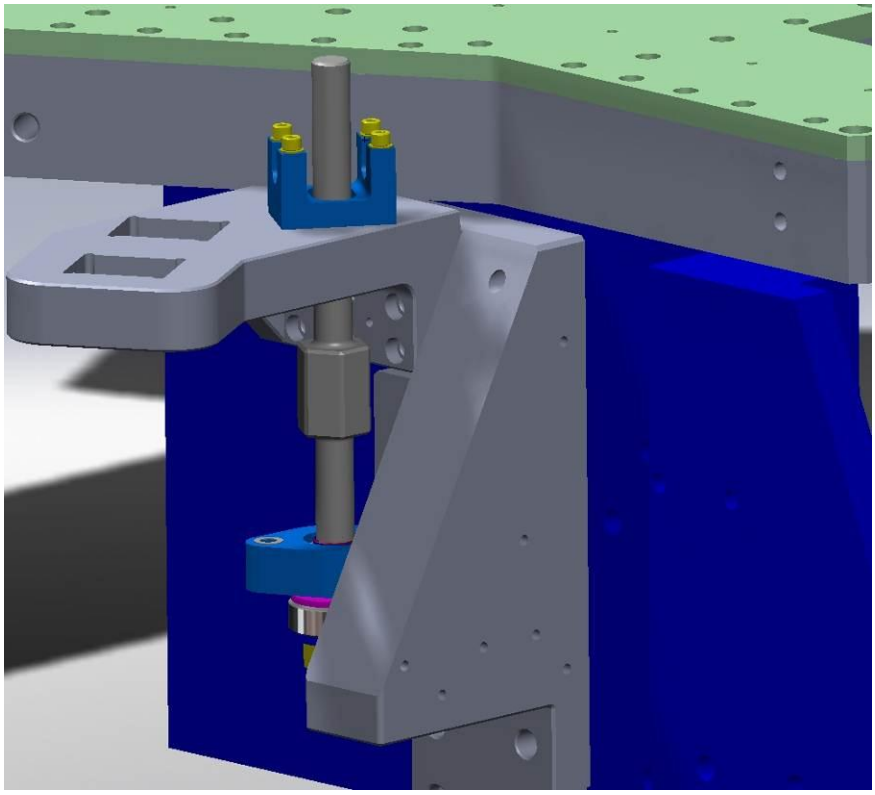


Figure 108: Installation of D0902454 Stage 1-2 Blade Puller Assembly Top Parts 1/2

1.67. Insert D0902190 Pre-Load Pivot on D0902193 Pre-Load Puller Bolt

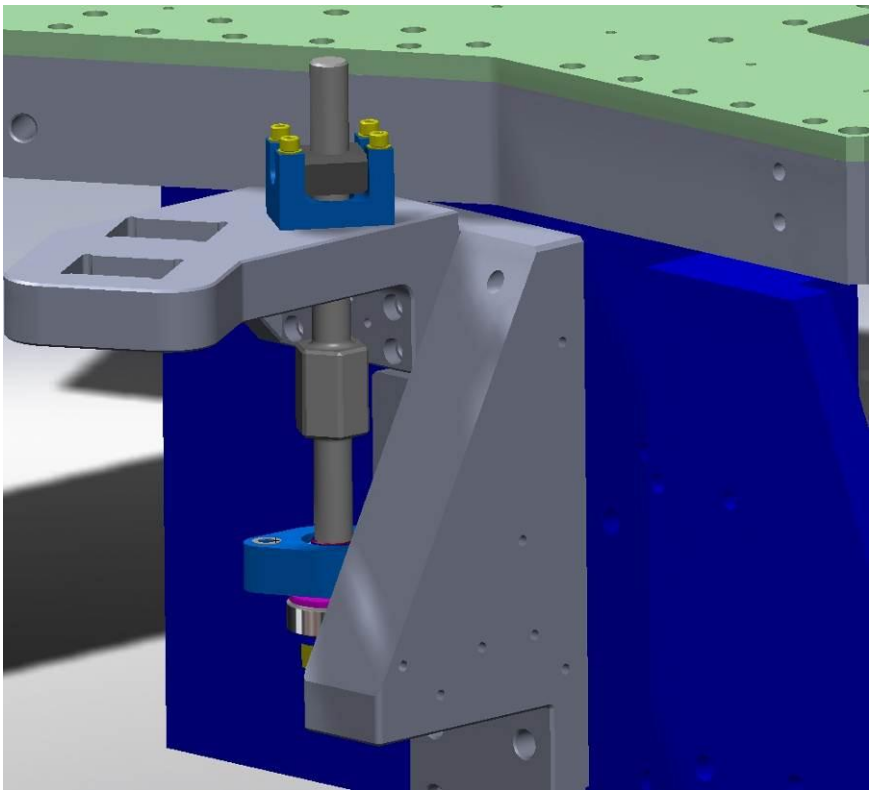


Figure 109: Installation of D0902454 Stage 1-2 Blade Puller Assembly Top Parts 2/2

1.68. Assemble D0902454 Stage 1-2 Blade Puller Assembly Bottom Parts

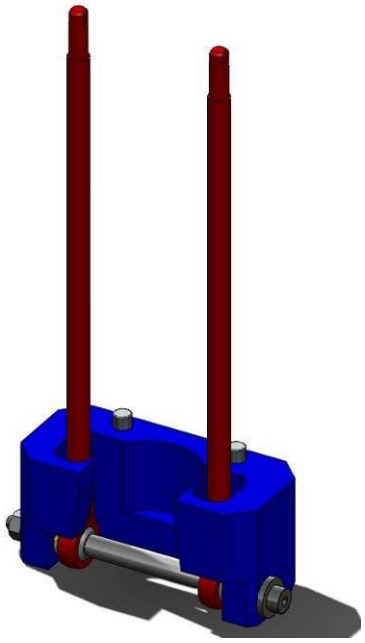


Figure 110: D0902454 Stage 1-2 Blade Puller Assembly Bottom Parts (starting point for this installation)

1.69. Slide D0902454 Stage 1-2 Blade Puller Assembly Bottom Parts from below into D0902187 Pre-Load Connection Block

- Slide the Bottom Part of D0902454 Stage 1-2 Blade Puller Assembly (see Figure 111 & Figure 112) through D0902187 Pre-Load Connection Block from below.
- Insert and snug (2) 5/16-18 Hex Nuts & 5/16" Washers onto D0902188 Pre-Load Tool Rod.

Note: Make sure to insert the (2) 5/16-18 Hex Nuts all the way until the end of the threaded part of D0902188 Pre-Load Tool Rod.

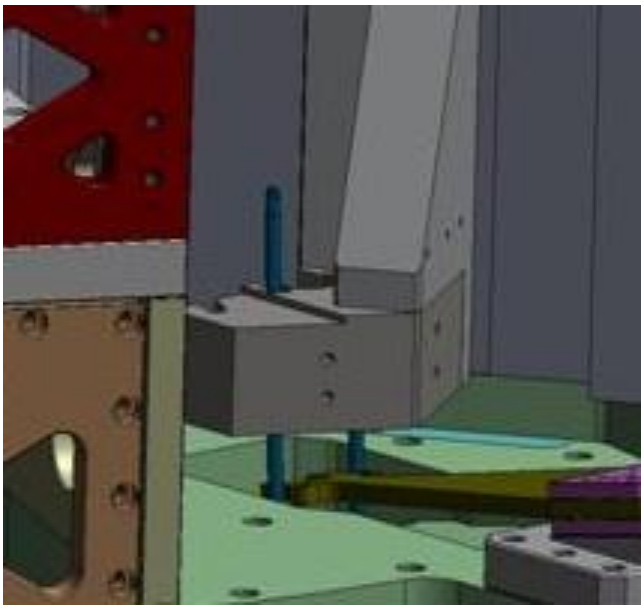


Figure 111: D0902188 Rods in place in D0902276 Flexure Rod Bracket

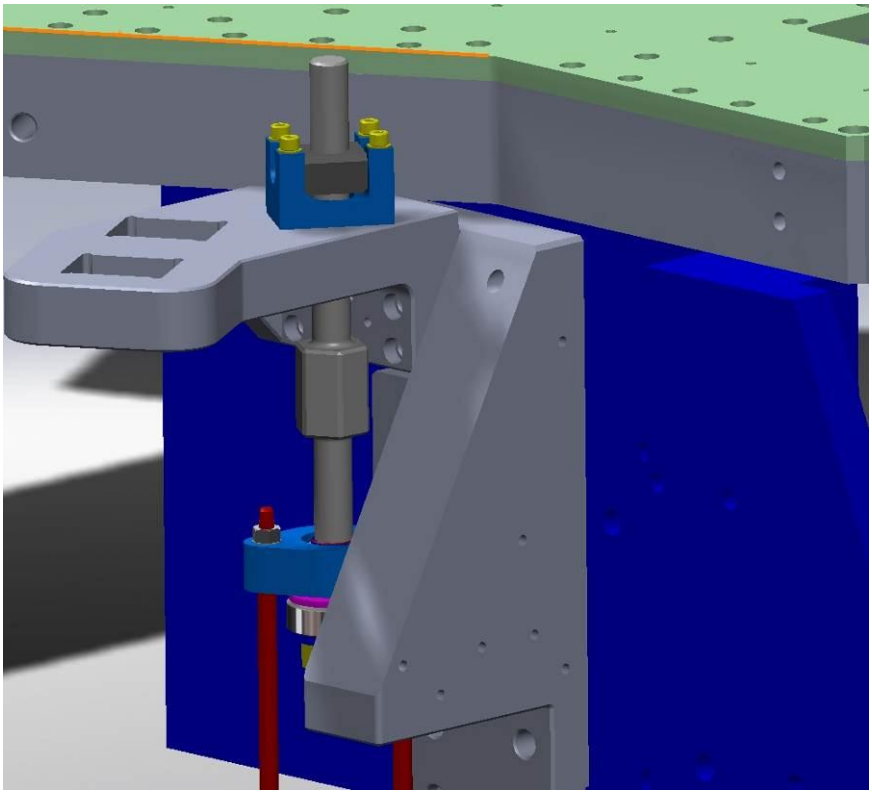


Figure 112: D0902454 Stage 1-2 Blade Puller Assembly mounted on D0902488 Pre-Load Bracket

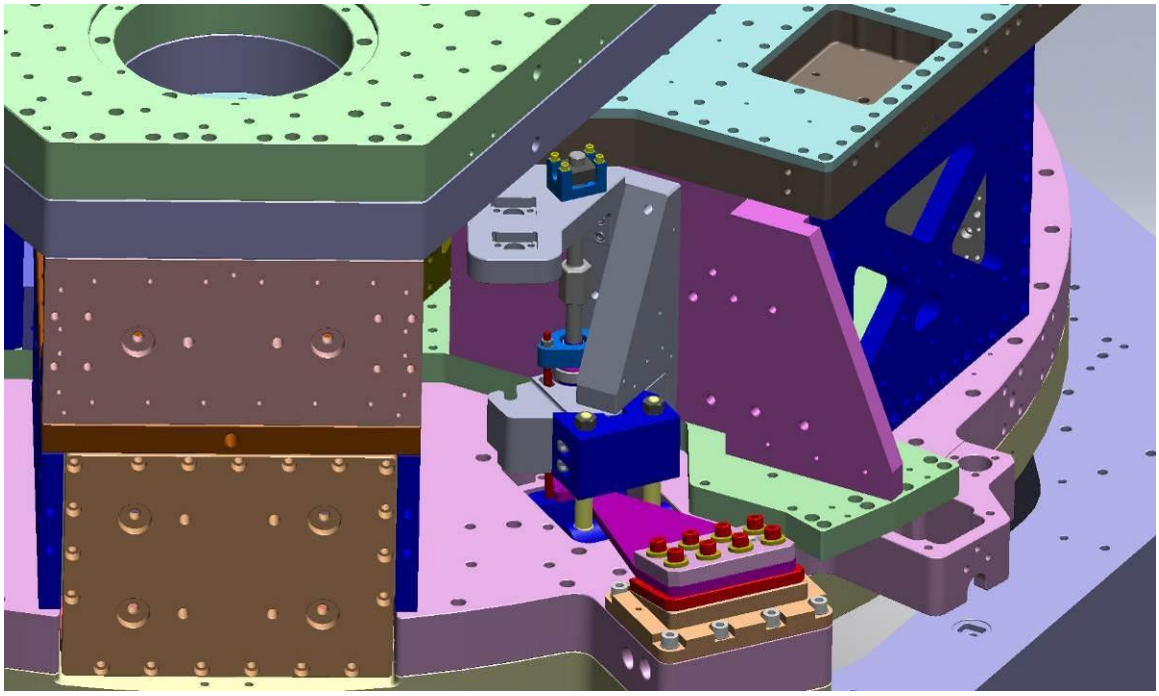


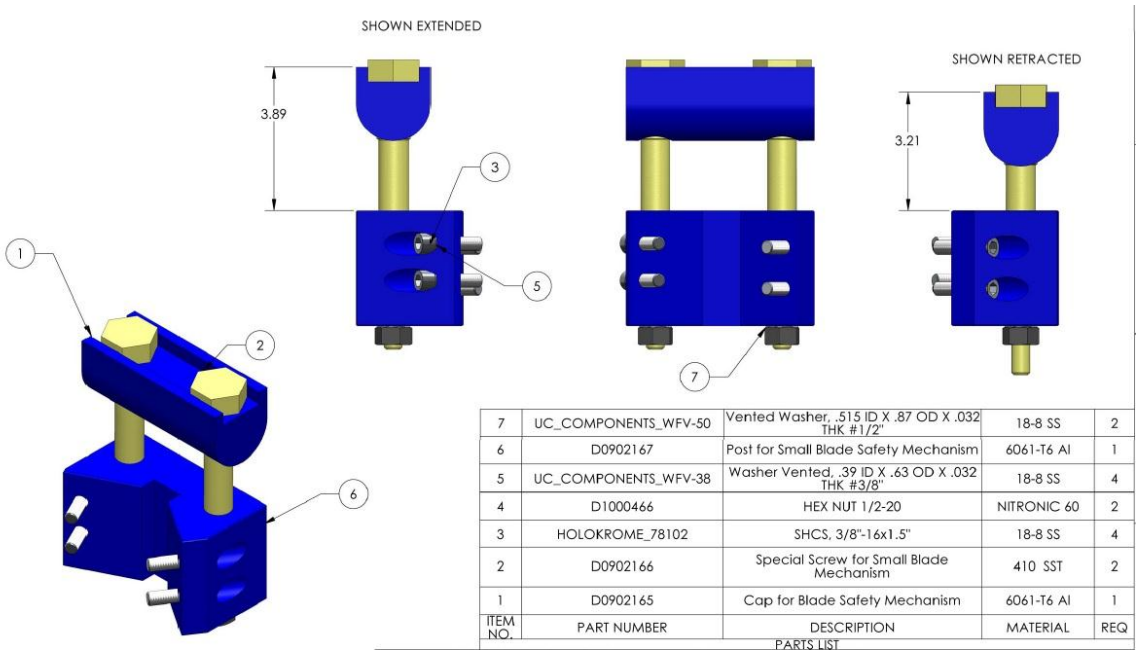
Figure 113: D0902454 Stage 1-2 Blade Puller assembled and installed on D0902488 Tooling Bracket

Note: Make sure all the bolts are secure before loading the spring. This includes the puller tooling and the bolts holding the spring to the spring saddle.

Install D0902164 Stage 1-2 Safety Mechanism and load D0902502 Stage 1-2 Blade Spring

Parts required

Quantity	Part Number	Description	Weight
1	D0902165	Safety Mechanism Cap	
2	D0902166	Safety Mechanism Special Crew	
1	D0902167	Safety Mechanism Post	
2	D1000466	Safety Mechanism Hex Nut 1/2-20	



PARTS LIST

ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ
7	UC_COMPONENTS_WFV-50	Vented Washer, .515 ID X .87 OD X .032 THK #1/2"	18-8 SS	2
6	D0902167	Post for Small Blade Safety Mechanism	6061-T6 Al	1
5	UC_COMPONENTS_WFV-38	Washer Vented, .39 ID X .63 OD X .032 THK #3/8"	18-8 SS	4
4	D1000466	HEX NUT 1/2-20	NITRONIC 60	2
3	HOLOKROME_78102	SHCS, 3/8"-16x1.5"	18-8 SS	4
2	D0902166	Special Screw for Small Blade Mechanism	410 SST	2
1	D0902165	Cap for Blade Safety Mechanism	6061-T6 Al	1

Figure 114: D0902164 Stage 1-2 Safety Mechanism

- Insert (2) D0902166 Safety Mechanism Special Screws into the D0902165 Safety Mechanism Cap.

- Slide this Sub-Assembly up through the D0901516 Cut-Out Optical Table hatch hole and place its screws up in front of D0902276 Flexure Rod Bracket.

Note: D0902502 Stage 1-2 Blade Spring needs to be in between these (2) D0902166 Safety Mechanism Special Screws as shown on Figure 115.

Hardware:
(4) 3/8-16 x 1.5" SHCS – MSC 75464669
(4) 3/8 Vented Washers - UCC_WFV-38

- Bring D0902167 Safety Mechanism Post over and attach it to the screws with the 1/2" nuts before attaching it to D0902276 Flexure Rod Bracket.

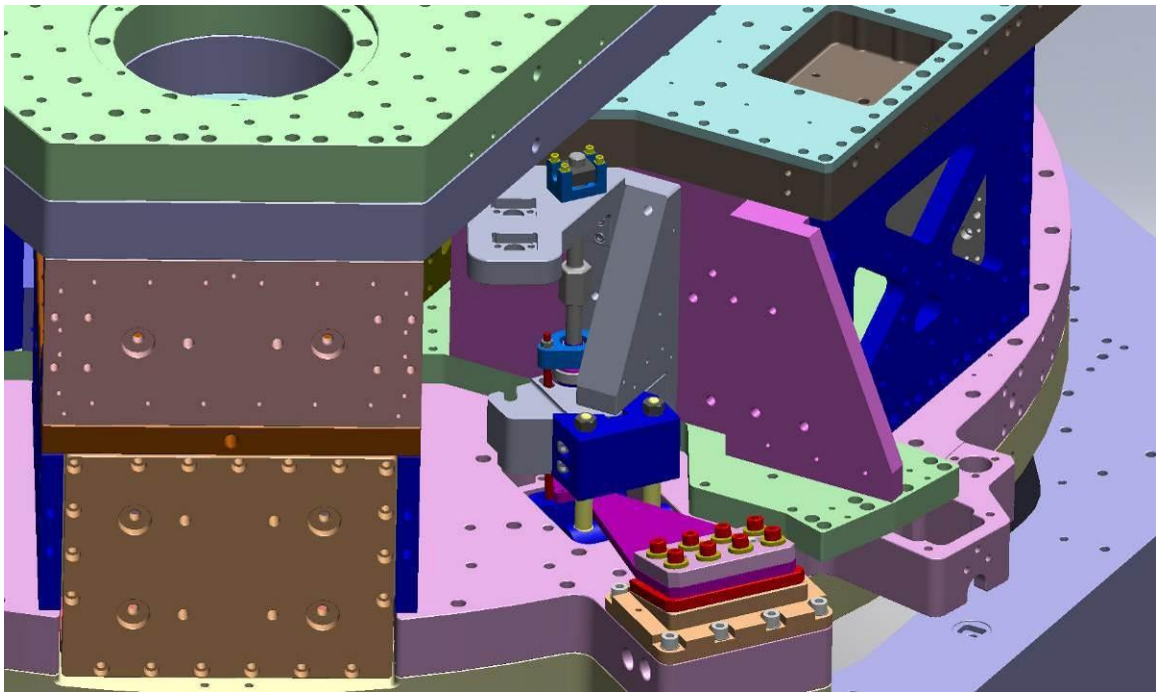


Figure 115: D0902164 Stage 1-2 Safety Mechanism & D0902454 Stage 1-2 Blade Puller Assembly on

LOADING D0902502 STAGE 1-2 BLADE SPRING:

1. Start pulling D0902164 Stage 1-2 Safety Mechanism up by threading down D1000466 Safety Mechanism Hex Nut 1/2-20 on top of D0902167 Safety Mechanism Post.

2. Start turning D0902193 Stage 1-2 Blade Puller Bolt with an open end wrench. This will pull the entire D0902454 Stage 1-2 Blade Puller up along with the D0902502 Stage 1-2 Blade Spring.

3. Keep alternating steps 1 & 2 to load D0902502 Stage 1-2 Blade Spring and maintain D0902164 Stage 1-2 Safety Mechanism close to it at the same time

1.70. Preload D0902502 Stage 1-2 Blade Spring until D0902104 Stage 1-2 Flexure Rod Assembly will fit between D0902502 Stage 1-2 Blade Spring and D0902276 Flexure Rod Bracket (~ the tip of D0902502 Stage 1-2 Blade Spring is horizontal).

Note: D0902502 Stage 1-2 Blade Spring should be slightly overloaded (~ few mils) to allow D0902103 Stage 1-2 Flexure Rod Assembly to slide in place.

1.71. Slide D0902104 Stage 1-2 Flexure Rod Assembly into place until D0901743 Bracket Flexure Shim makes contact with D0902502 Stage 1-2 Blade Spring tip internal hole (see Figure 116 & Figure 117).

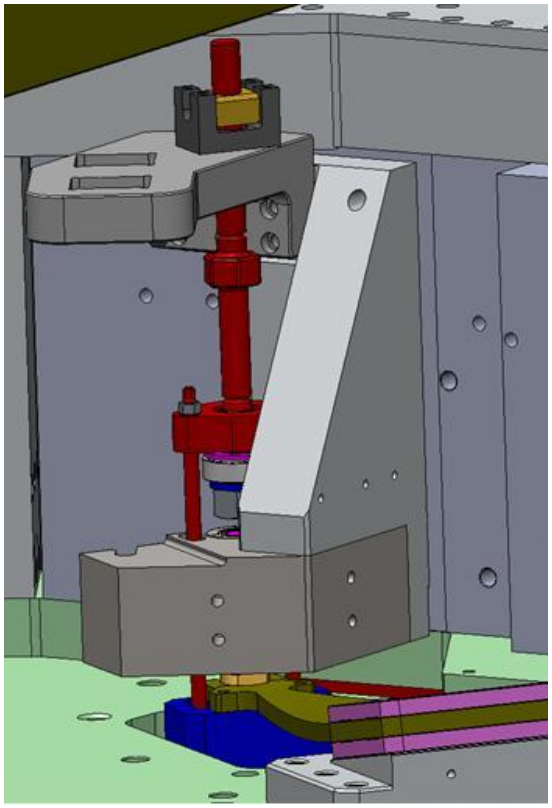


Figure 116: D0902454 Stage 1-2 Blade Puller and D0902103 Stage 1-2 Flexure Rod Assembly

1.72. Turn 90 degrees (in any direction) D0901743 Bracket Flexure Shim (this should turn D0902104 Stage 1-2 Flexure Rod Assembly) in order to lock it in place.

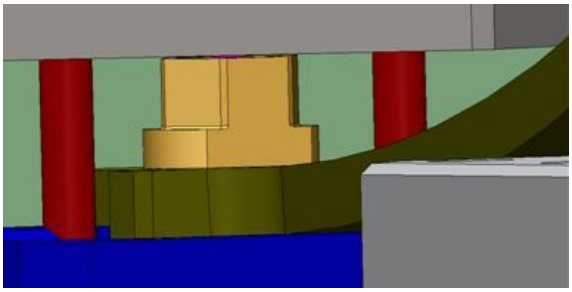


Figure 117: Detail on D0901743 Bracket Flexure Shim

1.73. Slightly back off D0902193 Stage 1-2 Blade Puller Bolt until D0902104 Stage 1-2 Flexure Rod Assembly is in tension.

1.74. Check D0901758 Flexure Rod verticality.

Note: Test verticality with a level or with a block with a trusted right angle. You may need mirror and light to properly see and check alignment of bottom of D0901758 Flexure Rod.

1.75. Once D0901758 Flexure Rod is in the correct position, back off screw completely, alternating by loading tool and safety tool.

DISASSEMBLE D0902502 STAGE 1-2 BLADE SPRING & D0902164 STAGE 1-2 SAFETY MECHANISM:

1. Start disassembling D0902164 Stage 1-2 Safety Mechanism by unscrewing D1000466 Safety Mechanism Hex Nut 1/2-20 on top of D0902167 Safety Mechanism Post.

2. Start unscrewing D0902193 Stage 1-2 Blade Puller Bolt with an open end wrench. This will release pressure from the entire D0902454 Stage 1-2 Blade Puller.

3. Keep alternating steps 1 & 2 to unload D0902502 Stage 1-2 Blade Spring and maintain D0902164 Stage 1-2 Safety Mechanism close to it at the same time

4. Once (2) D1000466 Safety Mechanism Hex Nuts 1/2-20 are completely out, remove D0902167 Safety Mechanism Post from D0902276 Flexure Rod Bracket.

Note: Make sure to hold D0902166 Safety Mechanism Special Screws & D0902165 Safety Mechanism Cap while removing D1000466 Safety Mechanism Hex Nut 1/2-20. Slide it through the Optical Table.

5. Unscrew (2) 5/16-18 Hex Nuts & 5/16" Washers completely from D0902188 Pre-Load Tool Rod releasing D0902454 Stage 1-2 Blade Puller Assembly Bottom Parts.

Note: Make sure to hold D0902454 Stage 1-2 Blade Puller Assembly Bottom Parts.

6. Slide D0902454 Stage 1-2 Blade Puller Assembly Bottom Parts under D0902276 Flexure Rod Bracket and take it out on the left side of D0902502 Stage 1-2 Blade Spring.

7. Remove completely D0902164 Stage 1-2 Safety Mechanism & D0902454 Stage 1-2 Blade Puller.

Note: **DO NOT REMOVE D0902488 TOOLING BRACKET BECAUSE IT WILL BE USED FOR THE LOADING OF D0901541 STAGE 0-1 BLADE SPRING!**

Parts required

Quantity	Part Number	Description	Weight
3	D0902487	Spring Hatch	

Prep Work for D0902487 Spring Hatch:

Hardware:
(6) 3/8-16 x 2 DIA Helicoils

- Install Nitronic 60 Helicoil threaded inserts into D0902487 (see Figure 118).

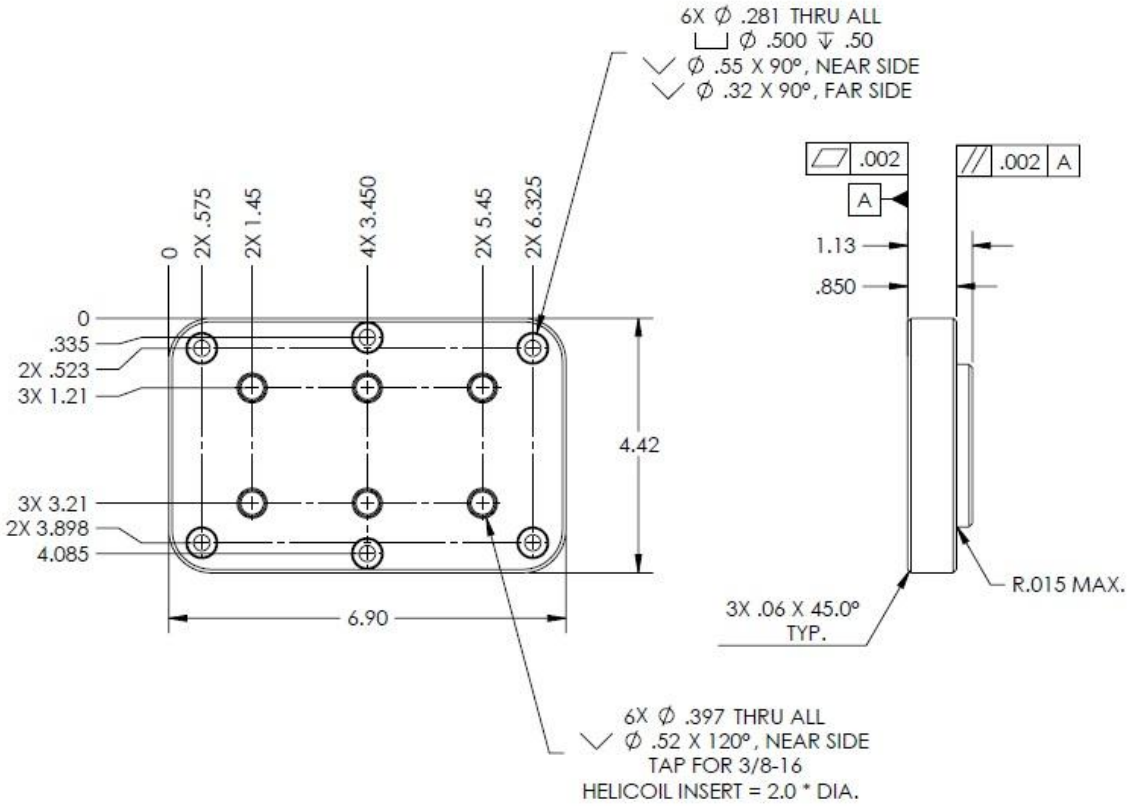


Figure 118: Prep Work for D0902487 Spring Hatch

- Attach D0902487 Spring Hatch from below to D0901516 Solid Optical Table.
- Repeat this step for the (2) other D0902487 Spring Hatch

Hardware:
(6) 1/4-20 x 1.25" SHCS – MSC_ 75464420
(6) 1/4 Vented Washers - UCC-WFV-25

- Insert all the screws from below through D0902487 Spring Hatch itself into D0901516 Solid Optical Table.
- Snug them and **torque them to 100 in.lbs (8.3 ft.lbs).**
- Repeat this step for the (2) other D0902487 Spring Hatches.

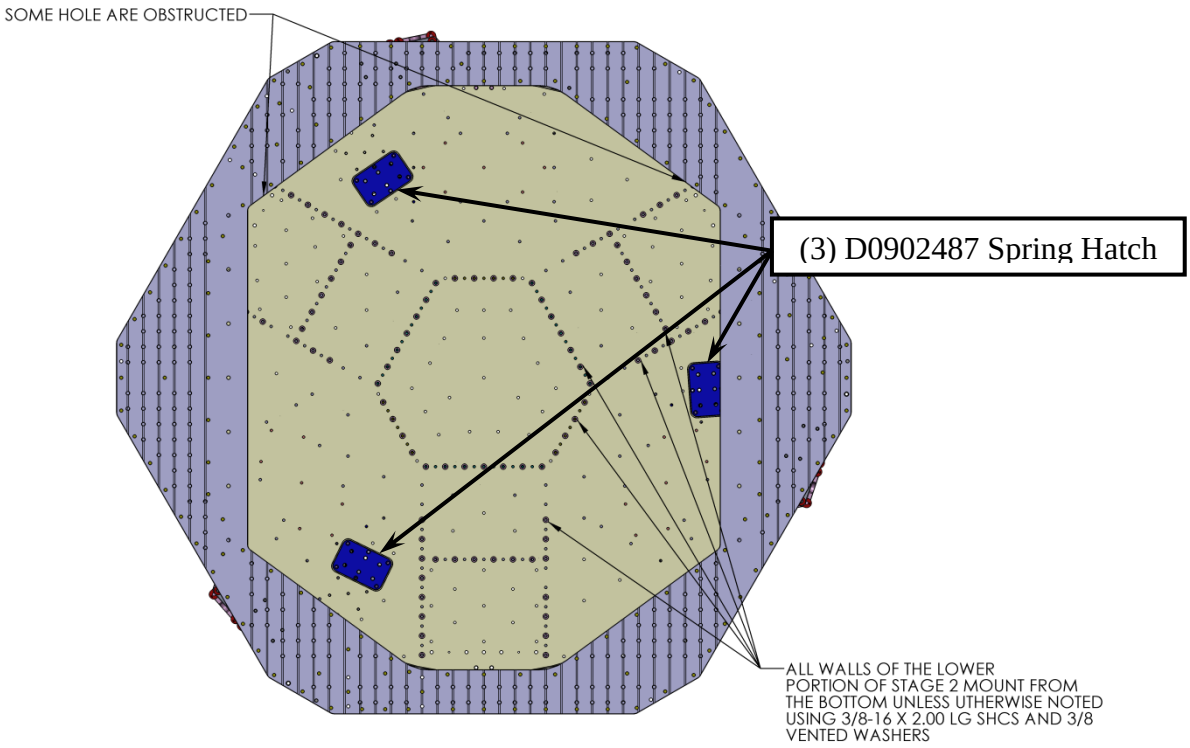


Figure 119: Locations of (3) D0902487 Spring Hatches (view from below the BSC-ISI)

Assemble D0902103 Stage 0-1 Flexure Assembly

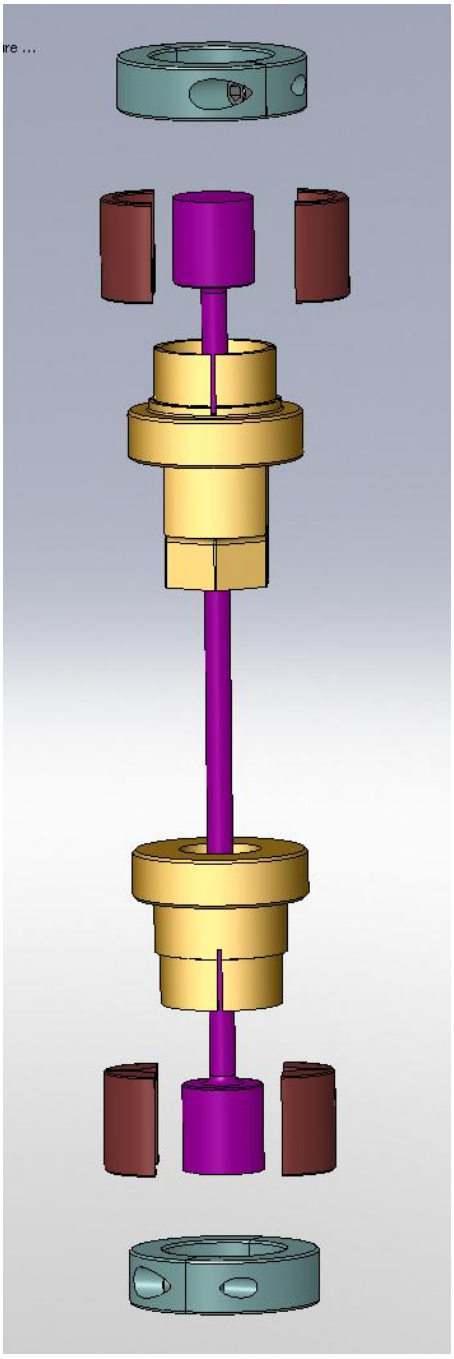


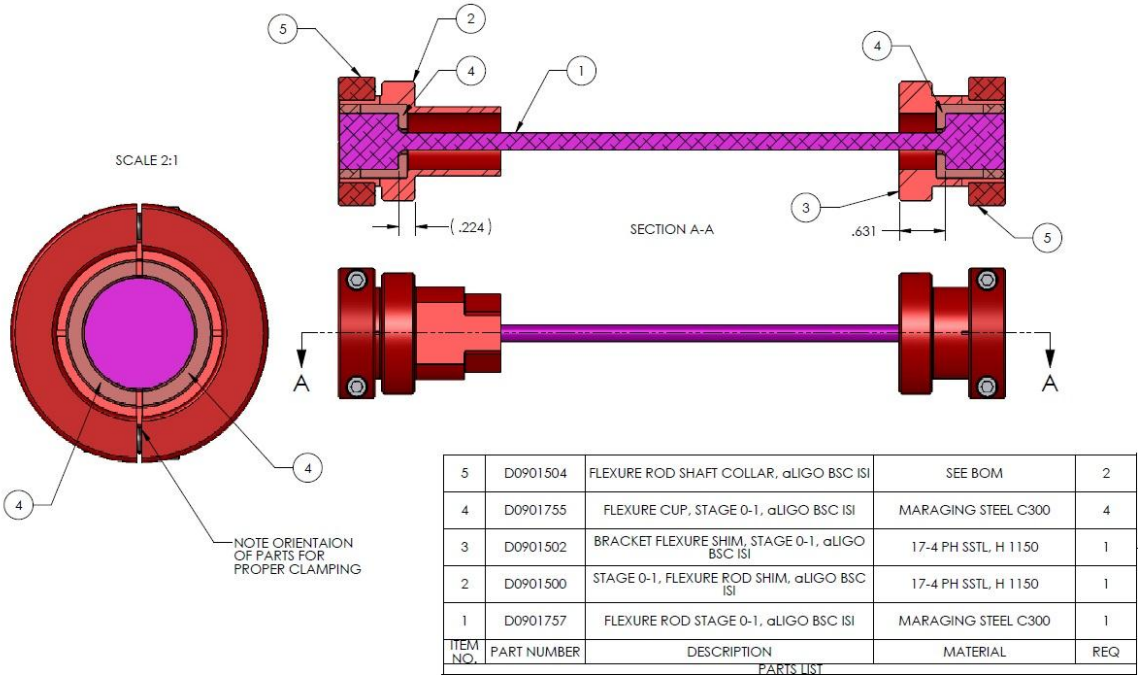
Figure 120: Exploded view of D0902103 Stage 0-1 Flexure Rod Assembly

Parts required

Quantity	Part Number	Description	Weight
3	D0901500	Stage 0-1 Flexure Rod Shim	
12	D0901755	Stage 0-1 Flexure Cup	
6	D0901502	Stage 0-1 Bracket Flexure Shim	
3	D0901757	Stage 0-1 Flexure Rod	
2	D0901504	Flexure Rod Shaft Collar	

Note: The Flexures are **fragile**! Before starting this section, check that all are still straight (e.g., by rolling them on a surface plate).

- Place D0901757 Stage 0-1 Flexure Rod vertical on a level surface.
- Have (2) D0901755 Stage 0-1 Flexure Cups sit on the bottom head of D0901757.
- Slide D0901502 Stage 0-1 Bracket Flexure Shim in place as shown on Figure 121.
- Slide D0901500 Stage 0-1 Flexure Rod Shim over and let it go in contact with D0901502.
- Place (2) other D0901755 Stage 0-1 Flexure Cups inside D0901500.
- Slide D0901500 Stage 0-1 Flexure Rod Shim up until D0901755 Stage 1-2 Flexure Cups are in contact with the top of D0901757 Stage 0-1 Flexure Rod.



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ
5	D0901504	FLEXURE ROD SHAFT COLLAR, aLIGO BSC ISI	SEE BOM	2
4	D0901755	FLEXURE CUP, STAGE 0-1, aLIGO BSC ISI	MARAGING STEEL C300	4
3	D0901502	BRACKET FLEXURE SHIM, STAGE 0-1, aLIGO BSC ISI	17-4 PH SSTL, H 1150	1
2	D0901500	STAGE 0-1, FLEXURE ROD SHIM, aLIGO BSC ISI	17-4 PH SSTL, H 1150	1
1	D0901757	FLEXURE ROD STAGE 0-1, aLIGO BSC ISI	MARAGING STEEL C300	1

PARTS LIST

Figure 121: D0902103 Stage 0-1 Flexure Rod Assembly

Hardware:

(4) #8-32 x 0.5" Ag-plated SHCS – UCC C-808-NA

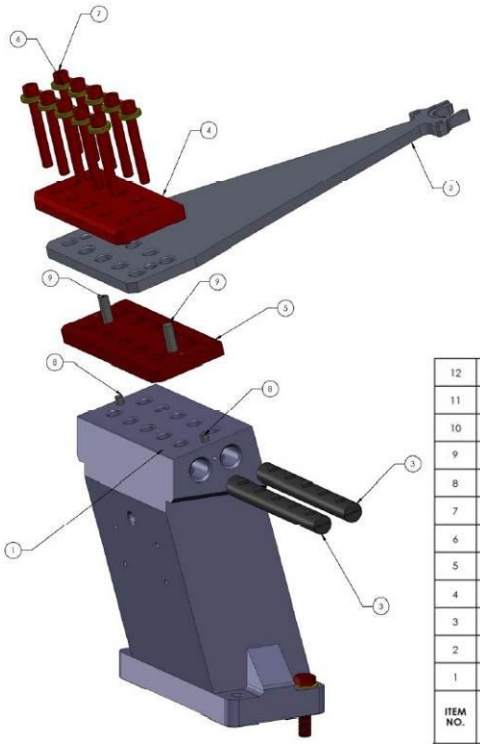
- Attach top D0901504 Flexure Rod Shaft Collar.
- Attach bottom D0901504 Flexure Rod Shaft Collar.
- Ensure that the rod heads are in an even position in the cups and **torque screws to 19.8 in.lbs (1.7 ft.lbs).**

Assemble and install D0901197 Stage 0-1 Blade Spring

Parts required

Quantity	Part Number	Description	Weight
3	D0901541	Stage 0-1 Blade Spring	
3	D0902697	Stage 0-1 Blade Spring Clamp Cap	
3	D1100570	Stage 0-1 Blade Angled Spacer	
6	D1002379	Barrel Nut Bars	

Hardware:
(10) 1/2-13 x 3.75" Eastwood Bolts Ag Plated – D1200676
(10) 1/2 Washers (.53 ID X 1.13 OD X .19 THK) – MSC 73250110
(2) 1/2" x 2" dowel pins – MSC 67602128



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	Loaded with Nominal Weight (2750lb per Spring)/QTY.
12	Tri-State Fasteners HCS10C0408	5/8-11x2-1/2 HHCS	304 SSTL	4
11	McMASTER_98019A514	WASHER, .65 ID X 1.32 OD X .07-.13 THK	300 SSTL	4
10	D0902103	BSC STAGE 0-1 FLEXURE ASSEMBLY	N/A	1
9	MCMASTER_99010A345	Dowel Pin, 1/2 od x 2 lg. x .5009"-.5011" thck	18-8 SS	2
8	MCMASTER_90145A624	Dowel Pin, 3/8"x1.0"	18-8 SS	2
7	D1200676	Custom Bolt from Eastwood, 1/2-13x3.75 SHCS 17-4	17-4 PH SSTL	10
6	MSC 73250110	Washer, .53 ID X 1.13 OD X .19 THK	18-8 SSTL	10
5	D1100570	Stage 0-1 Blades Angled Spacer, aLIGO BSC-ISI	304 SSTL	1
4	D0902697	SPRING CLAMP CAP, STAGE 0, aLIGO BSC ISI	17-4 PH SSTL, H 1150	1
3	D1002379	BARREL NUT BAR, SPRING POST, STAGE 0-1, aLIGO BSC ISI	NITRONIC 60	2
2	D0901541	BLADE SPRING, STAGE 0-1, aLIGO BSC ISI	MARAGING STEEL C300	1
1	D0901499	BLADE POST,STAGE 0-1, aLIGO BSC ISI	6061-T6 Al	1

Figure 122: Exploded View of D0901197 Stage 0-1 Blade Spring Assembly

- Place D1100570 Stage 0-1 Blades Angled Spacer on D0901499 Stage 0-1 Blade Post as shown on Figure 122, the position is determined by the (2) dowel pins inserted previously in D0901499 Stage 0-1 Blad Post. Make sure pins seat properly into mating hole and slot.
- Insert (2) 1/2" x 2” dowel pins in D1100570 Stage 0-1 Blades Angled Spacer as shown on Figure 122.
- Place D0901541 Stage 0-1 Blade Spring on D1100570 Stage 0-1 Blades Angled Spacer. Its location is determined by (2) 1/2" x 2” dowel pins previously inserted in D1100570.
- Place D0902697 Stage 0-1 Spring Clamp Cap on top of D0901541 Stage 0-1 Spring Blade.

Note: Its location is also determined by these (2) 1/2" x 2” dowel pins.

- Insert (4) D10002379 Barrel Nut Bars in sides of on D0901499 Stage 0-1 Blade Post as shown on Figure 122- *one short and one long* in each through hole.
- Insert and snug (8) 1/2”-13 x 3.75” Eastwood Bolts Ag Plated with (8) 1/2" McMaster 98125A033 Washers. Before torqueing, make sure that D0901541 Stage 0-1 Spring Blade & D0902697 Stage 0-1 Spring Clamp Cap are against the (2) 1/2" x 2” dowel pins. If they are a little bit loose, push D0901541 & D0902697 against these pins as shown by the black arrows on Figure 123.

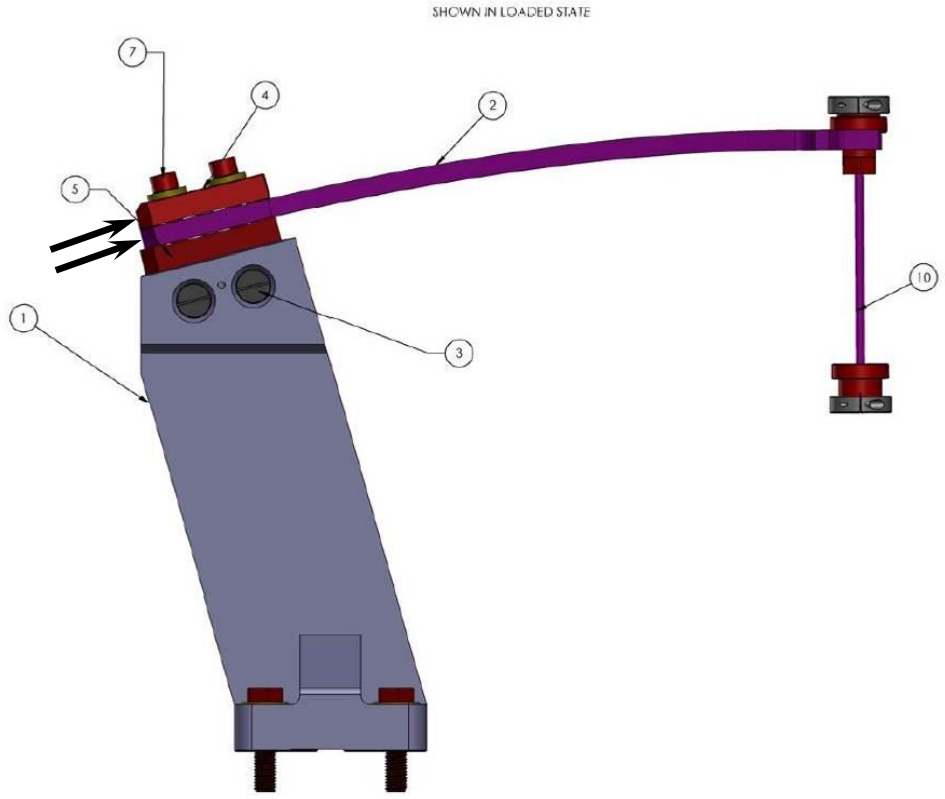


Figure 123: D0901197 Stage 0-1 Blade Assembly Drawing in the Loaded State

- **Torque them to 110 ft-lbs. DO NOT USE METHANOL OR ISOPROPANOL on these bolts, it would change the actual torque value on them!**
- Repeat these steps for the (3) other D0901499 Stage 0-1 Blade Posts.

Note: To align D0901541 Stage 0-1 Spring Blade on the saddle use an Alignment Rod (specially made tooling).

- Place the Alignment Rod in the "U" of the end of the blade spring and in the flexure rod bracket as shown on Figure 97, Figure 98 & Figure 99. The Rod will fit snugly and will determine if the spring is properly aligned before loading it.
- Make sure that the spring sits back against the notches on the post while doing this (e.g. the blade spring does not nudge forward and back while you're nudging it right and left).

Install D0901872 Safety Mechanism & D0902464 Stage 0-1 Blade Pusher for the loading of D0901541 Stage 0-1 Blade Spring

Parts required

Quantity	Part Number	Description	Weight
1	D0902488	Tooling Bracket	
1	D0902483	Saddle on Large Blades	
2	D0902593	Pusher Pivot Assembly	
2	D0902200	Top Saddle on Bracket	
2	D0902594	Threaded Pivot	
	D0902599	Blade Pusher Bolt	

Note: D0902488 Tooling Bracket is already mounted to D0902277 Flexure Rod Bracket Gusset (it has NOT been disassembled after the loading of D0902502 Stage 1-2 Spring Blade).

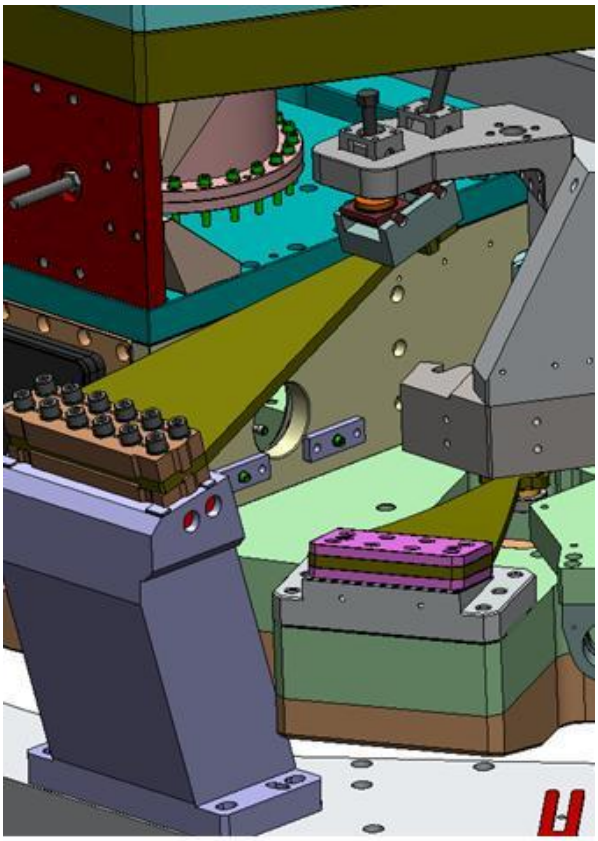


Figure 124: Unloaded D0901197 Stage 0-1 Blade Assembly

1.76. Thread D0902594 Threaded Pivot onto each D0902599 Blade Pusher Bolt and place it in D0902200 Top Saddle on Bracket as shown on Figure 125.

Note: The shorter D0902599 Blade Pusher Bolt is placed further out on D0902488 Tooling Bracket and the longer one is placed closer to the wall (i.e. the longer one will end up closer to the tip of D0901541 Stage 0-1 Spring Blade).

Hardware:
(8) 1/4-20 x 1.75" SHCS – MSC 75464461
(8) 1/4 Vented Washers - UCC-WFV-25

- Insert all the screws from top through D0902200 Top Saddle on Bracket itself into D0902488 pre-load bracket.
- Snug them and **torque them to 100 in.lbs (8.3 ft.lbs).**
- Repeat this step for the (2) other D0902464 Stage 0-1 Blade Pusher.
-

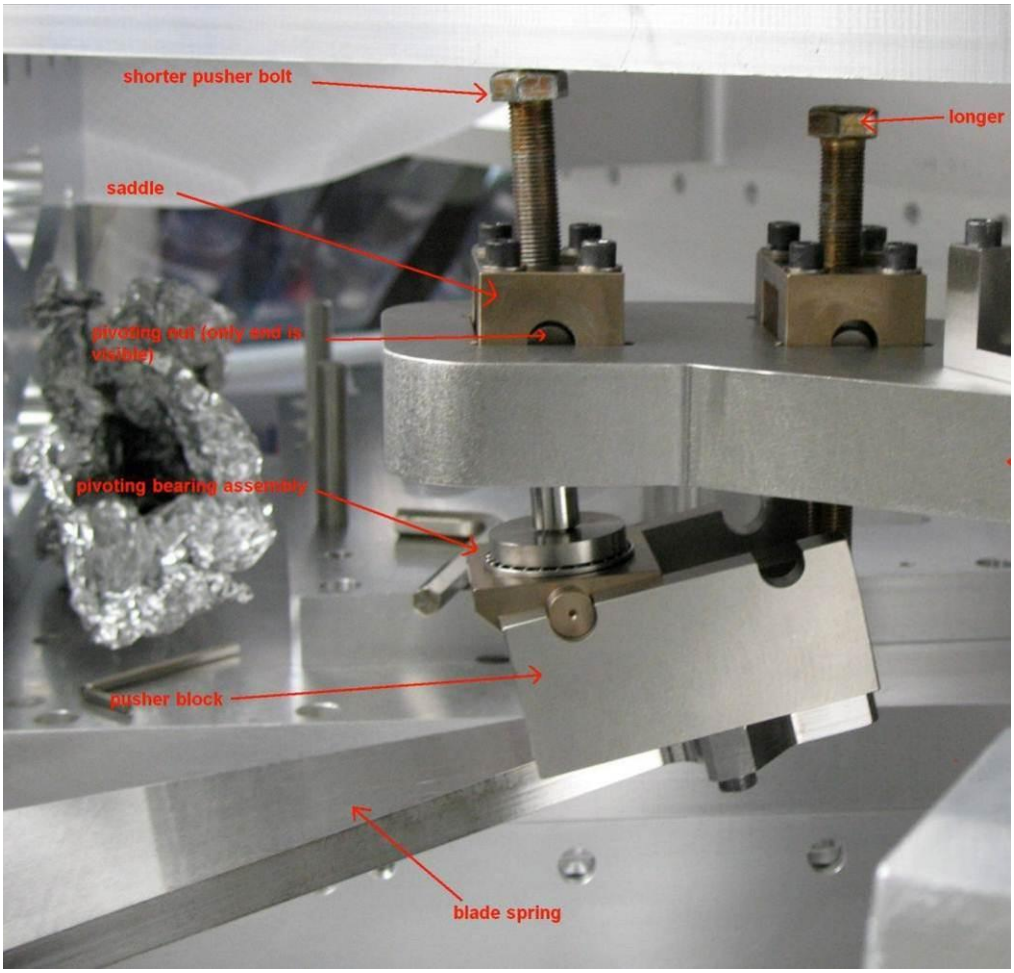


Figure 125: D0902464 Stage 0-1 Blade Pusher (LASTI 2007)

Hardware:

(8) 1/4-20 x 1.75" SHCS – MSC 75464461

- Place D0902483 Saddle on Large Blades to D0901541 Stage 0-1 Spring Blade tip (see Figure 125).
- Attach it in place with (2) 1/4-20 x 1.75" SHCS going up through D0901541 Stage 0-1 Spring Blade into D0902488 Tooling Bracket.
- Snug these (2) screws.

1.77. Assemble D0902593 Pusher Pivot Assembly.

Parts required

Quantity	Part Number	Description	Weight
1	D0902602	Bottom Pivot	
1	McMaster 5909K35	Thrust Bearing Needle Roller 1.687 od x .875 id x .078 thk	
1	D0902603	Bolt Cap	

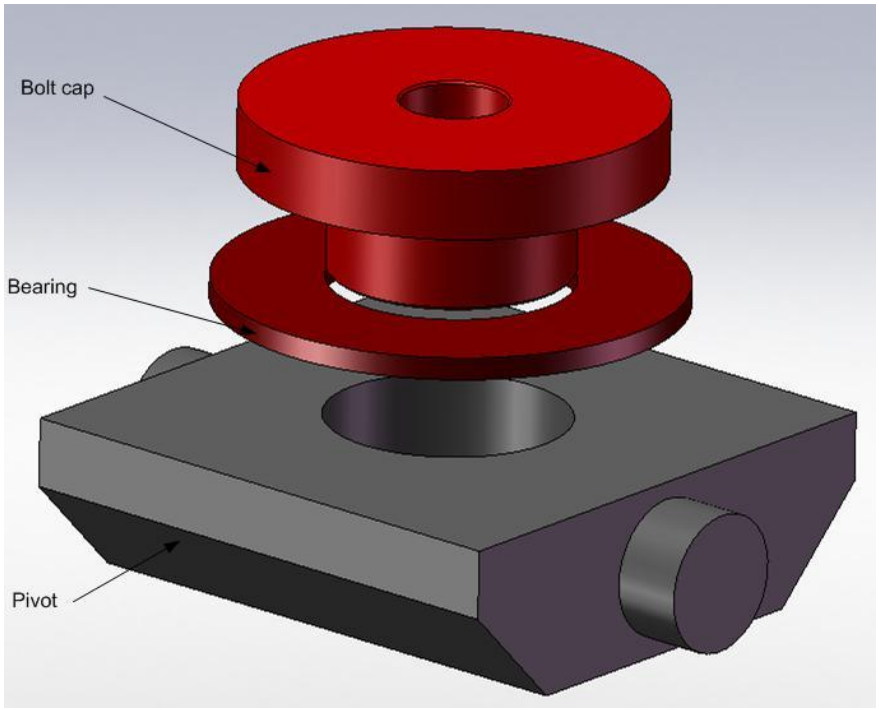


Figure 126: Exploded View of the D0902593 Pusher Pivot Assembly

1.78. Place the 1st D0902593 Pusher Pivot Assembly in D0902483 Saddle on Large Blades near the shorter D0902599 Blade Pusher Bolt as shown on Figure 125. The tip of D0902599 Blade Pusher Bolt should be placed into D0902593 Pusher Pivot Assembly.

Note: the second D0902593 Pusher Pivot Assembly will be used later with the longer D0902599 Blade Pusher Bolt.

Assemble D0901872 Stage 0-1 Safety Mechanism

Parts required

Quantity	Part Number	Description	Weight
1	D0902117	Stage 0-1 Safety Mechanism Cap	1
1	D0902118	Stage 0-1 Safety Mechanism Special Screw	1
1	D0902119	Stage 0-1 Safety Mechanism Right Post	1
1	D0902130	Stage 0-1 Safety Mechanism Left Post	1
1	D0902131	Stage 0-1 Safety Mechanism Center Part	1

Prep Work for D0901533 Upper Outer Wall:

Hardware:
(4) 1/4" x 5/8" dowel pins

- Press (2) 1/4" x 5/8" dowel pins into D0902119 Stage 0-1 Safety Mechanism Right Post as shown on Figure 127. Pins should sit about 0.25" above the surface.
- Press (2) 1/4" x 5/8" dowel pins into D0902130 Stage 0-1 Safety Mechanism Left Post as shown on Figure 127. Pins should sit about 0.25" above the surface.

1.79. Attach D0902131 Stage 0-1 Safety Mechanism Center Part between D0902119 Stage 0-1 Safety Mechanism Right Post & D0902130 Stage 0-1 Safety Mechanism Left Post

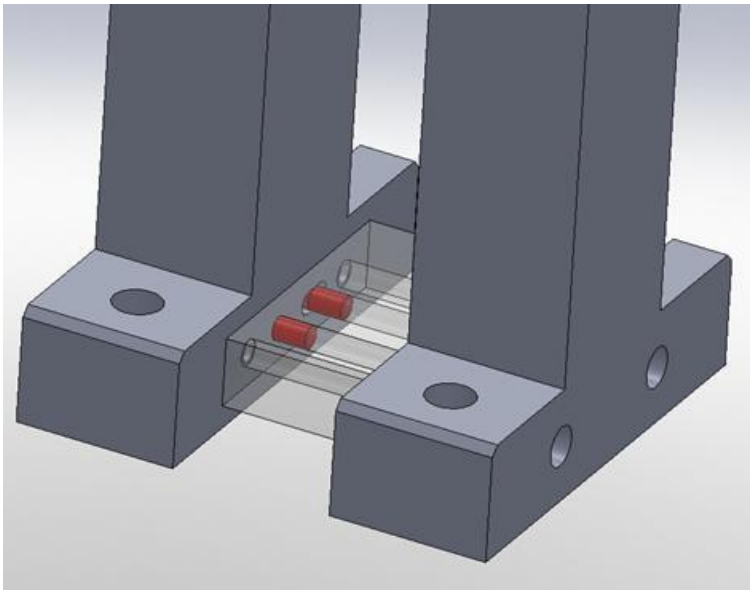


Figure 127: D0902131 Stage 0-1 Safety Mechanism Center Part of D0901872 Stage 0-1 Safety Mechanism

Hardware:

(2) 1/4-20 x 3.5" SHCS – MSC 05680350

- Place D0902131 Stage 0-1 Safety Mechanism Center Part in between D0902119 Stage 0-1 Safety Mechanism Right Post & D0902130 Stage 0-1 Safety Mechanism Left Post. D0902131 is located by the (4) pins previously installed in D0902119 & D0902130.
- Insert screws through D0902119 Stage 0-1 Safety Mechanism Right Post & through D0902131 Stage 0-1 Safety Mechanism Center Part, into D0902130 Stage 0-1 Safety Mechanism Left Post.
- Snug them and **torque up to 75.2 in.lbs (6.3 ft.lbs).**

1.80. Attach this Sub-Assembly on D0901517 Cut-Out Optical Table

Hardware:

(4) 1/2-13 x 2.5" SHCS – MSC 05684253
(4) 1/2 Vented Washers - UCC-WFV-50

- Insert screws through D0902119 Stage 0-1 Safety Mechanism Right Post & through D0902130 Stage 0-1 Safety Mechanism Left Post, into D0901517 Cut-Out Optical Table.
- Snug them and **torque up to 517 in.lbs (43.1 ft.lbs).**

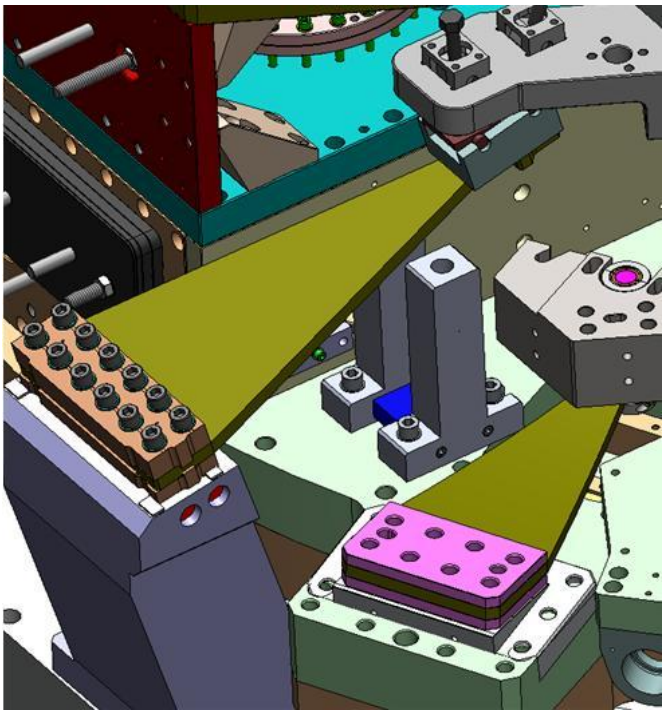


Figure 128: D0901872 Stage 0-1 Safety Mechanism half assembled

1.81. Place D0902117 Stage 0-1 Safety Mechanism Cap over the blade and thread (2) D0902118 Stage 0-1 Safety Mechanism Special Screws into D0902119 & D0902130 posts

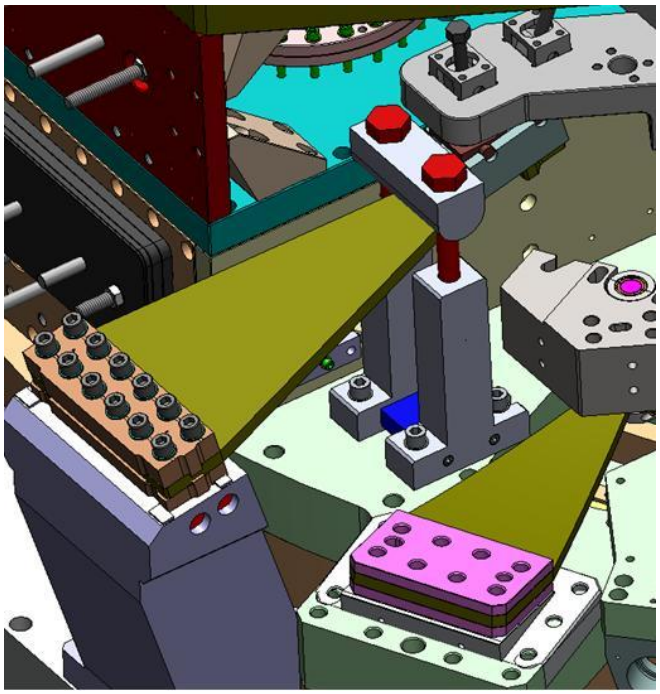


Figure 129: D0901872 Stage 0-1 Safety Mechanism fully assembled

Loading D0901541 Stage 0-1 Blade Spring using D0902464 Stage 0-1 Blade Pusher

- Start turning the first D0902599 Blade Pusher Bolt to begin pre-loading D0901541 Stage 0-1 Blade Spring.

Note: You'll need to load the 1st D0902599 Blade Pusher Bolt far enough to give clearance to place the 2nd D0902593 Pusher Pivot Assembly into D0902483 Saddle on Large Blades and load the longer D0902599 Blade Pusher Bolt tip into the bearing.

Note: D0902599 Blade Pusher Bolt might be twisted almost as far as it will go into D0902200 Top Saddle on Bracket.

Figure 130: 1st D0902599 Blade Pusher Bolt fully loaded on D0902464 Stage 0-1 Blade Pusher

- Place the 2nd D0902593 Pusher Pivot Assembly onto D0902483 Saddle on Large Blades and place the tip of the longer D0902599 Blade Pusher Bolt into the top of the bearing.

Note: This may be a tight fit and the bolt will need to be twisted up as far as it will go.

- Once the 2nd D0902599 Blade Pusher Bolt is in place, start loading it. The 1st one will eventually become loose.
- Load the 2nd one (the longer one) until the blade spring is flexed far enough to allow D0902103 Stage 0-1 Flexure Rod Assembly to fit between D0901541 Stage 0-1 Blade Spring and D0902276 Flexure Rod Bracket attached to Stage 1.

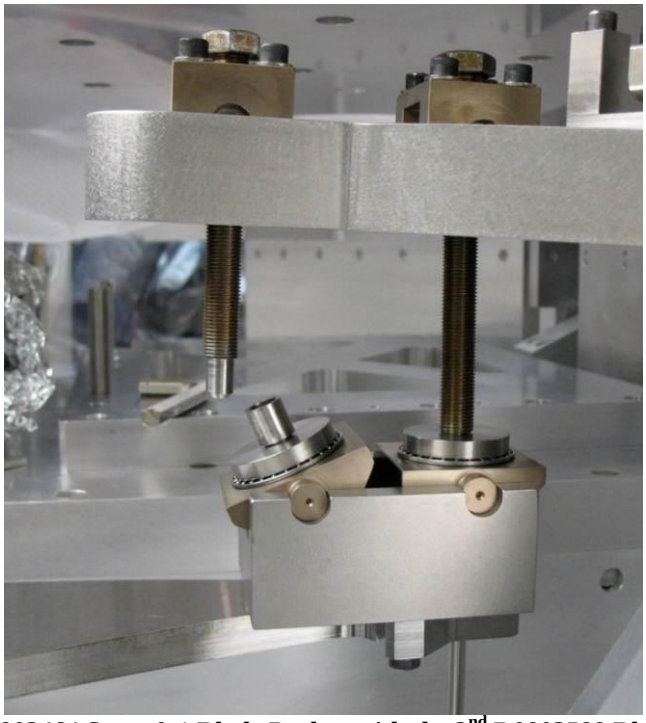


Figure 131: D0902464 Stage 0-1 Blade Pusher with the 2nd D0902599 Blade Pusher Bolt

- Slide D0902103 Stage 0-1 Flexure Rod Assembly into place until D0901500 Stage 0-1 Flexure Rod Shim makes contact with D0901541 Stage 0-1 Blade Spring tip internal hole (see Figure 132).
- Turn 90 degrees (any direction) to lock D0902103 Stage 0-1 Flexure Rod Assembly in place.
- Slightly back off the 2nd D0902599 Blade Pusher Bolt until the flexure is in tension.

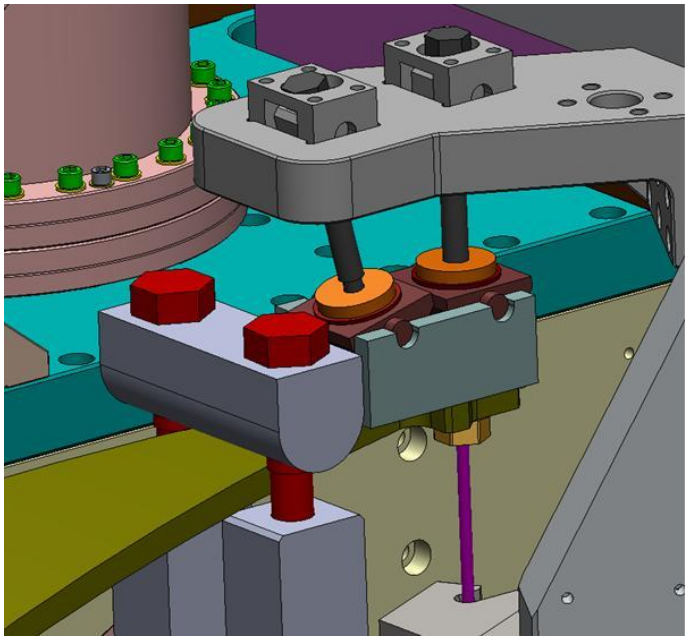


Figure 132: Stage 0-1 Blade fully loaded

1.82. Check D0901757 Stage 0-1 Flexure Rod verticality

Note: Test with vertical level or block with a trusted right angle. May need mirror and light to properly see and check alignment of bottom of D0901757.

- Once D0901757 Stage 0-1 Flexure Rod is in place, back off totally the 2nd D0902599 Blade Pusher Bolt.
- Remove D0902483 Stage 0-1 Blade Pusher, Saddle on Large Blades, D0902488 Tooling Bracket, & D0901872 Stage 0-1 Safety Mechanism.
- Repeat these steps for the (2) other D0901541 Stage 0-1 Blade Spring.

Check that all D1000854 Stage 0-1 Lockers & D1000855 Stage 1-2 Lockers are in locked position.

Remove D1001112 Stage 1-2 Tooling Standoff Pin Assembly & D1001110 Stage 0-2 Alignment Pin Assembly.

Note: This is the time to use the oval point set screws to remove D1001110 & D1001112 Pins from the Assembly, in case some of them stay stuck.

Install breadboards and dial indicators.

Parts required

Quantity	Part Number	Description	Weight
6	D0901282	Breadboard	

Hardware:

(12) 1/4-20 x 1" SHCS – MSC 75464404

- Install the D0901282 Breadboards as shown on Figure 133.
- Insert all screws.
- Snug and **torque up to 100 in.lbs (6.7 ft.lbs).**

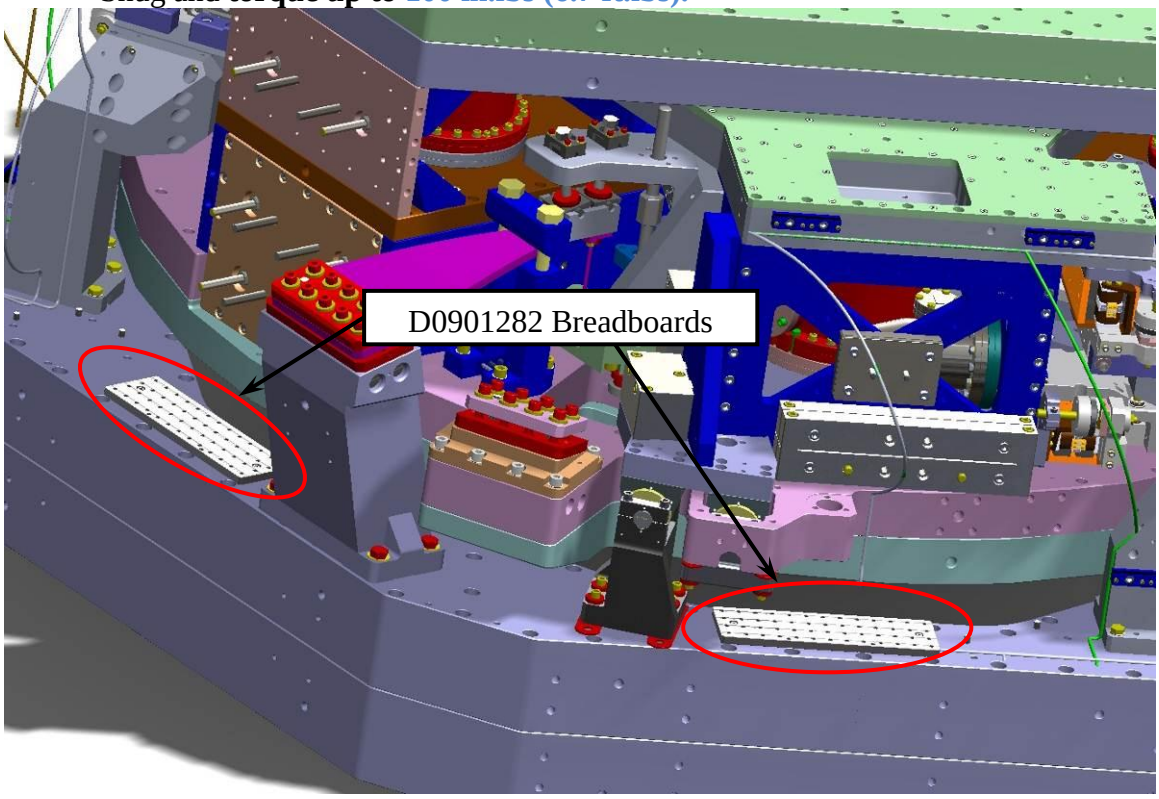


Figure 133: Location of D0901282 Breadboards on Stage 0

- Place dial indicators in order to measure vertical and horizontal positions of the Stages 1 and 2 relatively to Stage 0.

Note: When choosing placement of dial indicators make sure tooling posts removal is not blocked.

Note: If horizontal dial indicators are grossly out of whack with the positioning post measurements check that the spring flexure rods are nicely vertical and check that flexure rod shims are correctly seated in the end of the springs.

Check that Assembly is leveled with respect to Stage 0.

“Float” the System: remove positioning pins and distribute trim weight

Parts required

Quantity	Part Number	Description	Weight
15	D071200	Stage 2 Trim Masses	0.6, 2.2 or 15.6 lbs
3	D0902612	12 lbs Lateral Stage 1 Trim Mass	12 lbs
3	D0902613	15 lbs Lateral Stage 1 Trim Mass	15 lbs
6	D0902614	Front Lower Stage 1 Trim Mass	10 lbs
6	D0902615	Front Upper Stage 1 Trim Mass	10 lbs

1.83. Positioning pins should be removed to transfer weight of assembly from pins to springs. (e.g. “Float” the assembly.)

In case removal is difficult, the D050452 stage 0-2 pins and the D050453 stage 1-2 pins have jack screw locations (using round ended jack screws will prevent marring of surface under the pin).
Be careful not to disturb dial indicators as tooling posts are removed.

1.84. Once stages are floating check height gages to make sure assembly is level relative to stage 0 and at the pre-post removal height. Add trim weights bars to the stages 1 (Figure 134) and 2 until this is achieved.

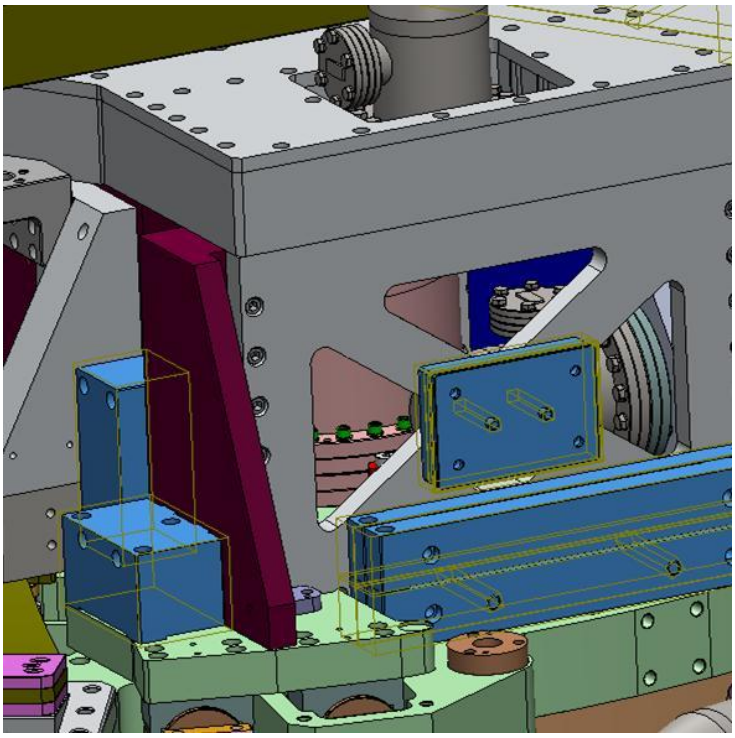


Figure 134: Stage 1 Trim weights shown in blue

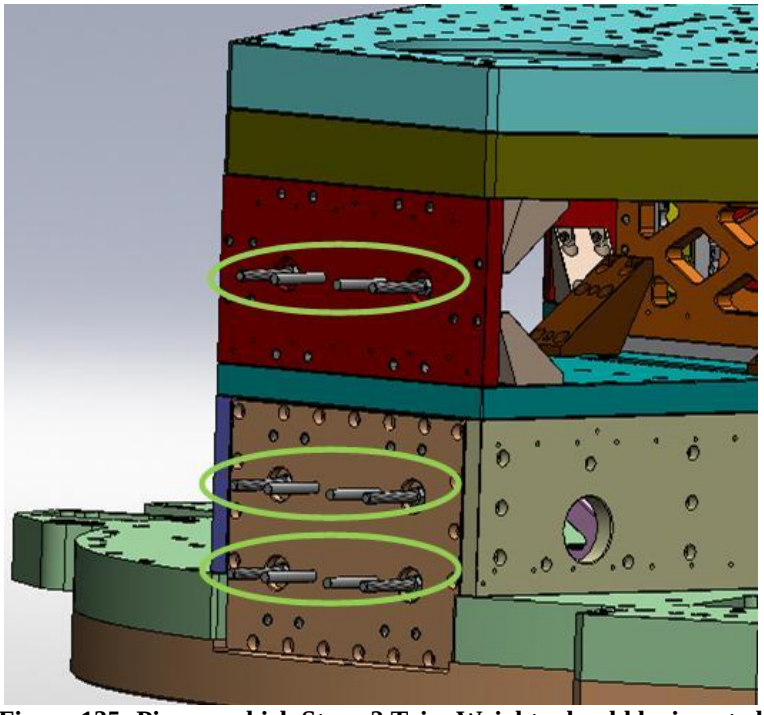


Figure 135: Pins on which Stage 2 Trim Weights should be inserted

Note: During the prototype assembly at LASTI extra weight was added as necessary to the top of the stage 1 top plate and bolted through the hole used for the lifting hooks. If such added weight were to be necessary, recall to distribute these weights as flat as possible.

Engage all locks before actuator installation

Install Vertical GS-13's

For assembly drawing, please see D0902777.

Note: To do the following steps, D0900857 Vertical GS-13 in pod must be already assembled like described in the following document E1000564-v2.

Parts required

Quantity	Part Number	Description	Weight
3	D0900857	Vertical GS-13 in pod	20 lbs
3	D0902541	Vertical GS-13 diaphragm	11 lbs

1.85. Attach the eyebolts to the top of the GS-13 Assembly and use the slings and the crane to carry each GS-13 over the Assembly (see Figure 136), precisely over the hole of D0901519 Keel Plate Up-Facing as shown on Figure 137.

Note: Make sure that the bottom of the pod is parallel to the ground, in order to ensure an easy positioning via the pins on Stage 2.

Note: Make sure that the GS-13 is oriented with the 3/8" x 1" vented dowel pin going in the slotted hole and the regular 3/8" x 1" dowel pin going in the blinded hole of D0900860 BSC Flange Pod Base GS-13.

Figure 136: Vertical GS-13 being craned over the Assembly

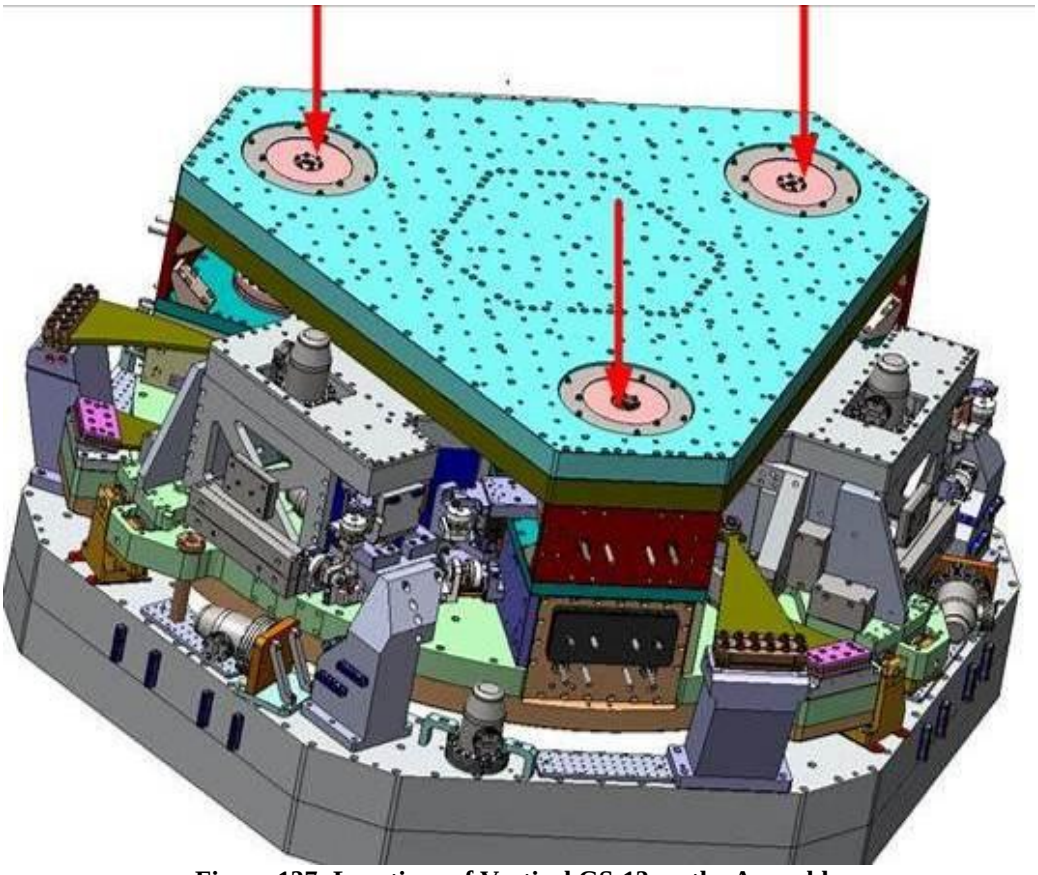


Figure 137: Locations of Vertical GS-13 on the Assembly

1.86. Lower the Vertical GS-13 carefully (1" clearance all around).

Hardware:
(3) 1/4-20 x 2.5" SHCS – MSC 05680251
(3) 1/4 Vented Washers - UCC-WFV-25

- It is positioned through 2 pins already installed into Stage 2; however, it might be helpful to drop the (3) 1/4-28x 2.5 screws through the bottom flange, in order to find the right position for the pod.
- Snug them and **torque them up to 75.2 in.lbs (6.3 ft.lbs).**

Figure 138: Lowering a Vertical GS-13 in place (LASTI dirty Assembly)

1.87. Remove eyebolts and place D0902541 Vertical GS-13 diaphragm over the GS-13.

1.88. Evaluate the gap between the top of the GS-13pod and the diaphragm and place adequate shims around the screw holes. (Standard value is thought to be 30 mils).

Note: Shims used for the same pod are expected to be identical +/-1 mil.

1.89. Attach Diaphragm to GS-13 Pod and to D0901517

- The inner perimeter of the diaphragm should be attached to the GS-13 pod with silver plated screws(circled in red on Figure 139) and the outer diameter to D0901519 Keel Plate Up-Facing with regular ones (circled in blue).

  Hardware:
  (3) 5/16-24 x 1" Ag-Plated SHCS – UCC_C-3116-NA
  (6) 5/16-24 x 1" SHCS – UCC_C-3116-N
  (9) 5/16 Vented Washers - UCC-WFV-31

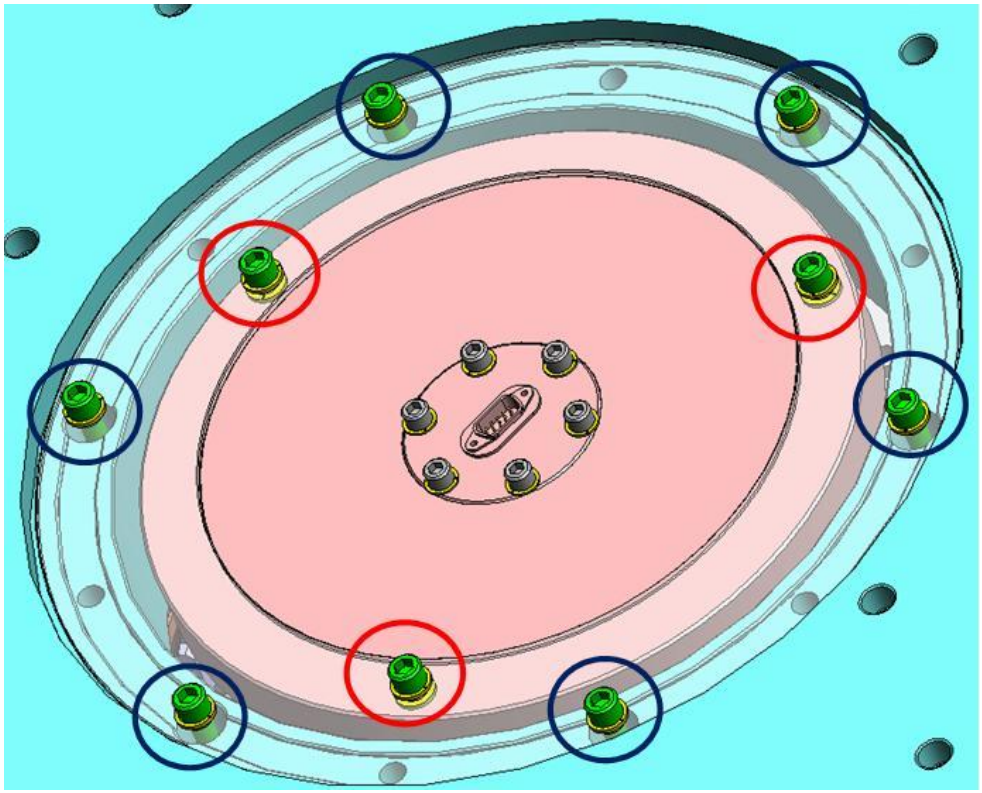


Figure 139: Vertical GS-13 attachment on D0901519 Keel Plate Up-Facing

1.90. Repeat these steps for all 3 GS-13 Pods.

Note: Shim difference between all 6 seismometers should not exceed 5 mils.

Install Stage 1-2 Actuators:

Note: Install actuators **with** lockdown bar attached.
Note: Remove dummy weights representing actuators as actuators are installed.

Parts required

Quantity	Part Number	Description	Weight
3	D0902530	Stage 1-2 Horizontal Actuator Assembly	
3	D0902531	Stage 1-2 Vertical Actuator Assembly	
3	D0902236	Stage 1-2 Vertical Actuator Bracket	

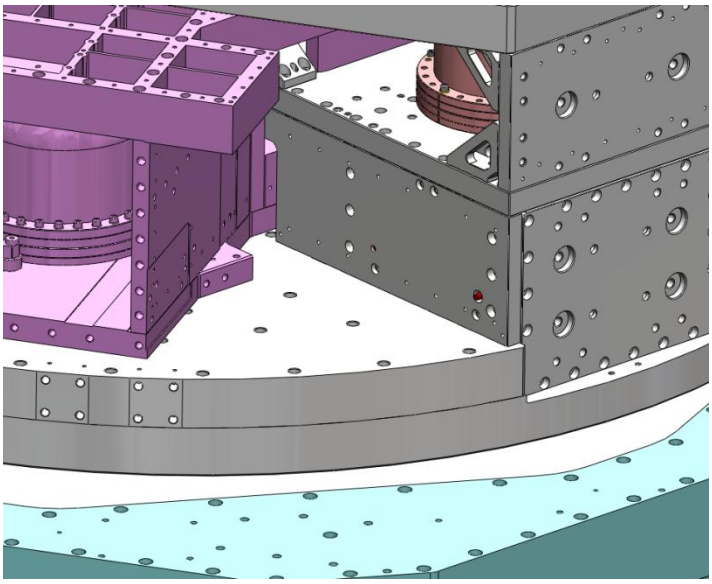
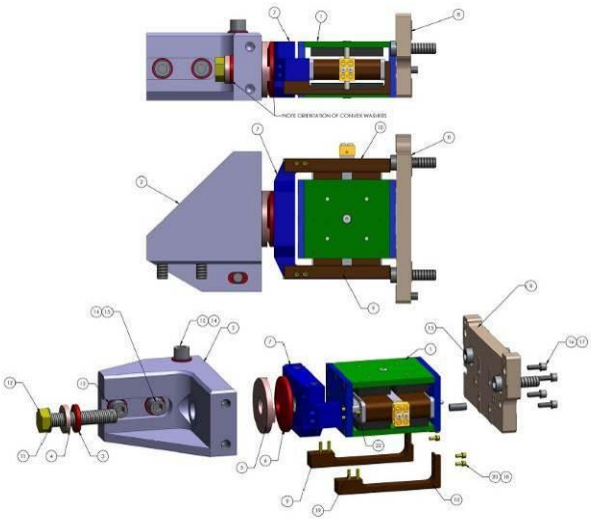


Figure 140: Actuators installation area

D0902530 Stage 1-2 Horizontal Actuators Assembly Installation

Note: To do the following steps, D0902530 Stage 1-2 Horizontal Actuators must be already assembled like described in the following document E1000380-v2.



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ
22	D1001737	Step Pin, Small Actuator, aLIGO BSC ISI	18-8 SSTL	2
21	McMaster_90145A539	Dowel Pin 1/4" (.2501) x 5/8" L 18.8 SST	18-8 Stainless	2
20	MCMASTER_92196A106	Screw 4-40 x .25" lg, SHCS	18-8 SSTL	4
19	MCMASTER_92196A113	SCREW, SHCS 4-40 X .75 LG.	18-8 SSTL	8
18	UCC WFV-04	Flat Washer, #4, .115 id x .209 od x .016 thk	18-8 SSTL	8
17	UC_COMPONENTS_WFV-08	Washer Vented, .17 ID X .304 OD X .032 THK #8	18-8 SS	4
16	UCC_C-808-NA	SHCS, 8-32 X .50 LG, AG PLATED	18-8 SS	4
15	HOLOKROME_78100	SHCS, 3/8"-16x1.25"	18-8 SS	5
14	UC_COMPONENTS_WFV-38	Washer Vented, .39 ID X .63 OD X .032 THK #3/8"	18-8 SS	3
13	MC MASTER 92217A520	3/8" Washer, 47/64" OD, 13/32" ID, 0.05" to 0.12" THCK	304, 316 OR 302 SSTL	3
12	McMASTER_92240A722	SCREW HEX HEAD, 1/2-13 X 2.5 FULL THD	18-8 SSTL	1
11	UC_COMPONENTS_WFV-50	Vented Washer, .515 ID X .87 OD X .032 THK #1/2"	18-8 SS	1
10	D0902154	SMALL ACTUATOR THERMAL BAR LEFT, aLIGO BSC ISI	COPPER	1
9	D0902153	SMALL ACTUATOR THERMAL BAR RIGHT, aLIGO BSC ISI	COPPER	1
8	D0902134	MAGNET TO STAGE2 INTERPOSER, aLIGO BSC ISI	6061-T6 Al	1
7	D0902155	SMALL ACTUATOR BOBBIN COIL BRACKET, aLIGO BSC ISI	6061-T6 Al	1
6	D1000678	SPHERICAL WASHER, 2 IN. OD CONVEX, aLIGO BSC ISI	304 SSTL	1
5	D0902156	SPHERICAL WASHER, 2 IN. OD CONCAVE, aLIGO BSC ISI	304 SSTL	1
4	D0902157	SPHERICAL WASHER, 1 IN. OD CONCAVE, aLIGO BSC ISI	304 SSTL	1
3	D1000679	SPHERICAL WASHER, 1 IN. OD CONVEX, aLIGO BSC ISI	304 SSTL	1
2	D0902162	SMALL HORIZONTAL ACTUATOR SLIDE BRACKET, aLIGO BSC ISI	6061-T6 Al	1
1	D1000584	SMALL ACTUATOR, aLIGO BSC-ISI	N/A	1

Figure 141: D0902530 Stage 1-2 Horizontal Actuators Assembly

Hardware:
(5) 3/8-16 x 1.25" SHCS – MSC 75464644
(5) 3/8 Vented Washers - UCC-WFV-38
(1) 1/2"-13 x 2.5" HHCS – MSC 67337089
(1) Spherical Washer 2 In. OD Concave - D0902156
(1) Spherical Washer 2 In. OD Convex – D1000678
(1) Spherical Washer 1 In. OD Convex – D1000679
(1) Spherical Washer 1 In. OD Concave – D0902157

- Insert (2) 3/8-16 x 1.25" SHCS with (2) 3/8" Vented Washers through D0902134 Magnet to Stage 2 Interposer into D0901521 Radial Left Walls. Snug them and **torque them up to 329 in.lbs.**
- Position D0902530 Stage 1-2 Horizontal Actuators Assembly against D0902279 Stage 1 Base Plate.
- Insert (3) 3/8-16 x 1.25" SHCS with (3) 3/8 Vented Washers through D0902162 Stage 1-2 Horizontal Actuator Slide Bracket into D0902279 Stage 1 Base Plate *(1 from the top & 2 from the side).*
- Position D0902162 Stage 1-2 Horizontal Actuator Slide Bracket with (1) 1/2"-13 x 2.5" HHCS Bolt & D0902157, D1000679, D0902156 & D1000678 Spherical Washers against D0902530 Stage 1-2 Horizontal Actuators Assembly, paying attention to properly order of these Spherical Washers (see Figure 141).
- Finger tighten (3) 3/8-16 x 1.25" SHCS while still allowing the bracket to slide.

- Finger tighten the 1/2”-13 x 2.5” HHCS, paying close attention to concentricity and height of the Spherical Washers (see Figure 142).
- Insure that D0902162 Stage 1-2 Horizontal Actuator Slide Bracket and Spherical Washers fully seat against the Actuator Assembly.

Note: A small Allen wrench may be useful to lift the Spherical Washers into the proper alignment.

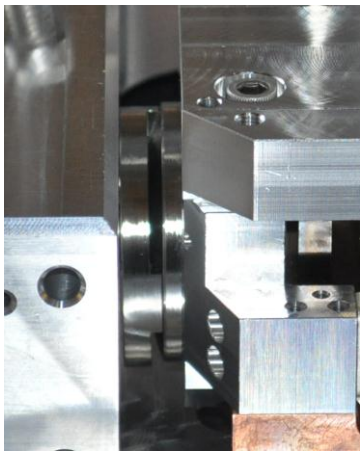


Figure 142: Improper Alignment of the Spherical Washers.

- Snug (3). 3/8-16 x 1.25” SHCS and **torque them up to 329 in.lbs (27.4 ft.lbs).**
- Snug (1). 1/2-13 x 2.5” HHCS and **torque them up to 517 in.lbs (43.1 ft.lbs).**

- Check actuator gaps in at least 8 different spots. If they are nominal, remove D0902136 Tooling Bracket.
- Check that both D1001737 Step Pins were removed.

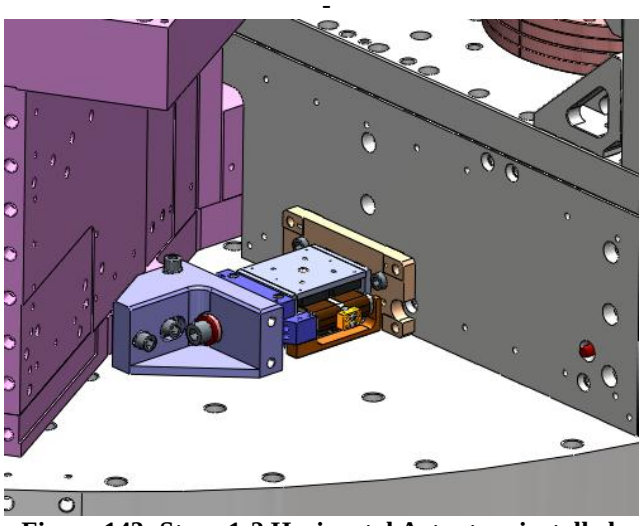


Figure 143: Stage 1-2 Horizontal Actuators installed.

- Check that Spherical Washers have not shifted.
- Check Actuator gaps again. If gaps have shifted beyond 0.100”±0.015”, remove D0902162 Stage 1-2 Horizontal Actuator Slide Bracket and D0902530 Stage 1-2 Horizontal Actuator Assembly, reinstall D0902136 Tooling Bracket and begin the installation all over again.

- Repeat the process for the (2) other D0902530 Stage 1-2 Horizontal Actuators Assemblies.

D0902531 Stage 1-2 Vertical Actuators Assembly Installation

Note: To do the following steps, D0902531 Stage 1-2 Vertical Actuators must be already assembled like described in the following document E1000387-v3.

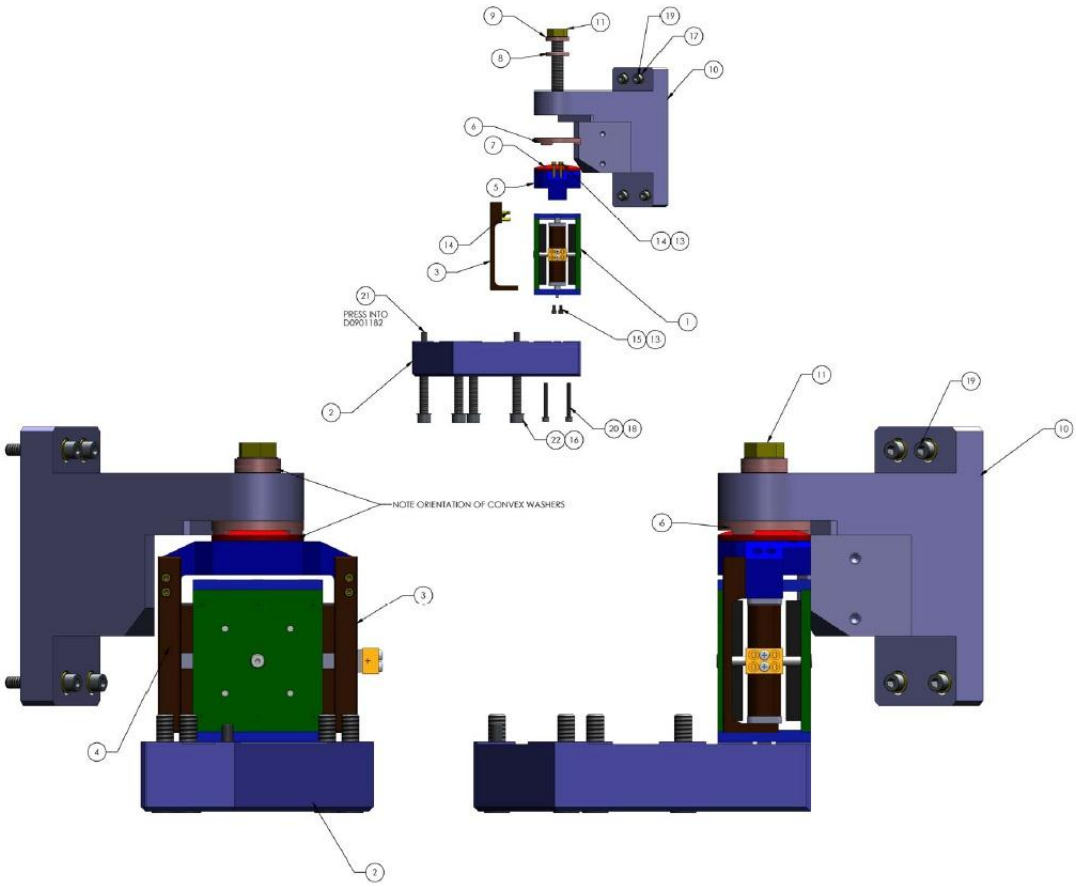


Figure 144: D0902531 Stage 1-2 Vertical Actuators Assembly Drawing

ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ
22	HOLOKROME_78104	SHCS, 3/8"-16x1.75"	18-8 SS	5
21	McMaster_90145A539	Dowel Pin 1/4" (.2501) x 5/8" L 18.8 SST	18-8 Stainless	2
20	UCC_C-824-NA	SHCS, 8-32 X 1.50 LG. AG PLATED	18-8 SS	4
19	HOLOKROME_78066	SHCS, 1/4"-20x1.5"	18-8 SS	4
18	UC_COMPONENTS_WFV-08	Washer Vented, .17 ID X .304 OD X .032 THK #8	18-8 SS	4
17	UC_COMPONENTS_WFV-25	Vented Washer, .255 ID X .468 OD X .032 THK #1/4	18-8 SSTL	4
16	UC_COMPONENTS_WFV-38	Washer Vented, .39 ID X .62 OD X .032 THK #3/8"	18-8 SS	5
15	MCMASTER_92196A106	SHCS, #4-40x.25"	AISI 304	4
14	MCMASTER_92196A113	SCREW, SHCS 4-40 X .75 LG.	18-8 SSTL	8
13	UCC WFV-04	Flat Washer, #4, .115 id x .209 od x .016 thk	18-8 SSTL	8
12	UC_COMPONENTS_WFV-50	Vented Washer, .515 ID X .87 OD X .032 THK #1/2"	18-8 SS	1
11	McMASTER_92240A722	SCREW HEX HEAD, 1/2-13 X 2.5 FULL THD	18-8 SSTL	1
10	D0902236	SMALL ACTUATOR VERTICAL BRACKET, aLIGO BSC ISI	6061-T6 Al	1
9	D0902157	SPHERICAL WASHER, 1 IN. OD CONCAVE, aLIGO BSC ISI	304 SSTL	1
8	D1000679	SPHERICAL WASHER, 1 IN. OD CONVEX, aLIGO BSC ISI	304 SSTL	1
7	D1000678	SPHERICAL WASHER, 2 IN. OD CONVEX, aLIGO BSC ISI	304 SSTL	1
6	D0902156	SPHERICAL WASHER, 2 IN. OD CONCAVE, aLIGO BSC ISI	304 SSTL	1
5	D0902155	SMALL ACTUATOR BOBBIN COIL BRACKET, aLIGO BSC ISI	6061-T6 Al	1
4	D0902153	SMALL ACTUATOR THERMAL BAR RIGHT, aLIGO BSC ISI	COPPER	1
3	D0902154	SMALL ACTUATOR THERMAL BAR LEFT, aLIGO BSC ISI	COPPER	1
2	D0902161	SMALL VERTICAL ACTUATOR MAGNET MOUNT, aLIGO BSC ISI	6061-T6 Al	1
1	D1000584	SMALL ACTUATOR, aLIGO BSC-ISI	N/A	1

Figure 145: D0902531 Stage 1-2 Vertical Actuators Assembly Bill of Material

Hardware:
(5) 3/8-16 x 1.75" SHCS – MSC 75464685
(5) 3/8 Vented Washers - UCC-WFV-38
(4) 1/4-20 x 1. 5" SHCS – MSC 75464446
(4) 1/4 Vented Washers - UCC-WFV-25
(1) 1/2"-13 x 2.5" HHCS – MSC 67337089
(1) Spherical Washer 2 In. OD Concave - D0902156
(1) Spherical Washer 2 In. OD Convex – D1000678
(1) Spherical Washer 1 In. OD Convex – D1000679
(1) Spherical Washer 1 In. OD Concave – D0902157

- Insert (1) 1/2"-13 x 2.5" HHCS Bolt & D0902157 & D1000679 Spherical Washers against D0902236 Stage 1-2 Vertical Actuator Bracket, paying attention to properly order of these Spherical Washers (see Figure 144).

- Attach D0902236 Stage 1-2 Vertical Actuator Bracket to D0902278 Stage 1 L4C Wall, by inserting (4) 1/4-20 x 1. 5" SHCS & (4) 1/4 Vented Washers, loose enough to allow movement of D0902236.
- Add D0902156 & D1000678 Spherical Washers on top (see Figure 144 for the right order), while holding screw in place.
- Lower D0902531 Stage 1-2 Vertical Actuator Assembly into place (see Figure 144.)
- Insert and snug (5) 3/8-16 x 1.75" SHCS & (5) 3/8 Vented Washers through D0902161 Stage 1-2 Vertical Actuator Magnet Mount into D0901520 Stage 2 Mid Plate.
- **Torque them up to 329 in.lbs (27.4 ft.lbs).**

- Lift D0902236 Stage 1-2 Actuator Vertical Bracket tight against D0902155 Stage 1-2 Actuator Bobbin Coil Bracket thru Spherical Washers.

Note: There should be no gaps between the Spherical Washers.

- Ensure that D0902236 Stage 1-2 Actuator Vertical Bracket is sitting flush against D0902278 Stage 1 L4C Wall, and tighten (4) 1/4-20 x 1. 5" SHCS.
- **Torque them up to 100 in.lbs (8.3 ft.lbs).**

Note: For this part, the help of a second assembler may be needed (see Figure 146).

Figure 146: D0902236 Stage 1-2 Actuator Vertical Bracket is flush against D0902278 Stage 1 L4C Wall before tightening the 1/2"-13 x 2.5" HHCS Bolt

- Make sure that Spherical Washers are concentric and centered on the 1/2"-13 x 2.5" HHCS Bolt and slowly tighten.

Note: The use of a torque wrench is not possible due to space constraints, so snug as tight as you can 1/2"-13 x 2.5" HHCS Bolt with an open-end wrench.

- Check Actuator gaps in at least 8 different spots. If they are nominal, remove D0902137 Tooling Bracket.
- Check that Spherical Washers have not shifted.
- Repeat the process for the other (2) D0902531 Stage 1-2 Vertical Actuators Assemblies.

- Check all D0902531 Stage 1-2 Vertical Actuators Assemblies Bobbin-Magnet gaps (they should be identical)

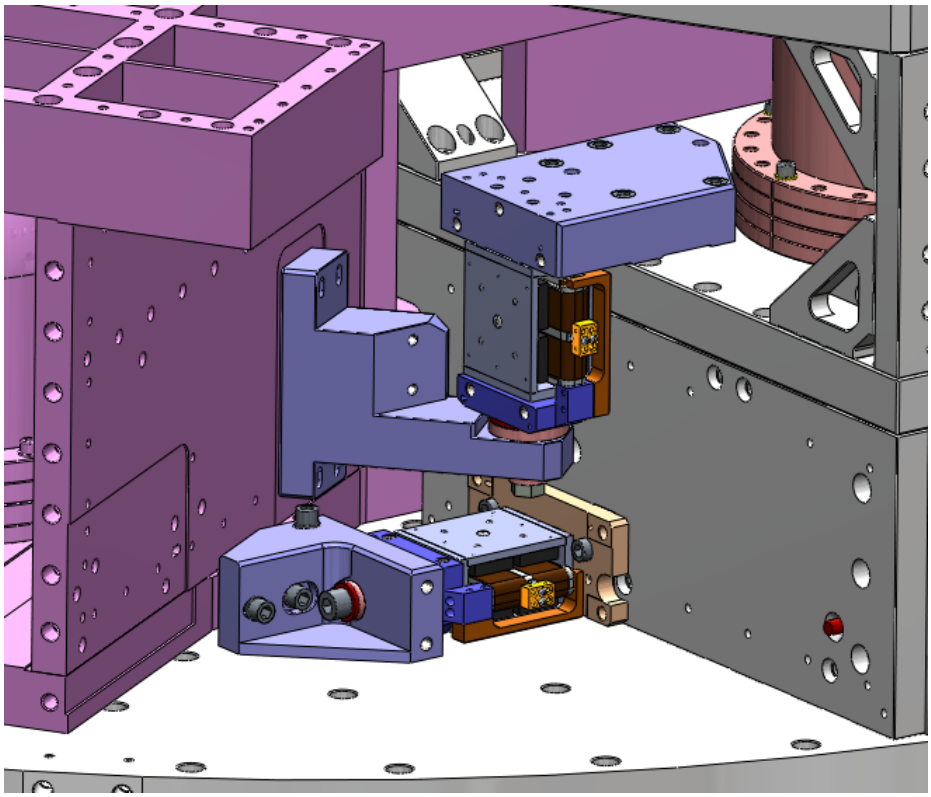


Figure 147: Both Horizontal & Vertical Stage 1-2 Actuator Assemblies installed

Install Stage 0-1 Actuators:

Note: Install actuators **with** lockdown bar attached
Note: Remove dummy weights representing actuators as actuators are installed.

Parts required

Quantity	Part Number	Description	Weight
3	D0901554	Actuator Post Stage 0-1	
3	D1000310	Stage 0-1 Horizontal Actuator Assembly with Tooling (see E1000393 for Assembly Procedure)	
3	D0901103	Stage 0-1 Vertical Actuator Assembly with Tooling (see E1000419 for Assembly Procedure)	
6	D0902424	Horizontal Actuator L connector	
3	D0902422	Large Vertical Actuator Connector Right	
3	D0902428	Large Vertical Actuator Connector Left	
3	D0901183	Large Vertical Actuator Post Bridge	

Prep Work for D0901554 Stage 0-1 Actuator Post:

Hardware:
(1) 3/8-16 x 1 DIA Helicoils
(4) 3/8-16 x 2 DIA Helicoils

- Install Nitronic 60 Helicoil threaded inserts into D0901554. See Figure 148.

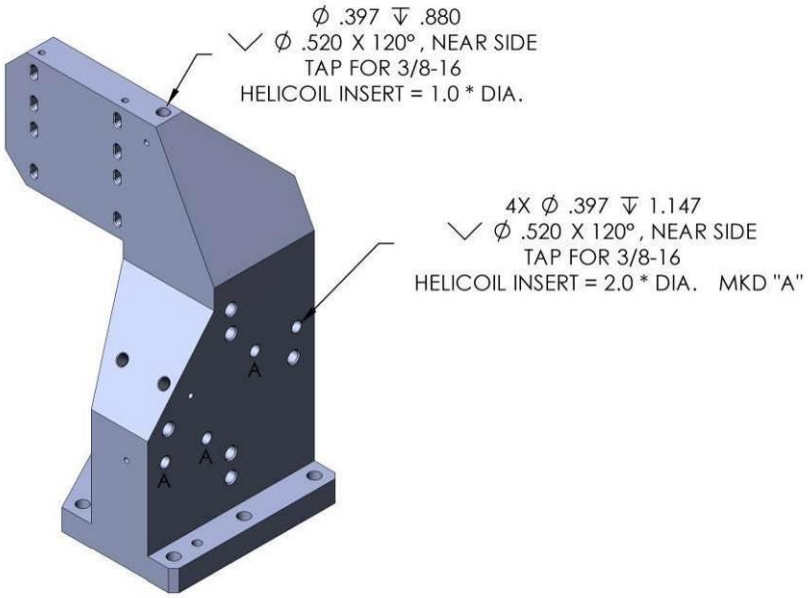


Figure 148: Prep Work for D0901554 Stage 0-1 Actuator Post

Hardware:
(2) 1/2-13 x 2" HHCS – MSC 67337048
(4) 1/2-13 x 2.5" HHCS – MSC 67337089
(6) 1/2 Vented Washers - UCC-WFV-50
(4) 1/4-20 x 1.5" SHCS – MSC 75464446
(4) 1/4 Vented Washers - UCC-WFV-25

- Insert (2) 1/2-13 x 2" SHCS and washers into the post holes which will lie under Stage 2.
- With two people, lift D0901554 Stage 0-1 Actuaor Post onto Stage 0. Its position is determined by dowels pins already inserted in D0900895 Top Part of Stage 0. With the use of feeler gauges, ensure that there are no gaps between the Post and Stage 0 greater than 0.002".
- Insert (4) 1/2-13 x 2.5" HHCS.
- Snug them and **torque all screws up to 805 in.lbs (67 ft.lbs).**
- Repeat this step for the (2) other D0901554 Stage 0-1 Actuator Posts.

D0901102 Stage 0-1 Horizontal Actuator Assembly

See D0901102 for details.

Note: To do the following steps, D0901102 Stage 0-1 Horizontal Actuator must be already assembled like described in the following document E1000393-v2.

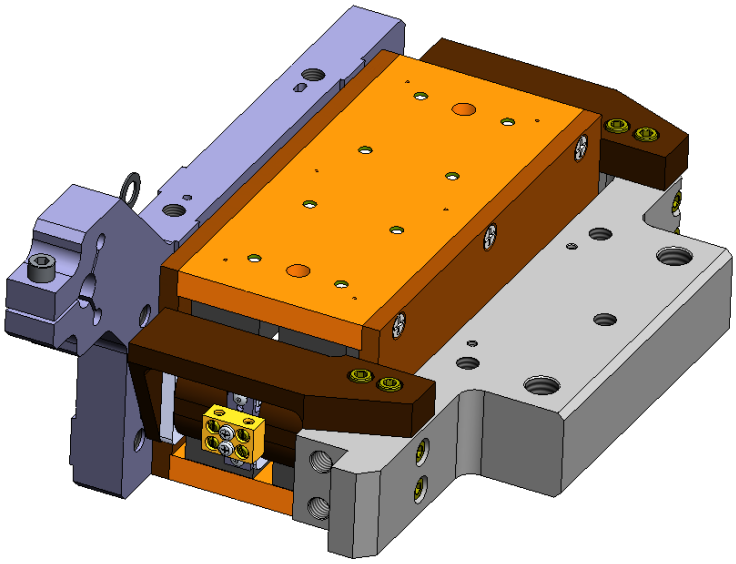


Figure 149: D0901102 Stage 0-1 Horizontal Actuator Assembly ready for install (Tooling Bar hidden)

Hardware:
(4) 5/16-18 x 1.125" SHCS – McMaster 92196A584
(4) 5/16 Vented Washers - UCC-WFV-31

- Attach D0902310 Stage 0-1 Actuator Magnet Bracket of the Actuator Assembly to D0902278 Stage1 L4C Wall, positioned with (2) 1/4" x 5/8" dowel pins already inserted in D0902310.
- Insert screws from back side of D0902278 Stage1 L4C Wall.
- Snug them and **torque them up to 132 in.lbs (11 ft.lbs).**

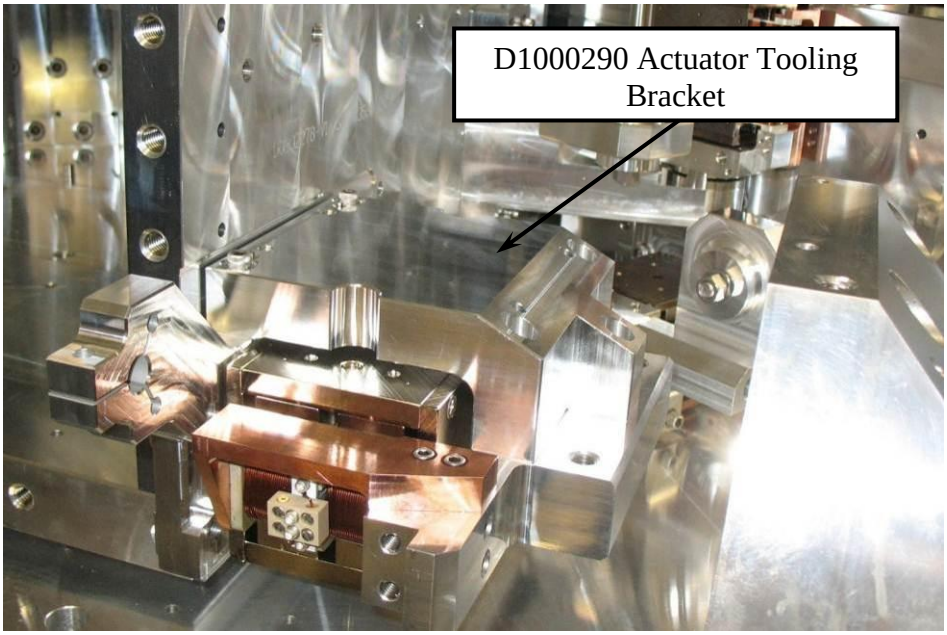
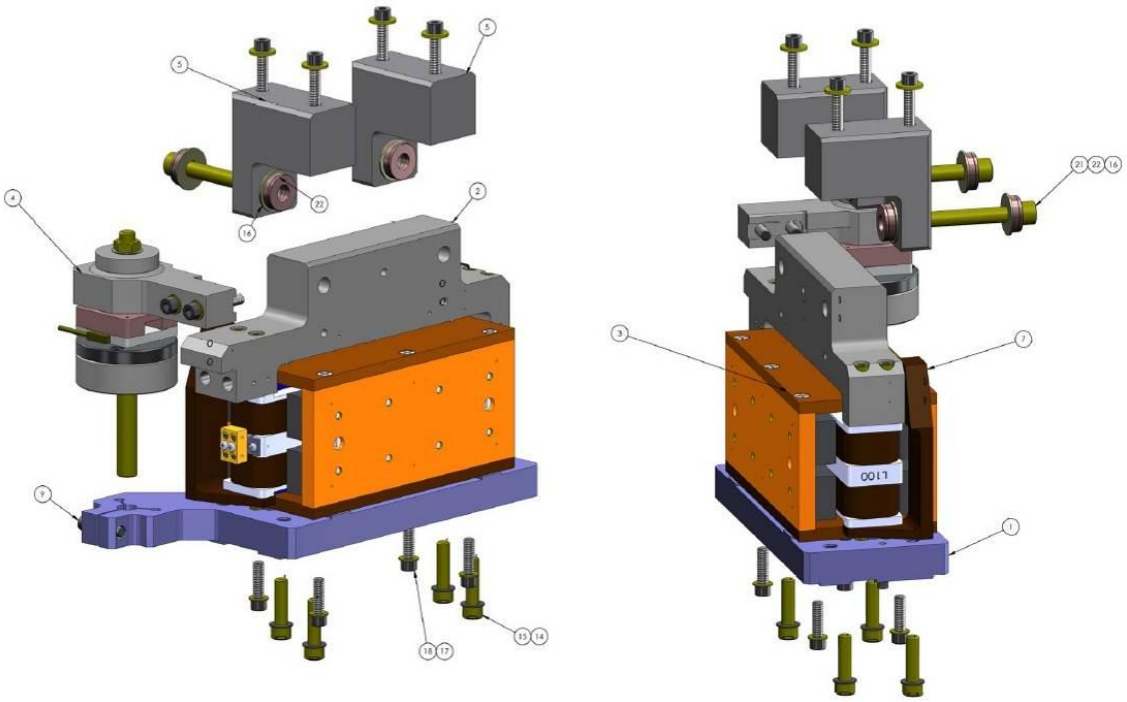


Figure 150: D0901102 Stage 0-1 Horizontal Actuator Assembly (with D1000290 Actuator Tooling Bracket) on the ISI

Note: **Attaching D0901102 Stage 0-1 Horizontal Actuator Assembly to D0901554 Stage 0-1 Actuator Post needs to WAIT until the Stages of the BSC-ISI have been floated and any twisting issues have been solved in order not to damage the actuators.**

Hardware:
(2) 3/8-16 x 2.25" SHCS – MSC 05682224
(4) Spherical Washers .406 ID x .88 OD x .25 THK – McMaster 91944A450
(4) 3/8 Flat Washers 1" OD- McMaster 92141A051

- Slide (2) D0902424 Horizontal Actuators L Connectors to D0901554 Stage 0-1 Actuator Post in place and attach them loosely to D0901102 Stage 0-1 Horizontal Actuator Assembly as shown on Figure 151 (see also the exact order in which to put the different types of washers).



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	Running Config/QTY.
23	D1002282	STEP PIN, LARGE ACTUATOR, aLIGO BSC ISI	18-8 SS	2
22	McMaster_91944A450	Spherical Washer .406 id x .88 od x .25 thk	18-8 SSTL	4
21	MCMASTER_92196A633	SHCS 3/8-16 x 2.25 lg. 1 1/4 to full thd	18-8 SSTL	2
20	HOLOKROME_78066	Screw 1/4-20 x 1.5 lg SHCS	18-8 SS	4
19	MSC_7322886	WASHER .28 ID X .63 OD X .05-.08 THK	300 SSTL	4
18	HOLOKROME_78060	SHCS, 1/4"-20x.875"	18-8 SS	4
17	UCC WFV-25	Flat Washer, Vented .255 ID, .46 OD, .032 THK	18-8 SSTL	4
16	MCMASTER_92141A051	Flat Washer, 3/8" ID, 1" OD	18-8 SS	4
15	McMaster_92196A584	Screw, SHCS, 5/16-18 x 1 1/8 lg.	18-8 SSTL	4
14	UC_COMPONENTS_WFV-31	Washer Vented, .328 ID X .562 OD X .032 THK #5/16	18-8 SSTL	4
13	McMaster_92196A291	Screw SHCS, 10-32 x 1.375 lg.	18-8 SSTL	4
12	UC_COMPONENTS_WFV-10	Washer Vented, 0.195 ID, 0.354 OD, 0.032 THK #10	18-8 SS	8
11	McMaster_92196A271	Screw SHCS 10-32 x .62 lg.	18-8 SSTL	4
10	UC_COMPONENTS_H-1006	Hex Head Machine Screw, 10-32 x 3/8 lg vented	18-8 SSTL	4
9	HOLOKROME_78062	SHCS, 1/4"-20x1.0"	18-8 SS	1
8	McMaster_90145A539	Dowel Pin 1/4" (.2501) x 5/8" L 18.8 SST	18-8 Stainless	2
7	D1000175	THERMAL BAR, LEFT, LARGE ACTUATOR, aLIGO BSC ISI	COPPER	1
6	D1000176	THERMAL BAR, RIGHT, LARGE ACTUATOR, aLIGO BSC ISI	COPPER	1
5	D0902424	HORIZONTAL ACTUATOR L CONNECTOR, STAGE 0-1, aLIGO BSC ISI	6061-T6 Al	2
4	D1000478	SENSOR ASSEMBLY HORIZONTAL, aLIGO BSC ISI	N/A	1
3	D0902749	Large Actuator, aLIGO SEI HAM-ISI & BSC-ISI	N/A	1
2	D0902427	ACTUATOR COIL BRACKET HORIZONTAL, STAGE 0-1, aLIGO BSC ISI	6061-T6 Al	1
1	D0902310	ACTUATOR MAGNET BRACKET, STAGE 0-1, aLIGO BSC ISI	6061-T6 Al	1

Figure 151: D0901102 Stage 0-1 Horizontal Actuator Assembly drawing with Mounting Hardware

Hardware:
(4) 1/4-20 x 1.5" SHCS – MSC 75464446
(4) 1/4 Vented Washers – UCC-WFV-25

- Insert screws through the back side of D09015541 Actuator Post into D0902424 Horizontal Actuators L Connectors and hand tight them.
- Progressively tighten Spherical Washer, and 1/4-20 x 1.5" SHCS, making sure that the Spherical Washers are concentric and centered on the 3/8-16 x 2.25" SHCS.
- **Torque the (4) 1/4-20 x 1.5" SHCS up to 100 in.lbs (8.3 ft.lbs) and (2) 3/8-16 x 2.25" SHCS up to 236 in.lbs (19.7 ft.lbs).**

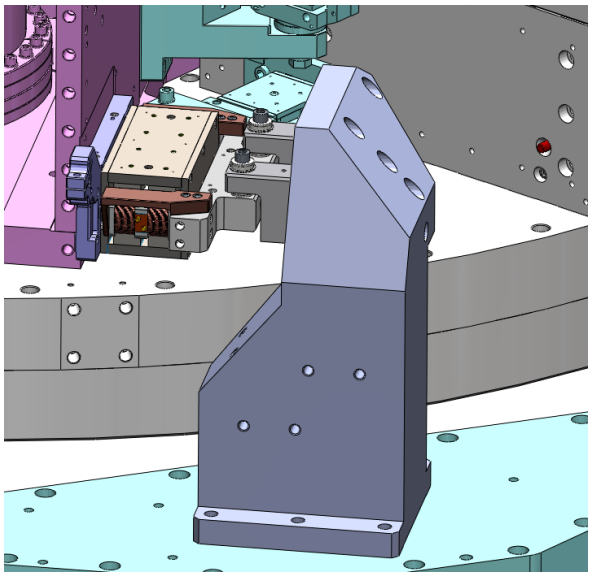


Figure 152: D0901102 Stage 0-1 Horizontal Actuator Assembly installed on D0901541 Actuator Post

- Remove D1000290 Stage 0-1 Actuator Tooling Bracket.
- Check Actuator Bobbin-Magnet gaps with go/no go shims.

Note: 85 mils should go in, 115 should not.

- Repeat this process for the other (2) D0901102 Stage 0-1 Horizontal Actuator Assemblies.

D0901103 Stage 0-1 Vertical Actuator Assembly

Use drawing D0901103 for details.

Note: To do the following steps, D0901103 Stage 0-1 Vertical Actuator must be already assembled like described in the following document E1000419-v2.

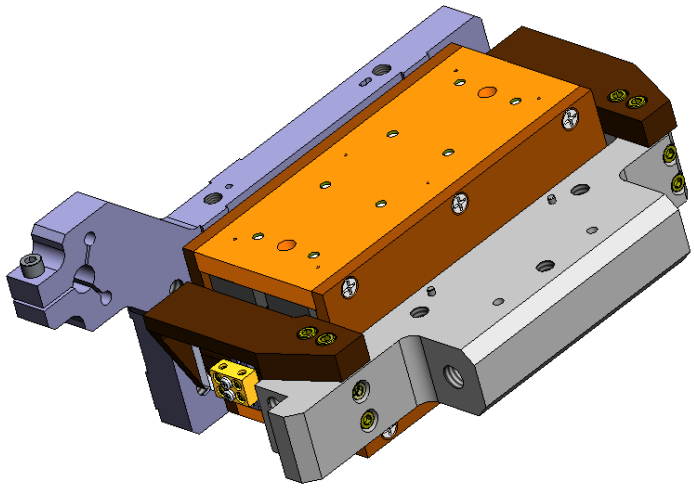
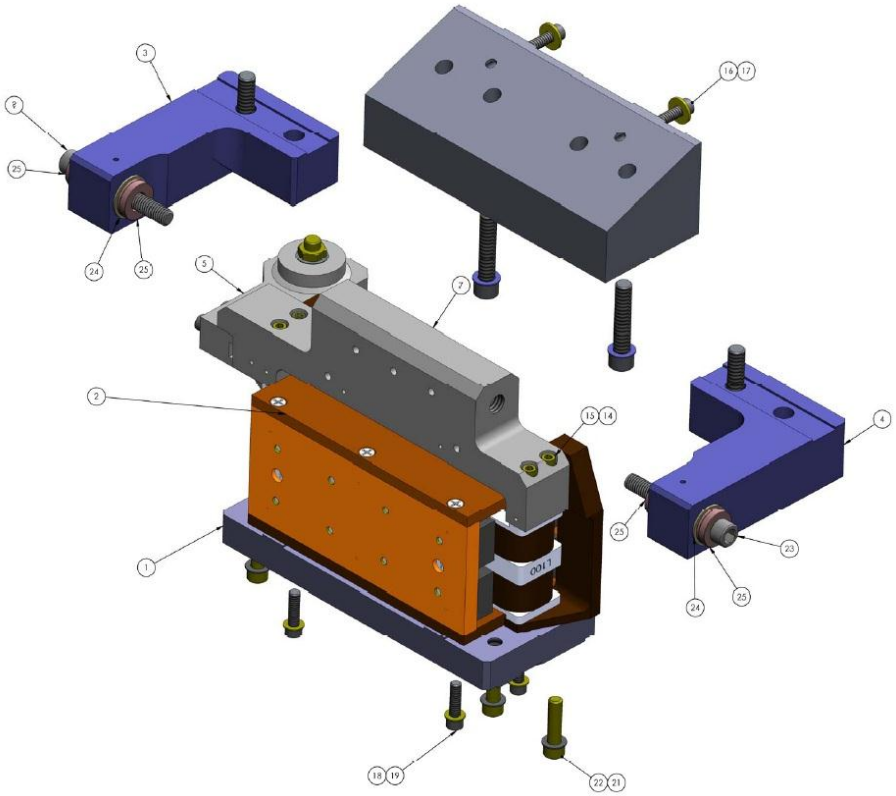


Figure 153: D0901103 Stage 0-1 Vertical Actuator Assembly per E1000394 (D1000290 Actuator Tooling Bracket)

***Note:* Attaching D0901103 Stage 0-1 Vertical Actuator Assembly to D0901554 Stage 0-1 Actuator Post needs to WAIT until the Stages of the BSC-ISI have been floated and any twisting issues have been solved in order not to damage the actuators.**

Hardware:
(2) 3/8-16 x 2.25" SHCS – MSC 05682224
(4) Spherical Washers .406 ID x .88 OD x .25 THK – McMaster 91944A450
(4) 3/8 Flat Washers 1" OD- McMaster 92141A051

- Mount D0902428 Stage 0-1 Vertical Actuator L Connector Left & D0902422 Stage 0-1 Vertical Actuator L Connector Right to D0902426 Stage 0-1 Actuator Coil Bracket, and leave the connections loose.



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	Running Config/QTY.
28	D1002282	STEP PIN, LARGE ACTUATOR, aLIGO BSC ISI	18-8 SS	2
27	McMaster_90145A539	Dowel Pin 1/4" (.2501) x 5/8" L 18.8 SST	18-8 Stainless	2
26	MCMASTER_90145A470	DOWEL PIN 1/8 OD X 3/8 LG	18-8 SS	2
25	McMaster_91944A450	Spherical Washer .406 id x .88 od x .25 thk	18-8 SSTL	4
24	MCMASTER_92141A051	Flat Washer, 3/8" ID, 1" OD	18-8 SS	4
23	MC_MASTER 92196A635	SHCS, 3/8"-16x2.75"	Material <not specified>	2
22	McMaster_92196A584	Screw, SHCS, 5/16-18 x 1 1/8 lg.	18-8 SSTL	4
21	UC_COMPONENTS_WFV-31	Washer Vented, .328 ID X .562 OD X .032 THK #5/16	18-8 SSTL	4
20	McMaster_92196A271	Screw SHCS 10-32 x .62 lg.	18-8 SSTL	4
19	HOLOKROME_78060	SHCS, 1/4"-20x.875"	18-8 SS	4
18	UC_COMPONENTS_WFV-25	Vented Washer, .255 ID X .468 OD X .032 THK #1/4	18-8 SSTL	4
17	MSC_7322886	WASHER .28 ID X .63 OD X .05-.08 THK	300 SSTL	4
16	HOLOKROME_78066	Screw 1/4-20 x 1.5 lg SHCS	18-8 SS	4
15	McMaster_92196A291	Screw SHCS, 10-32 x 1.375 lg.	18-8 SSTL	4
14	UC_COMPONENTS_WFV-10	Washer Vented, 0.195 ID, 0.354 OD, 0.032 THK #10	18-8 SS	8
13	UC_COMPONENTS_H-1006	Hex Head Machine Screw, 10-32 x 3/8 lg vented	18-8 SSTL	4
12	HOLOKROME_78062	SHCS, 1/4"-20x1.0"	18-8 SS	1
11	UC_COMPONENTS_WFV-38	Washer Vented, .39 ID X .63 OD X .032 THK #3/8"	18-8 SS	4
10	HOLOKROME_78104	SHCS, 3/8"-16x1.75"	18-8 SS	4
9	D0901183	LARGE VERT. ACTUATOR POST BRIDGE, STAGE 0-1, aLIGO BSC ISI	6061-T6 Al	1
8	D1000175	THERMAL BAR, LEFT, LARGE ACTUATOR, aLIGO BSC ISI	COPPER	1
7	D0902426	Large Vert. Actuator Coil Bracket, Stage 0-1, aLIGO BSC ISI	6061-T6 Al	1
6	D1000176	THERMAL BAR, RIGHT, LARGE ACTUATOR, aLIGO BSC ISI	COPPER	1
5	D1000477	SENSOR ASSEMBLY VERTICAL, aLIGO BSC ISI	N/A	1
4	D0902422	LARGE VERT. ACTUATOR CONNECTOR RIGHT, STAGE 0-1, aLIGO BSC ISI	6061-T6 Al	1
3	D0902428	LARGE VERT. ACTUATOR CONNECTOR LEFT, STAGE 0-1, aLIGO BSC ISI	6061-T6 Al	1
2	D0902749	Large Actuator, aLIGO SEI HAM-ISI & BSC-ISI	N/A	1
1	D0902310	ACTUATOR MAGNET BRACKET, STAGE 0-1, aLIGO BSC ISI	6061-T6 Al	1

Figure 154: D0901103 Stage 0-1 Vertical Actuator Assembly Exploded View

Hardware:
(2) 3/8-16 x 1.75" SHCS – MSC 75464685
(4) 3/8 Vented Washers – UCC WFV-38

- Attach hand tight D0901183 Stage 0-1 Vertical Actuator Post Bridge. To D0902428 Stage 0-1 Vertical Actuator L Connector Left & D0902422 Stage 0-1 Vertical Actuator L Connector Right.

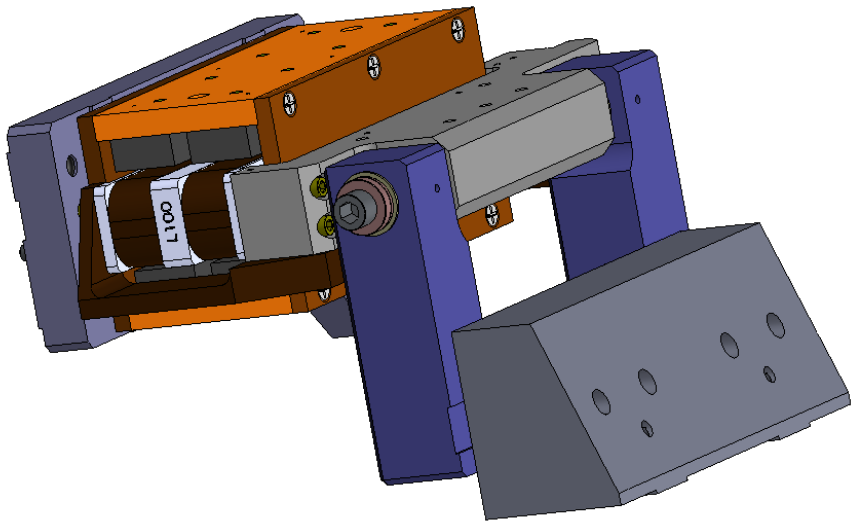


Figure 155: D0901103 Stage 0-1 Vertical Actuator Assembly ready for install (D1000290 Actuator Tooling Bracket hidden)

Hardware:
(4) 5/16-18 x 1.125" SHCS – McMaster 92196A584
(4) 5/16 Vented Washers – UCC WFV-31

- Attach D0902310 Stage 0-1 Horizontal Actuator Magnet Bracket to D0902273 Stage1 Close Out Plate (SHCS from top side of plate) as shown on Figure 156 & Figure 157.
- **Torque these screws up to 132 in.lbs (11 ft.lbs).**

Hardware:
(4) 1/4-20 x 1. 5" SHCS – McMaster 92196A584
(4) 1/4 Vented Washers – UCC WFV-25

- Attach D0901183 Stage 0-1 Vertical Actuator Post Bridge to D0901554 Actuator Post (SHCS going from the back side of D0901554 Actuator Post into D0901183).
- Progressively tighten Spherical Washer, and 1/4-20 x 1.5" SHCS, making sure that the Spherical Washers are concentric and centered on the 3/8-16 x 2.25" SHCS.

- **Torque the (4) 1/4-20 x 1.5" SHCS up to 100 in.lbs (8.3 ft.lbs), (2) 3/8-16 x 2.25" SHCS up to 236 in.lbs (19.7 ft.lbs), and (2) 3/8-16 x 1.75" SHCS up to 329 in.lbs (27.4 ft.lbs).**

- Remove D1000290 Stage 0-1 Actuator Tooling Bracket.
- Check Actuator Bobbin-Magnet gaps with go/no go shims.

Note: 85 mils should go in, 115 should not.

- Repeat this process for the other (2) D0901103 Stage 0-1 Vertical Actuator Assemblies.

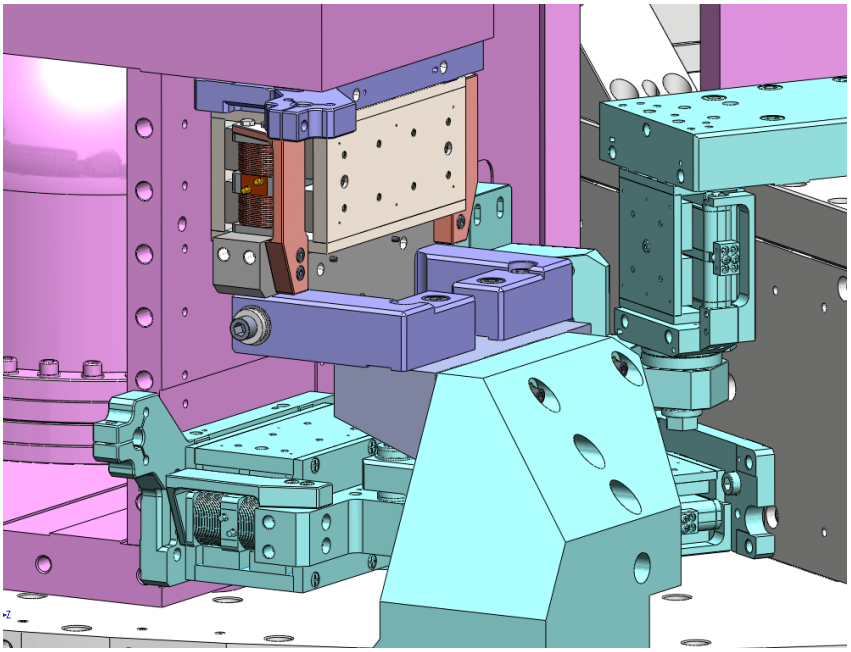


Figure 156: D0901102 & D0901103 Actuators Assemblies fully installed

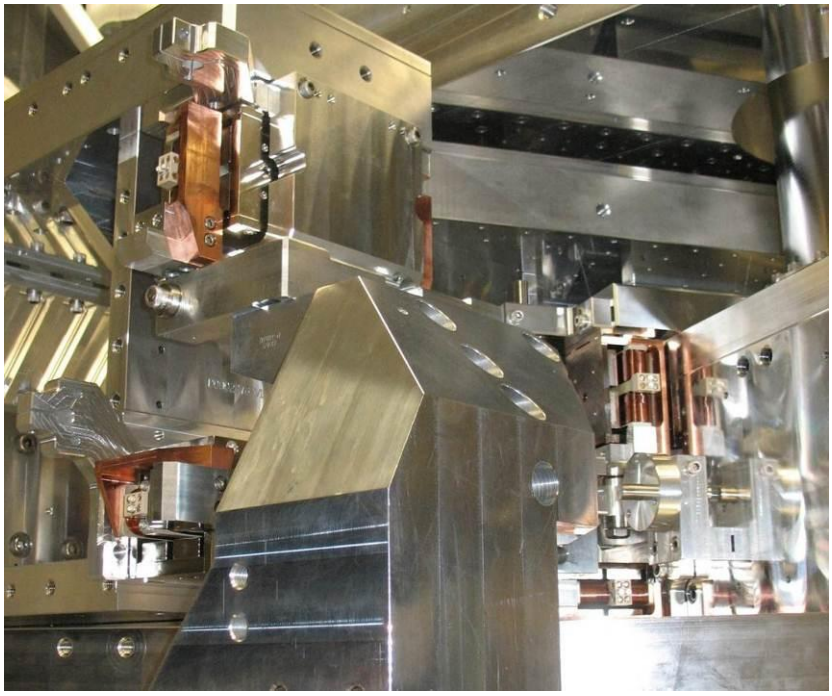


Figure 157: D0901102 & D0901103 Actuators Assemblies installed on the BSC-ISI (LASTI dirty build)

Install Stage 1 L4C's

Note: To do the following steps, D047820 L4C Pod Assembly must be already assembled like described in the following document E1000618-v2.

Parts required

Quantity	Part Number	Description	Weight
6	D047820	L4C Pod Assembly	
3	D0902283	L4C Interposer	

Hardware:
(2) 10-24 x 1.125" Vented Ag-Plated SHCS – D0902801/McMaster 94035A575
(2) #10 Vented Washers – UCC WFV-10
(1) 1/4-20 x 1.125" Vented Ag-Plated SHCS – UCC_C-2018-A
(1) 1/4 Vented Washers – UCC WFV-25

1.91. Install Vertical L4Cs

- Put D047820 L4C Pod Assembly in position as shown on Figure 158.

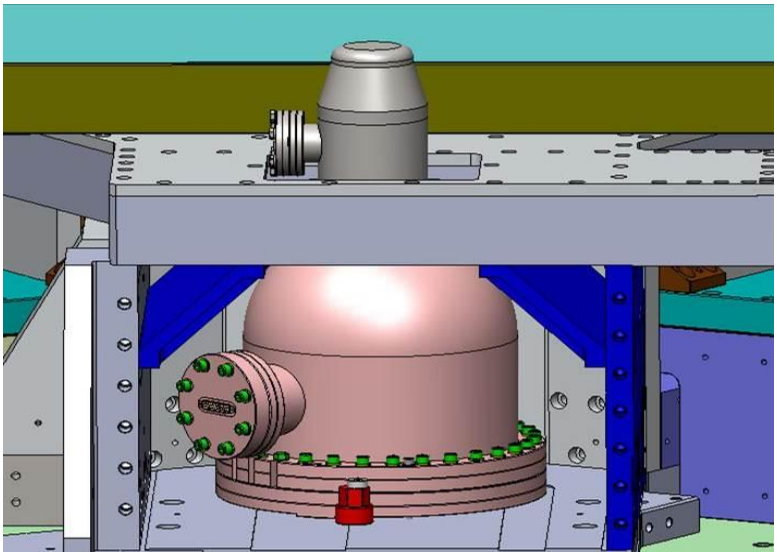


Figure 158: Placement of Vertical L4C's

- Insert all the screws from below through D0902273 Stage 1 Close Out Plate into D047823 L4C Base Plate Flange.

- Snug all the screws and **torque 10-24 x 1.125" Vented Ag-Plated SHCS up to 22 in.lbs torque 1/4-20 x 1.125" Vented Ag-Plated SHCS up to 75 in.lbs (6.3 ft.lbs).**
- Repeat this step for the (2) other D047820 L4C Pod Assemblies.

1.92. Attach Horizontal L4C to D0902283 Interposer Plate

Prep Work for D0902283 Interposer Plate:

Hardware:
(1) 3/8-16 x 2 DIA Helicoils

- Install Nitronic 60 Helicoil threaded inserts into D0902283. See Figure 159.

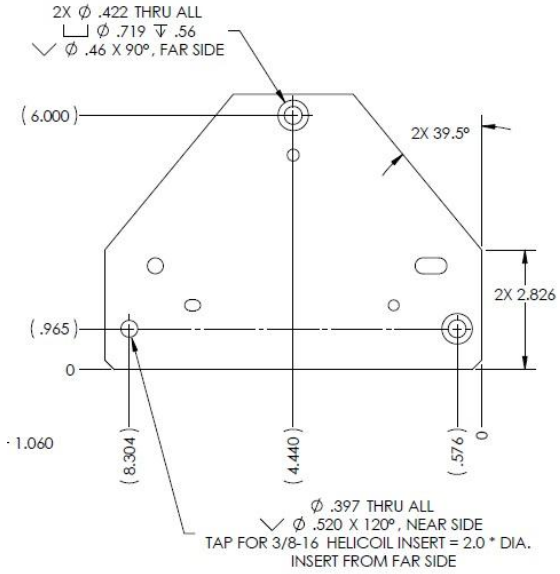


Figure 159: Prep Work for D0902283 Interposer Plate

Hardware:
(2) 10-24 x 1.125" Vented Ag-Plated SHCS – D0902801/McMaster 94035A575
(2) #10 Vented Washers – UCC WFV-10
(1) 1/4-20 x 1.125" Vented Ag-Plated SHCS – UCC_C-2018-A
(1) 1/4 Vented Washers – UCC WFV-25

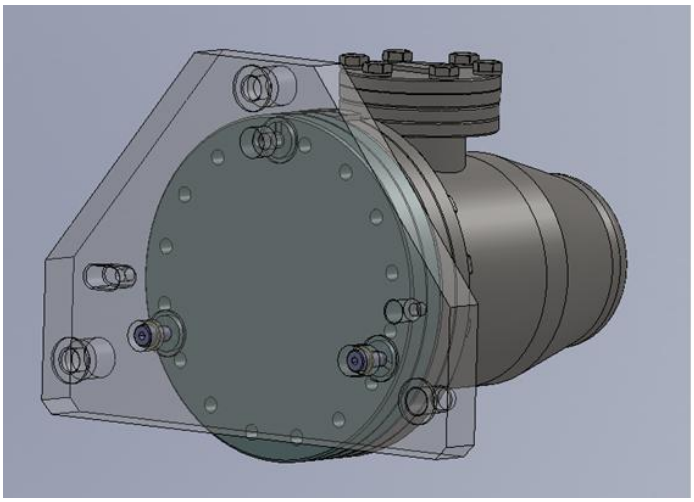


Figure 160: Horizontal L4C on D0902283 Interposer Plate

- Insert all the screws from below through D0902283 Interposer Plate into D047823 L4C Base Plate Flange as shown on Figure 160.
- Snug all the screws and **torque 10-24 x 1.125" Vented Ag-Plated SHCS up to 22 in.lbs torque 1/4-20 x 1.125" Vented Ag-Plated SHCS up to 75 in.lbs (6.3 ft.lbs).**
- Repeat this step for the (2) other D047820 L4C Pod Assemblies.

Hardware:
(3) 3/8-16 x 1.25" SHCS – MSC 75464644
(3) 3/8 Vented Washers – UCC WFV-38

- Attach D0902283 Interposer Plate onto D0902278 L4C Wall as shown on Figure 161.

Note: There are 2 dowel pins already installed in D0902278 L4C Wall, to position D0902283. (2) 3/8-16 x 1.25" SHCS are attached from the Trillium bay into D0902278 L4C Wall, the third one goes from the outside in.

- Snug all the screws and **torque them up to 329 in.lbs (27 ft.lbs).**

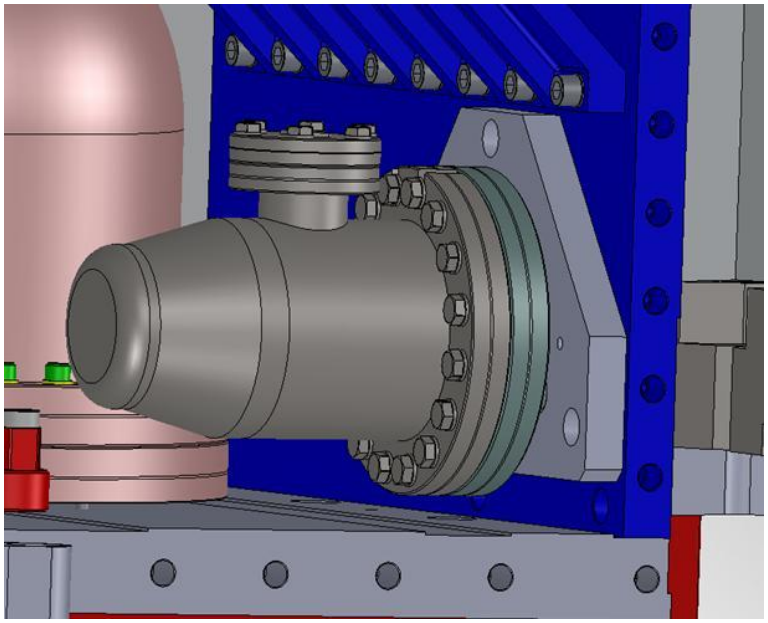


Figure 161: Horizontal L4C attached on Stage 1

Install stage 1 close-out door

Parts required

Quantity	Part Number	Description	Weight
3	D0902281	Stage 1 Door	

Prep Work for D0902281 Stage 1 Door:

Hardware:
(4) 1/4-20 x 2 DIA Helicoils
(19) 3/8-16 x 2 DIA Helicoils
(2) 1/2" x 3.5 dowel pins
(2) 3/8" x 2.5" dowel pins

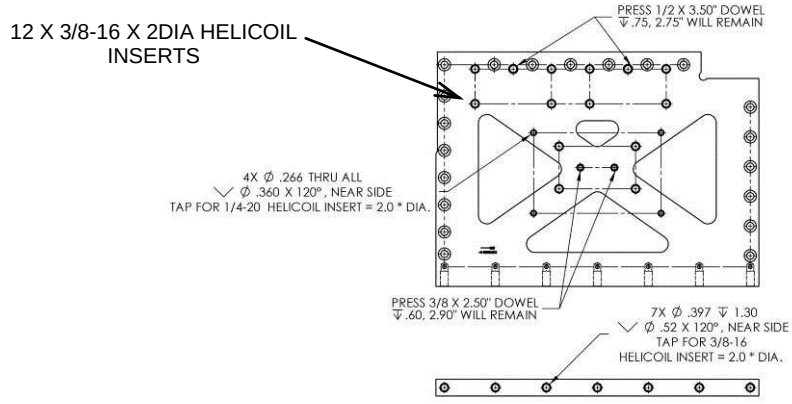


Figure 162: Prep Work for D0902281 Stage 1 Door

- Install Nitronic 60 Helicoil threaded inserts into D0902281. See Figure 162.
- Press (2) 3/8" x 2.5" dowel pins into D0902281. Pins should be flush on the back of D0902281 as shown on Figure 162.
- Press (2) 1/2" x 3.5" dowel pins into D0902281. Pins should be flush on the back of D0902281 as shown on Figure 162.

  Hardware:
  (27) 3/8-16 x 1.25" SHCS – MSC 75464644 – 7 from the top & 20 from the side
  (27) 3/8 Vented Washers – UCC WFV-38

- Hold D0902281 Stage 1 Door in place and attach it from the front (circled in red on Figure 163) and from the top (as shown in yellow on Figure 163)

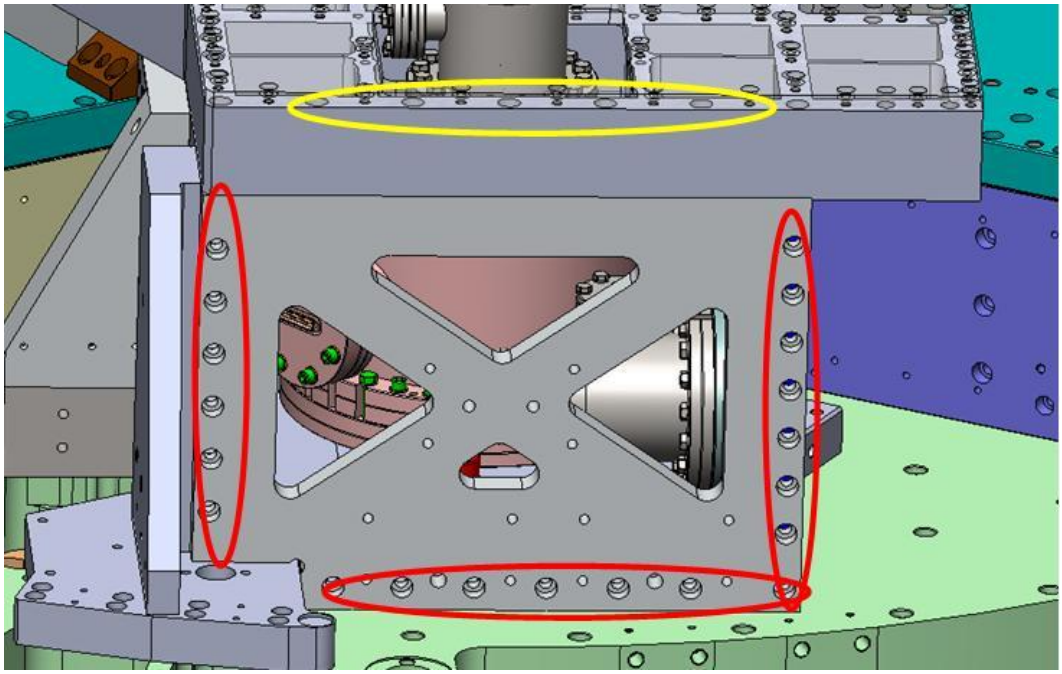


Figure 163: D0902281 Stage 1 Door attachment

Install Capacitive Position Sensors

Parts required

Quantity	Part Number	Description	Weight
3	D0902529	Stage 1-2 Horizontal Position Sensor Assembly	
3	D0902534	Stage 1-2 Vertical Position Sensor Assembly	
3	D1000477	Stage 0-1 Vertical Position Sensor Assembly	
3	D1000478	Stage 0-1 Horizontal Position Sensor Assembly	

Stage 1-2 Vertical Position Sensors:

Hardware:
(2) 1/4-20 x 1.25" SHCS – MSC 75464420
(2) 1/4 Vented Washers – UCC WFV-25

- Insert D0902251 Vertical Sensor Target Mount onto D0902161 Actuator Magnet Mount, positioned by (2) dowel pins previously inserted in D0902251.
- Insert SHCS through D0902251 into D0902161.
- Snug them and **torque them up to 100 in.lbs (8.3 ft.lbs).**

Hardware:
(1) 1/4-20 x 1.5" SHCS – MSC 75464446
(1) 1/4 Vented Washers – UCC WFV-25

- Slide D1000468 Position Sensor Target Assembly into the D0902251 Vertical Sensor Target Mount.
- Insert SHCS into D0902251 Vertical Sensor Target Mount.
- Snug it and **torque it up to 100 in.lbs (8.3 ft.lbs).**

Hardware:
(2) 1/4-20 x 1.5" SHCS – MSC 75464446
(2) 1/4 Vented Washers – UCC WFV-25

- Position the remaining half of D0902534 Vertical Position Sensor onto D0902236 Stage 1-2 Actuator Vertical Bracket, using the dowel pins previously inserted in D0902249.

- Insert SHCS through D0902249 Stage 1-2 Vertical Position Sensor Mount into D0902236 Stage 1-2 Actuator Vertical Bracket.
- Snug it and **torque it up to 100 in.lbs (8.3 ft.lbs).**
- Repeat these steps for the (2) other Stage 1-2 Vertical Position Sensors.

Stage 1-2 Horizontal Position Sensors:

Hardware:
(2) 1/4-20 x 2" SHCS – MSC 75464487
(2) 1/4 Vented Washers – UCC WFV-25

- Insert D0902252 Stage 1-2 Horizontal Sensor Target Mount onto D0901521 Stage 1 Left Radial Wall as shown on Figure 164.
- Insert SHCS through D0902251 into D0902161.
- Snug them and **torque them up to 100 in.lbs (8.3 ft.lbs).**

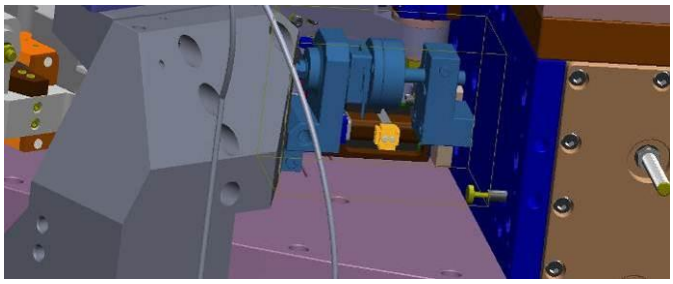


Figure 164: Stage 1-2 Horizontal Position Sensor Installed (highlighted in blue)

Hardware:
(1) 1/4-20 x 1.75" SHCS – MSC 75464461
(1) 1/4 Vented Washers – UCC WFV-25

- Slide D1000468 Position Sensor Target Assembly into the D0902252 Horizontal Sensor Target Mount.
- Insert SHCS into D0902252 Horizontal Sensor Target Mount.
- Snug it and **torque it up to 100 in.lbs (8.3 ft.lbs).**

Hardware:
(2) 1/4-20 x 1.75" SHCS – MSC 75464461
(2) 1/4 Vented Washers – UCC WFV-25

- Position the remaining half of D0902529 Horizontal Position Sensor onto D0902162 Stage 1-2 Horizontal Actuator Slide Bracket, using the dowel pins previously inserted in D0902250.
- Insert SHCS through D0902250 Stage 1-2 Horizontal Position Sensor Mount into D0902162 Stage 1-2 Horizontal Actuator Slide Bracket.
- Snug it and **torque it up to 100 in.lbs (8.3 ft.lbs).**
- Repeat these steps for the (2) other Stage 1-2 Horizontal Position Sensors.

Stage 0-1 Horizontal Position Sensors:

Hardware:
(1) 1/4-20 x 1" SHCS – MSC 75464404
(1) 1/4 Vented Washers – UCC WFV-25

- Slide the D1000468 Position Sensor Target Assembly into D0902310 Actuator Magnet Bracket.
- Insert SHCS into D0902310.
- Snug it and **torque it up to 100 in.lbs (8.3 ft.lbs).**

Hardware:
(2) 1/4-20 x 1.5" SHCS – MSC 75464446
(2) 1/4 Vented Washers – UCC WFV-25

- Position D1000467 Position Sensor Assembly (the remaining half of D1000478 Stage 0-1 Vertical Position Sensor Assembly) to side of D0902427 Actuator Coil Bracket.
- Insert SHCS into D0902310.
- Snug it and **torque it up to 100 in.lbs (8.3 ft.lbs).**
- Repeat these steps for the (2) other Stage 0-1 Vertical Position Sensors.

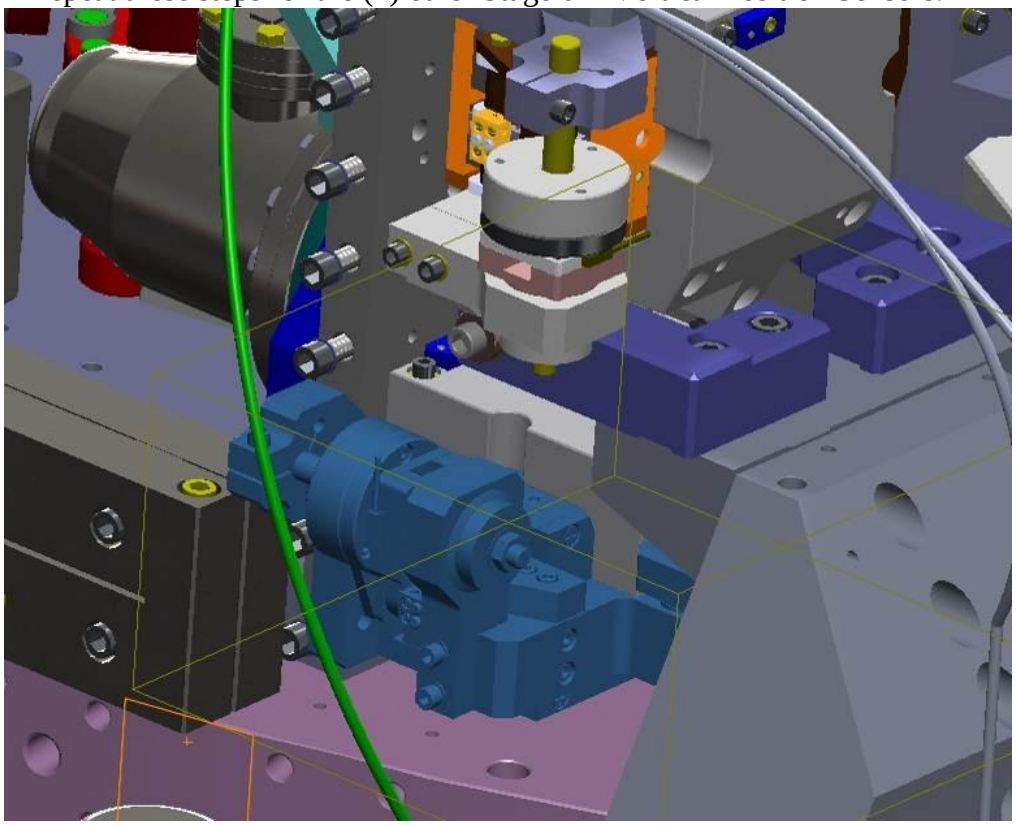


Figure 165: Stage 0-1 Vertical Position Sensor installed (highlighted in blie)

Stage 0-1 Horizontal Position Sensors:

Repeat steps 1 and 2 from Vertical Stage 0-1 Position Sensor Installation in .

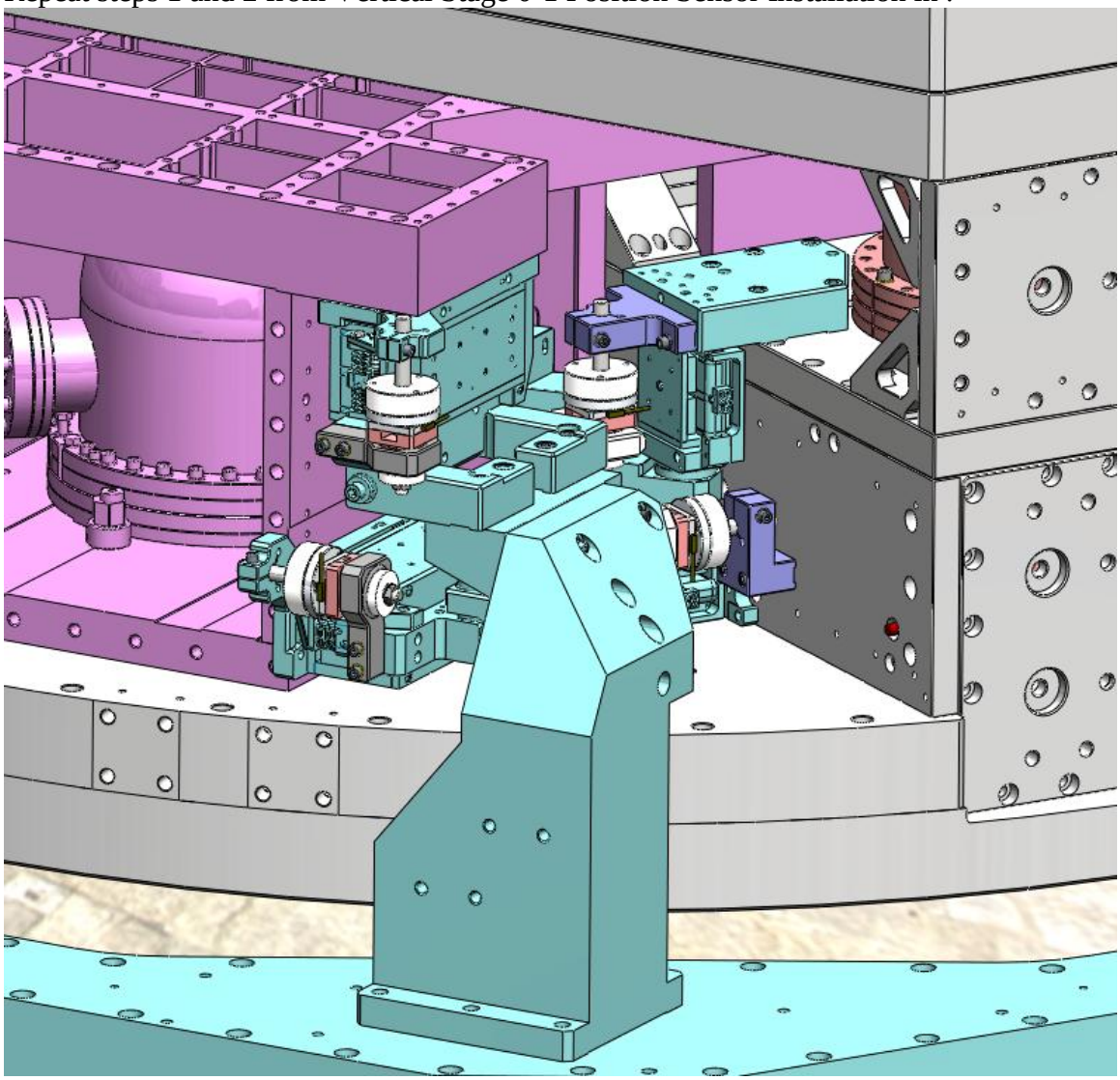


Figure 166: Final installation with Actuators and Position Sensors in place

ISI Assembly Complete:

After the ISI Assembly has been completed, cabling will be run to the actuators and sensors. Testing will be completed before the ISI is moved to the BSC chamber.

Test plan DCC# E09...

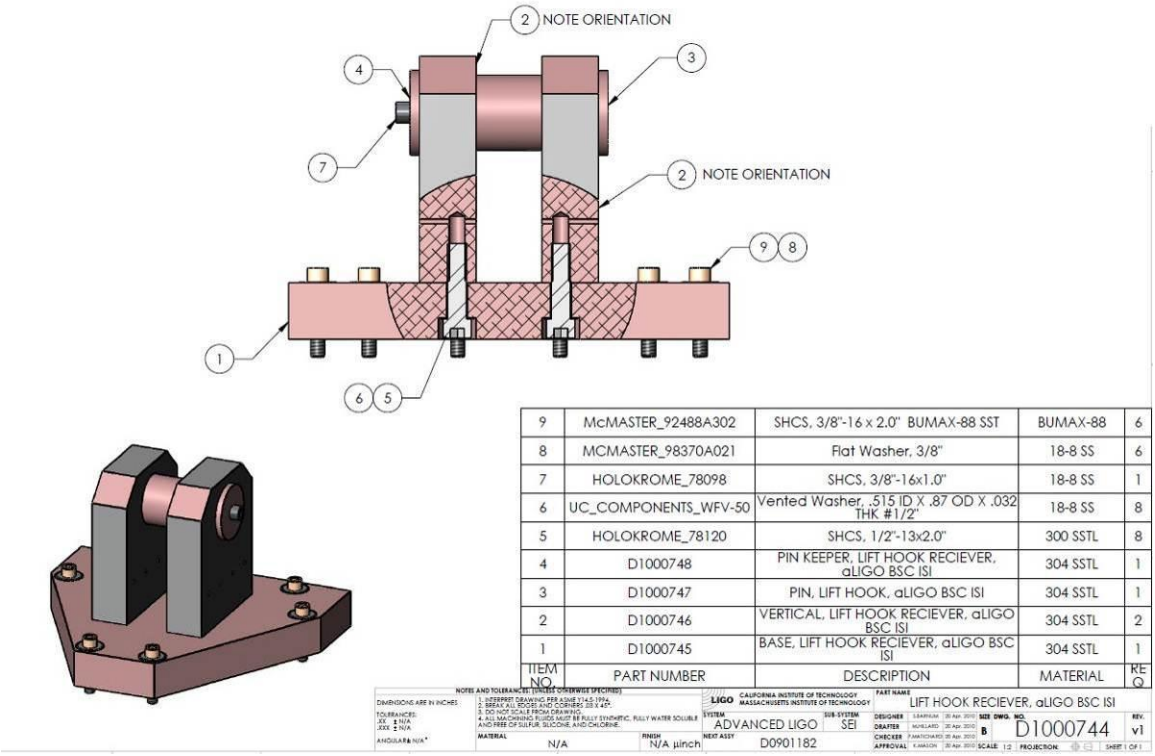
Moving the BSC (to a container or chamber)

The lifting tooling for the BSC is composed of (1) D1000744 Main Hook Assembly and (3) D1000756 Safety Hooks.

Main hook assembly

Parts required

Quantity	Part Number	Description
1	D1000745	Lift Hook Base
2	D1000746	Lift Hook Vertical
1	D1000747	Lift Hook Pin
1	D1000748	Lift Hook Pin Keeper



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ
9	McMASTER_92488A302	SHCS, 3/8"-16 x 2.0" BUMAX-88 SST	BUMAX-88	6
8	MCMASTER_98370A021	Flat Washer, 3/8"	18-8 SS	6
7	HOLOKROME_78098	SHCS, 3/8"-16x1.0"	18-8 SS	1
6	UC_COMPONENTS_WFV-50	Vented Washer, .515 ID X .87 OD X .032 THK #1/2"	18-8 SS	8
5	HOLOKROME_78120	SHCS, 1/2"-13x2.0"	300 SSTL	8
4	D1000748	PIN KEEPER, LIFT HOOK RECIEVER, aLIGO BSC ISI	304 SSTL	1
3	D1000747	PIN, LIFT HOOK, aLIGO BSC ISI	304 SSTL	1
2	D1000746	VERTICAL, LIFT HOOK RECIEVER, aLIGO BSC ISI	304 SSTL	2
1	D1000745	BASE, LIFT HOOK RECIEVER, aLIGO BSC ISI	304 SSTL	1

LIGO — CALIFORNIA INSTITUTE OF TECHNOLOGY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY
PART NAME: LIFT HOOK RECIEVER, aLIGO BSC ISI
SYSTEM: ADVANCED LIGO | SUB-SYSTEM: SEI
MATERIAL: N/A | FINISH: N/A µinch | NEXT ASSY: D0901182
SIZE: B | DWG. NO.: D1000744 | REV.: v1
SCALE: 1:2 | PROJECTION: | SHEET 1 OF 1

Figure 167: D1000744 Lift Hook Receiver Assembly Drawing

1.93. Attach (2) D1000746 Lift Hooks Vertical onto the base D1000745 Lift Hook Base (see Figure 167)

Hardware:
(8) 1/2-13 x 2" SHCS – MSC 75464883
(8) 1/2 Vented Washers – UCC WFV-50

- Insert SHCS through D1000745 into D1000746.
- Snug them and **torque them up to 805 in.lbs (67 ft.lbs).**

1.94. Slide D1000747 Lift Hook Pin through (2) D1000746 Lift Hooks Vertical and into D1000748 Lift Hook Pin Keeper (see Figure 167)

Hardware:
(1) 3/8-16 x 1" SHCS – MSC 75464628
(1) 3/8 Vented Washers – UCC WFV-38

- Insert SHCS through D1000748 into D1000747.
- Snug it and **torque it up to 329 in.lbs (27 ft.lbs).**

Safety Hook Assembly

Parts required

Quantity	Part Number	Description
1	D1000753	Lift Hook Safety Base

Hardware:
(1) 5/8-11 Hoist Ring – McMaster 3026T420

1.95. Thread Hoist Ring onto the D100753 Lift Hook Safety Base (see Figure 168)

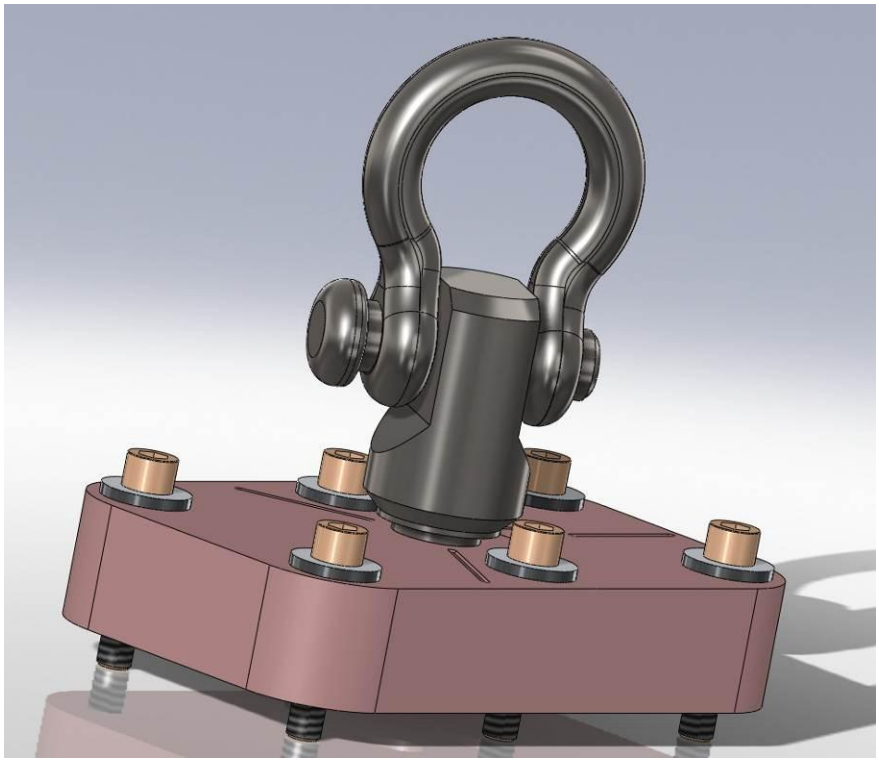


Figure 168: D1000756 Safety Lift Hook Receiver

1.96. Place D1000744 Lift Hook Receiver Assembly and (3) D1000756 Safety Lift Hook Receivers onto D0901519 Keel Plate Up-Facing as shown on Figure 169 & Figure 170

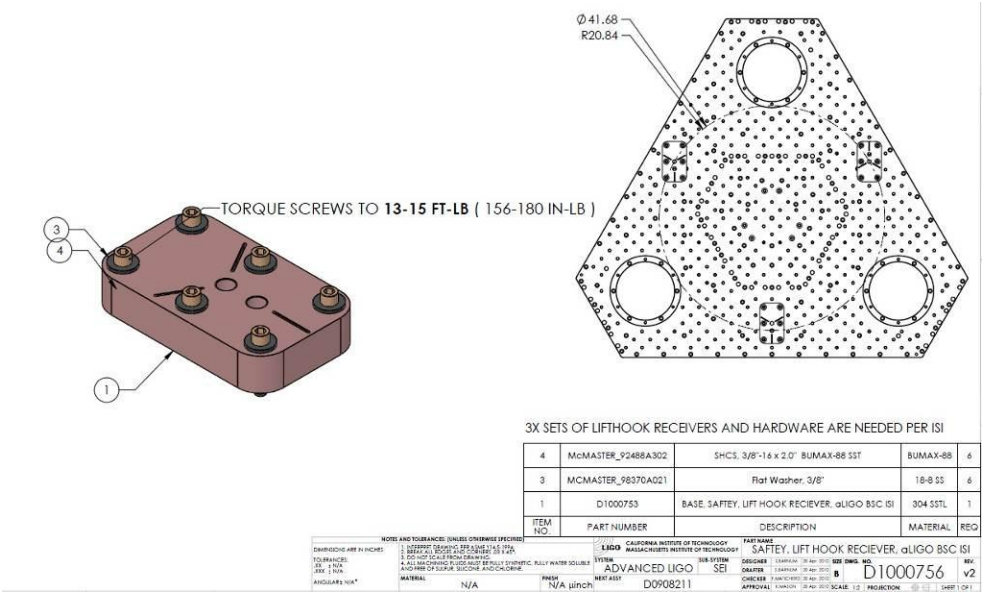


Figure 169: D1000756 Safety Lift Hook Receiver Assembly Drawing

Hardware:
(24) 3/8-16 x 2" Bumax SHCS
(24) 3/8 Flat Washers – McMaster 98370A021

- Insert SHCS.
- Snug it and **torque it up to 345 in.lbs (28.8 ft.lbs).**

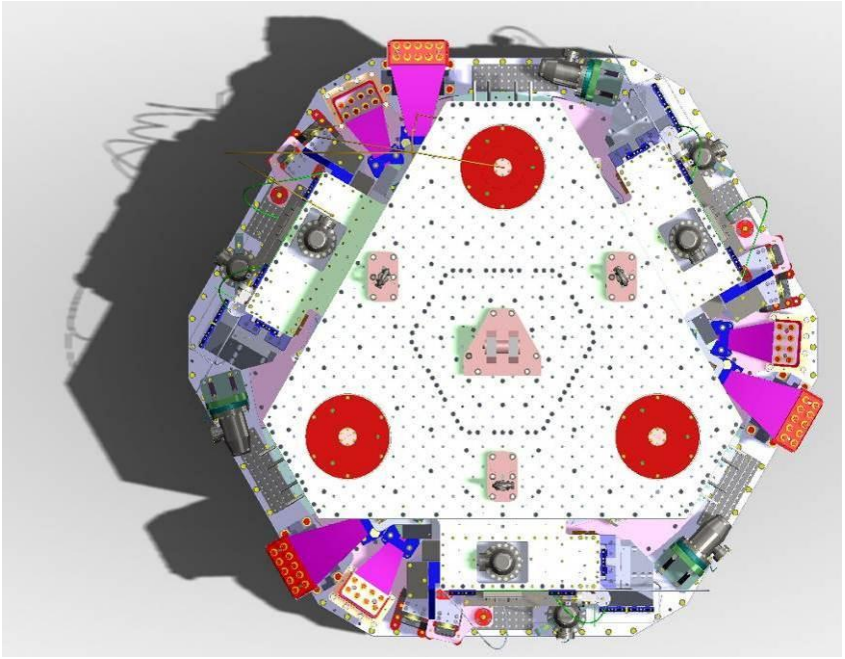


Figure 170: BSC-ISI Assembled (Top View)

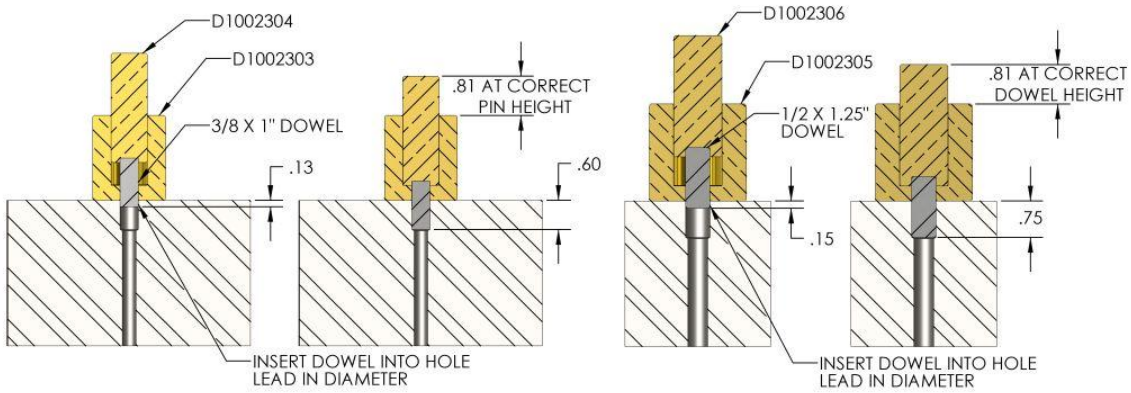
Appendix A Alignment Pins and helicoils in parts

Several parts (especially large plates) should already have alignment pins and helicoils inserted in. At LASTI an arbor press was used to add the pins. Please refer to E1000402 for positioning of those.

Appendix B Alternate Procedure for Aligning Lock Pins

Outlined here is a procedure for aligning the center pins in both the 0-1 and 1-2 locks. The is an "alternate" because at the time of writing this assembly document appropriate material had not yet been found for the shims used. These shims are green lettering below. (Material used for prototype was not cleanable.)

Appendix C: dowel pin manual insertion using tooling



Appendix D. Torque Specifications

Refer to T110066 for more complete torque specs

Material: Stainless Steel (tensile strength ≥ 70 ksi)
Screw Type: Socket Head Cap Screw (SHCS)
Mfgr./Vendor: McMaster-Carr, or U-C Components

Thread	*Torque (in-lbs)*	*Torque (ft-lbs)*
M2-.4mm	2	-
#10-32	32	-
1/4"-20	75	6
5/16"-24	142	12
3/8"-16	236	20
3/8"-24	259	22
1/2"-13	517	43
1/2"-20	541	45

Material: Stainless Steel
Screw Type: Socket Head Cap Screw (SHCS)
Mfgr./Vendor: Holo-Krome

Thread	*Torque (in-lbs)*	*Torque (ft-lbs)*
#8-32	30	-
#10-32	48	-
1/4"-20	100	8
3/8"-16	329	27

Material: Stainless Steel A-286
Screw Type: Hex Head Cap Screw (SHCS)
Mfgr./Vendor: McMaster-Carr

Thread	*Torque (in-lbs)*	*Torque (ft-lbs)*
1/2"-13	1,320	110