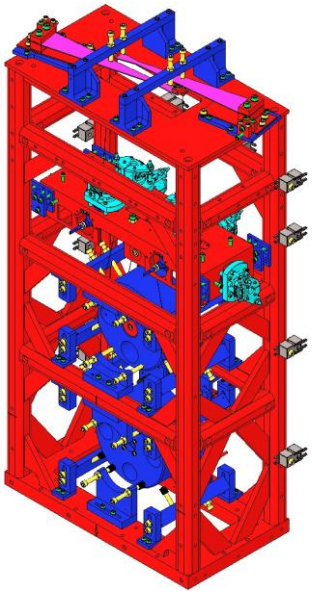


Fig 1: HSTS

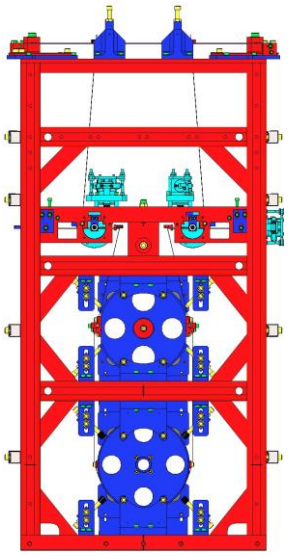


Fig 2: Front

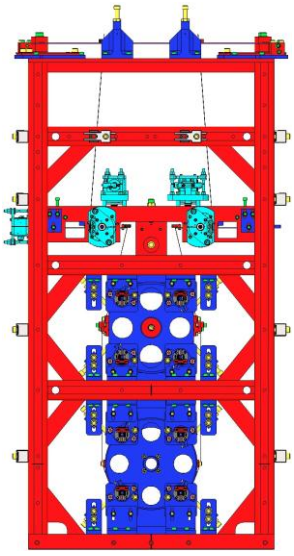


Fig 3: Rear

1 Safety

Review E0900332 HSTS Assembly and Installation Hazard Analysis.

2 Objective and Scope

Subassembly and Final Assembly of the aLIGO HAM Small Triple Suspension, including:

1) General considerations for assembly;
2) Use of the Assembly Fixtures.

3 Documents

E0900332	HSTS Assembly and Installation Hazard Analysis
E1100471	HSTS Assembly and Installation Documentation
G1100107	HSTS Introduction
T0900435	HSTS Final Design Document
E030518	HSTS Assembly Instructions (this document)
D020700	HSTS Assembly
D040391	HSTS Assembly Fixtures
E0900334	HSTS Installation Procedure
T0900467	HSTS Test Plan
T0900559	HSTS Choice of Blades
E0900047	LIGO Contamination Control Plan
E1000169	Blade Characterization Spreadsheet
E960022	LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures
E990196	Magnet/Standoff Assembly Preparation Specification (needs to be updated.)
T000053	aLIGO, Universal Suspension Subsystem Design Requirements
T010007	Cavity Optics Suspension Subsystem Design Requirements

T010103 aLIGO Suspension System Conceptual Design
T0900559 Blade Pairings Spreadsheet

4 Documenting the Assembly Process

4.1 Documents

T1100003 Building Suspensions Subassemblies in ICS.

4.2 Procedure

1. See the above document.
2. Data for each Final Assembly will be stored in ICS; using a Process Traveler is optional:

Item	Assembly 1 Part Name	Assembly 1 Part Number	Serial Number	Position	Variant	Weight
Each Mass	X	X	X	X		X
Each Blade	X	X	X	X		
Each Blade Clamp	X	X	X	X	X	
Each OSEM	X	X	X	X		
Each Optic	X	X	X			X

Note regarding Subassembly weights: Each Subassembly must have 3 distinct weights recorded:

1) Estimated Weight Calculated by SolidWorks;
2) Actual Weight Measured by a lab scale after built to the nominal mass;
3) Balanced Weight Totaled after Suspension is balanced (i.e. Actual Weight ± Add-On Weights). When Addable weights are used, note their location on the Mass.

5 Vacuum Compatibility

5.1 General Handling

All procedures must be performed in a clean room environment while suited up in:

- Coverall with Hood
- Boot style shoe covers
- LIGO-approved latex gloves
- Glove Liners and Safety Glasses when working with Wire

All Tables surfaces used for Class A components should be wiped down daily with Isopropanol.

Review E0900047 Contamination Control Plan for details. All HSTS parts are Class A hardware and once cleaned and baked should not come into contact with anything but Class A or B hardware.

5.2 Cleaning Components

Clean items per E960022 Vacuum Compatibility, Cleaning Methods and Qualification Procedures.

5.3 Inspection

After baking, sample check the cleanliness of blind-tapped and through-tapped holes with a clean swab dampened with alcohol for a minimum of 10% of the holes in case any material has leached out during baking. If any discoloration of the swab is evident, then the part must go through at least one more wash cycle before repeating the bake. After inspection, wrap items per E960022.

6 Fasteners

6.1 Silver Plated Stainless Steel

All Silver Plated fasteners are also SSTL, and so are labeled simply “AgPlated”, not “AgPlated SSTL”.

6.2 Screw Applications

Screw Type	Screw Description	Receiver Application
AgPlated SSTL	Silver-Plated Stainless Steel	• Stainless Steel threads • Aluminum Threads • Helicoil Threads • Rare Vacuum Compatibility situations
SSTL	Stainless Steel	
Vented	SSTL Screw with holes	

6.3 Helicoils

Helicoils are specified for:

- Certain SSTL applications to avoid using AgPlated fasteners;
- Certain applications where assembly / disassembly recurs.
- Helicoils are cleaned, baked and installed with clean tools in a Class 100 clean room.

6.4 Torque Values

- Except where noted, Socket Head Cap Screws are to be tightened per the following table, which is based on T1100066 – Torque Values.
- “Generic” applies to Screws that are non-plated, non-vented, and not marked as Holokrome.
- Holokrome Screws are marked as such on the Screw.
- UC (UC Components, Supplier) Screws are AgPlated.
- All Screws are UNC (coarse threaded), except Pitch Adjustment Set Screw.

	Torque (in-lb)				
Supplier	**Generic** (unmarked)	**Holokrome**	**UC**	**UC**	**UC**
Type	**Unplated**	**Unplated**	**Ag-Plated**	**Ag-Plated, Vented**	**Vented**
Size					
#2-56	2.5	4	4	2.9	2.9
#4-40	5.2	6	6	6.7	6.7
#8-32	19.8	30	30	25.2	25.2
¼-20	75.2	100	100	85.8	85.8

6.5 Tightening Screw Pairs

To ensure proper alignment of components and to ensure even clamping pressure, it is important to perform the final few turns of the bolts evenly, almost in tandem. That is, after pairs of Screws have first been assembled and snugged up finger tight, when drawing up the Screws to their final Torque value, each Screw should be turned no more than ¼ turn before switching to the opposite screw.

7 Overview of Assembly Process

7.1 General sequence:

1) Subassemblies are built first, in any convenient order.
2) Main Assembly is built, mostly from Subassemblies.

Main Assembly sequence:

1) Rotational Adjusters
2) Intermediate Mass
3) Lower Wire
4) Lower Mass
5) Upper Mass + Upper and Intermediate Wires
6) Balancing
7) OSEMS

7.2 Frame of Reference

Using the Right-Hand-Rule when viewed from behind the Weldment, with the origin at the center bottom of the Weldment, the positive X, Y and Z directions are shown at right.

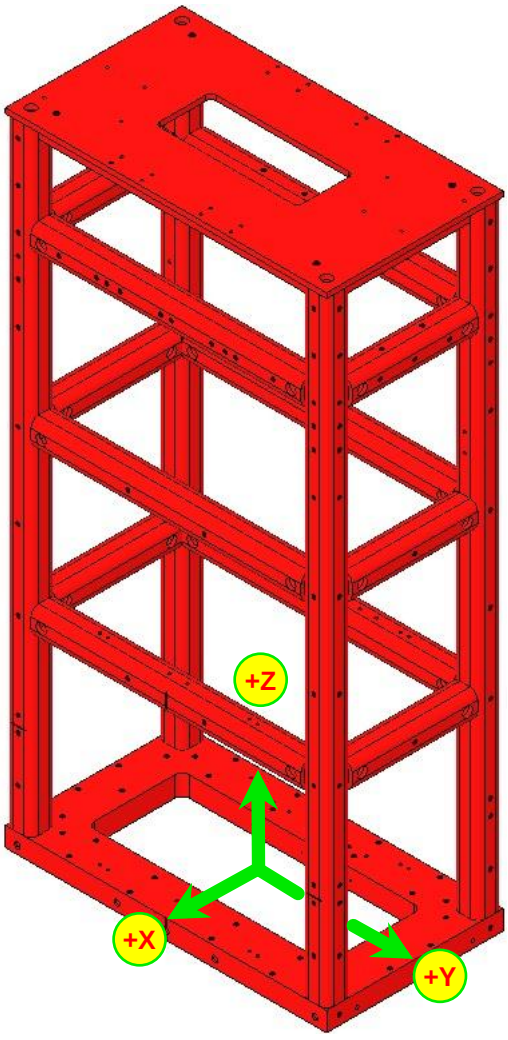


Fig 4: Frame of Reference

8 Safety – Handling Suspension Wire

The Wire used for all Suspensions is a hard temper carbon steel, delivered on large spools. When unwound for cleaning, cutting and preparation for clamp-wire-clamp assembly, care must be taken such that the wire's strong potential energy (making it act like a coiled spring) does not cause injury.

1. Safety Glasses, provided in all Clean Room garbing areas, must be worn during all wire work.
2. Glove Liners should be worn under the latex clean-room gloves as a protective layer and extra barrier. The E0900047 Contamination Control Plan, p. 13, provides further information on Glove Liners.
3. For easier holding, bend a small section (~3") of the end of the Wire. The bent section can be hooked around your thumb and held by your index finger. Un-spool the proper length of Wire – including extra for handling – and control the area of the Wire that will be cut. Add a 2nd bend at the newly cut end for easier handling.
4. Change your gloves and wipe each Wire at least 3 times each, until nothing further appears on each Wipe, using:
   a. A Cleaning Wipe with Methanol;
   b. A Cleaning Wipe with Acetone;
   c. A Cleaning Wipe with Isopropanol;

   changing Wipes until the wire is completely clean. Clean the Wire while it is coiled; do not stretch the wire until it is taut for cleaning. It can be laid down on a clean surface during this process. Clean one section at a time.
5. Transfer the Wire to the Assembly Jig. Use the Jig clamps to hold the Wire in place, and then cut off and discard the bent Wire ends.

9 Assembly of Upper Wires

9.1 Documents

E0900332 HSTS Assembly and Installation Hazard Analysis
D0901854 Upper Wire Assembly, HSTS
E960022 Vacuum Compatibility, Cleaning Methods and Qualification Procedures

9.2 Materials

Qty	Unit	Part Number	Description
1	Each	D0902108	Upper Wire Jig Assembly, HSTS
4	Each	D980184	LOS Clamp, Long
1	Each	D020481	Upper Mass C-Clamp, HSTS
1	Each	D0901999	Upper Mass Wire Clamp, Inside, Angled, HSTS
1	Each	D0901998	Upper Mass Wire Clamp, Outside, Angled, HSTS
1	Each	D020198	Upper Blade Wire Clamp, HSTS
1	Each	D0901994	Upper Blade Wire Clamp, Outside, Angled, HSTS
2	Each	N/A	SHCS, #4-40 X 0.375", Ag-Plated SSTL
4	Each	N/A	#4 Flat Washer
2	Each	N/A	SHCS, #4-40 X 0.625", Ag-Plated SSTL
1	Spool	N/A	Steel Music Wire, 0.014" Diameter
1	Each	N/A	Weight Hanger
1	Set	N/A	Interlocking Test Weights (1kg, 2kg)
1	Set	N/A	Test Weights (1g – 500g)
1	Bag	PNHS-99	Polynit Heatseal Wipes
1	Bottle	N/A	Methanol
1	Bottle	N/A	Acetone
1	Bottle	N/A	Isopropanol

9.3 Procedure

2 Upper Wire Assemblies are required per HSTS. Wire Assemblies should only be assembled as needed (NOT assembled ahead of time and stored for later use).

Wear safety glasses and glove liners per E0900332.

1. Ensure that all parts of the Upper Wire Jig Assembly (D0902108) have been processed to Class B per E960022.
2. Confirm that the Wire Jig is assembled completely and correctly per the drawing.
3. Attach the Jig to an Optical Table using 4X LOS Long Clamps (D980184). Position the Jig so that the end with the Wire Jig Pin Support (D0900563) extends beyond the edge of the Optical Table by approximately 3" to allow clearance for the Interlocking Test Weights.

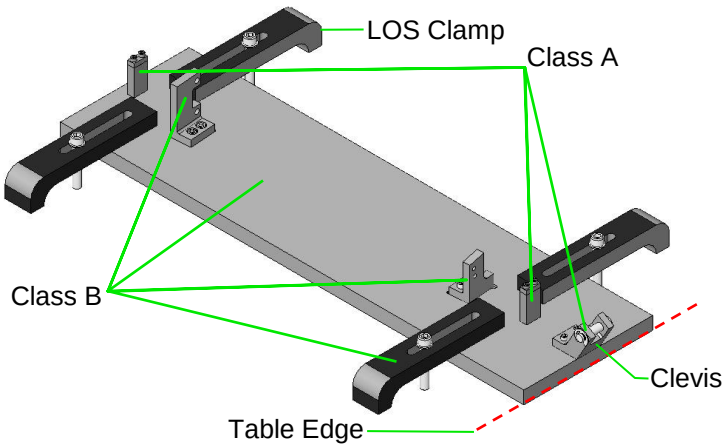


Fig 5: Upper Wire Jig (to be changed)

4. Assemble the two ends of the Wire Assembly (referred to as the C-Clamp and L-Clamp) before attaching them to the Wire Jig. Do not tighten the SHCS.

   Each C-Clamp includes:
   - 1X D020481 Upper Mass C-Clamp, HSTS
   - 1X D0901999 Upper Mass Wire Clamp, Inside, Angled, HSTS
   - 1X D0901998 Upper Mass Wire Clamp, Outside, Angled, HSTS
   - 2X SHCS, #4-40 X 0.625", Ag-Plated SSTL
   - 2X #4 Flat Washers

   Each L-Clamp includes:
   - 1X D020198 Upper Blade Wire Clamp, HSTS
   - 1X D0901994 Upper Blade Wire Clamp, Outside, Angled, HSTS
   - 2X SHCS, #4-40 X 0.375", Ag-Plated SSTL
   - 2X #4 Flat Washers

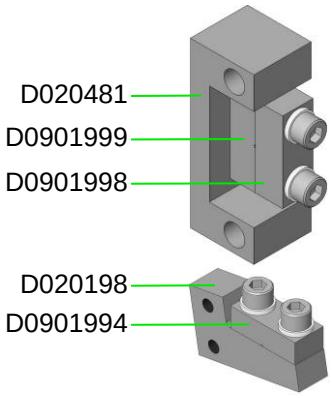


Fig 6: Clamps

5. On the Wire Jig, attach one C-Clamp to the outboard side of the Upper Wire Clamp Mount (D0902110) using:
   - 2X SHCS, #8-32 X 0.5", Ag-Plated SSTL

6. On the Wire Jig, attach one L-Clamp to the outboard side of the Blade Clamp Mount (D0902111) using:
   - 2X SHCS, #4-40 X 0.5", Ag-Plated SSTL

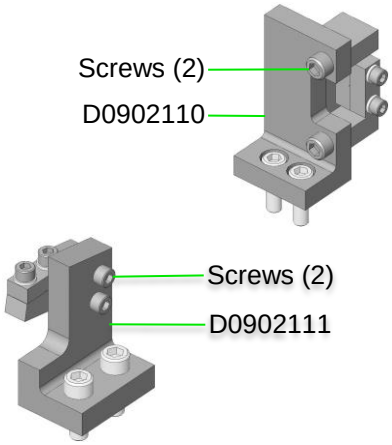


Fig 7: Clamp Mounts

7. Unspool approximately 36" of 0.014" diameter Steel Music Wire. Clean the Steel Music Wire as described in Section 12.4. Cut the Steel Music Wire from the spool using dirty wire cutters.
8. Feed the Steel Music Wire through the Wire Jig and Clamps in the order shown:
   1) Over the Clevis Pin
   2) Through the first Wire Start Post (D1100580 and D1000583)
   3) Through the L-Clamp
   4) Through the C-Clamp
   5) Through the second Wire Start Post
9. Tighten the SHCS in the second Wire Start Post after feeding approximately 0.5" of Steel Music Wire through the clamp.

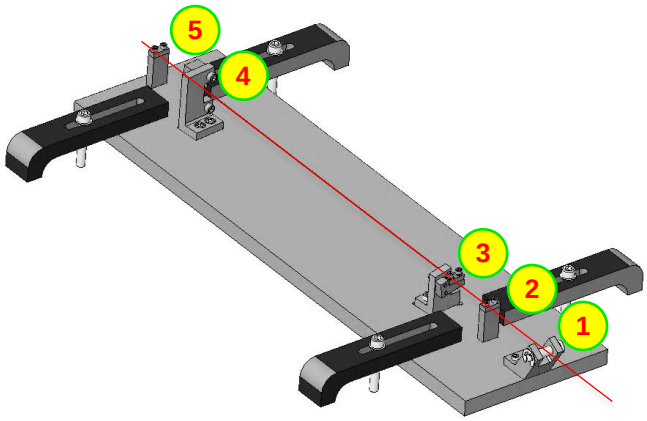


Fig 8: Wire Path

Fig 9: Hanging Weight

10. Using a Weight Hanger, Interlocking Test Weights and a set of small Test Weights, make up a hanging weight with a mass of 4.483 kg. Note that the Weight Hanger and Test Weights are not clean.
11. Tie the end of the Steel Music Wire hanging over the Clevis Pin around the hook on the Weight Hanger. The Steel Music Wire should now be taut, due to the hanging weight.
12. Allow the hanging weight to hang from the Steel Music Wire for at least 5 minutes. Be careful of hands and feet underneath the hanging weight.
13. Measure the length of the wire between inboard sides of the C-Clamp and L-Clamp. The desired length is 294.13 mm.
14. Tighten the SHCS in the clamps in the order shown. The SHCS in clamps 2 (C-Clamp) and 3 (L-Clamp) should be torqued to 6 in-lb. When tightening the SHCS in the C-Clamp and L-Clamp, ensure that the inboard surfaces of the two halves of each clamp are completely parallel.
15. Remove the hanging weight from the wire.
16. Using clean wire cutters, cut the Steel Music Wire in two locations as shown, as close to the outboard sides of the C-Clamp and L-Clamp as possible.
17. Before removing the Wire Assembly from the Wire Jig, record part serial numbers, the measured wire length and the mass of the hanging weight to be included in the ICS assembly load.

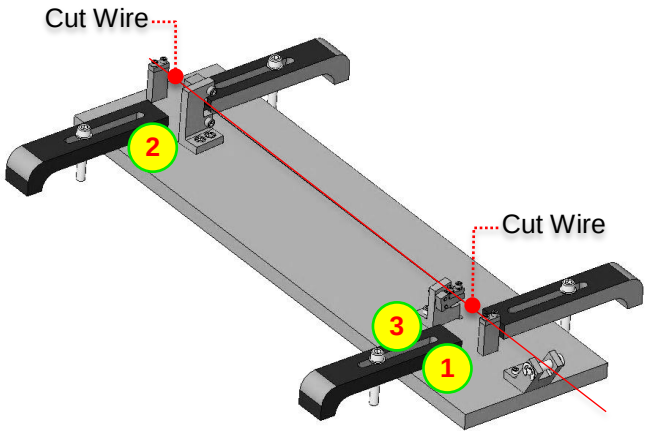


Fig 10: Clamping and Cutting the Wire (backwards)

18. Loosen the #8-32 X 0.5” and #4-40 X 0.5” SHCS to remove the Wire Assembly from the Wire Jig. Loosen the SHCS in the Wire Start Posts and discard the leftover Steel Music Wire. The completed Upper Wire Assembly is shown in Figure 11.
19. Create an assembly load in ICS for the Upper Wire Assembly. Use the serial number of D020481 as the serial number of the assembly (D0901854).

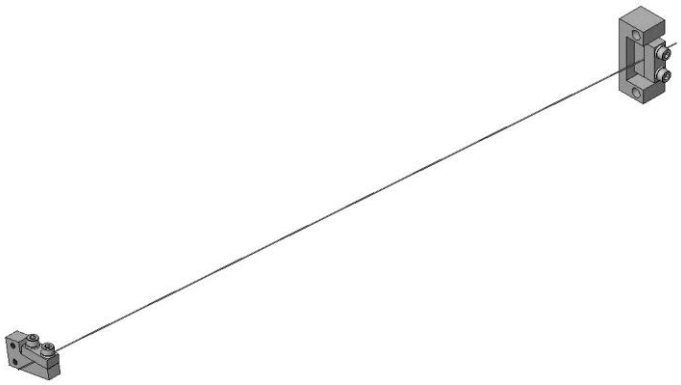


Fig 11: Upper Wire Assembly

NOTE: If a wire breaks, the Upper Wire Assembly can be disassembled and certain parts can be reused. Parts that can be reused include D020481, D0901998, D020198 and hardware. These parts can only be used if there is no damage caused to the part (grooves, nicks, etc.) caused by wire clamping.

Parts that CANNOT be reused include D0901999 and D0901994. These parts must be marked as defective in ICS and quarantined from usable production parts.

10 Assembly of Intermediate Wires

10.1 Documents

E0900332 HSTS Assembly and Installation Hazard Analysis
D0901905 Intermediate Wire Assembly, HSTS
E960022 Vacuum Compatibility, Cleaning Methods and Qualification Procedures

10.2 Materials

Qty	Unit	Part Number	Description
1	Each	D0902526	Intermediate Wire Jig Assembly, HSTS
4	Each	D980184	LOS Clamp, Long
1	Each	D020132	Lower Blade Wire Clamp, HSTS
1	Each	D030044	Lower Blade Wire Clamp Plate, Angled, HSTS
1	Each	D0901904	Intermediate Wire Clamp Mount, Lower, HSTS
1	Each	D0901903	Intermediate Wire Clamp, Outside, HSTS
2	Each	N/A	SHCS, #2-56 X 0.375", Ag-Plated SSTL
2	Each	N/A	#2 Flat Washer
2	Each	N/A	SHCS, #4-40 X 0.375", Ag-Plated SSTL
2	Each	N/A	#4 Flat Washer
1	Spool	N/A	Steel Music Wire, 0.0079" Diameter
1	Each	N/A	Weight Hanger
1	Each	N/A	Interlocking Test Weight (1kg)
1	Set	N/A	Test Weights (1g – 500g)
1	Bag	PNHS-99	Polynit Heatseal Wipes
1	Bottle	N/A	Methanol
1	Bottle	N/A	Acetone
1	Bottle	N/A	Isopropanol

10.3 Procedure

4 Intermediate Wire Assemblies are required per HSTS. Wire Assemblies should only be assembled as needed (NOT assembled ahead of time and stored for later use).

Wear safety glasses and glove liners per E0900332.

1. Ensure that all parts of the Intermediate Wire Jig Assembly (D0902526) have been processed to Class B per E960022.
2. Confirm that the Wire Jig is assembled completely and correctly per the drawing.
3. Attach the Jig to an Optical Table using 4X LOS Long Clamps (D980184). Position the Jig so that the end with the Wire Jig Pin Support (D0900563) extends beyond the edge of the Optical Table by approximately 3" to allow clearance for the Interlocking Test Weights.

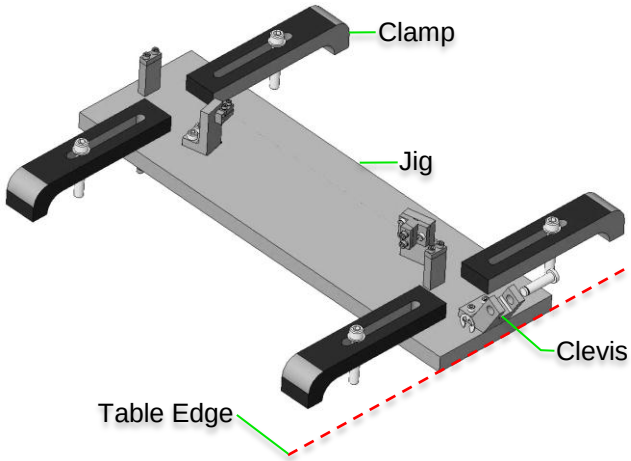


Fig 12: Intermediate Wire Jig (to be changed)

4. Assemble the two ends of the Wire Assembly (referred to as the Lower Blade Wire Clamp and the Intermediate Wire Clamp) before attaching them to the Wire Jig. Do not tighten the SHCS.

   Each Lower Blade Wire Clamp includes:
   - 1X D020132 Lower Blade Wire Clamp, HSTS
   - 1X D030044 Lower Blade Wire Clamp Plate, Angled, HSTS
   - 2X SHCS #2-56 X 0.375", Ag-Plated SSTL
   - 2X #2 Flat Washers

   Each Intermediate Wire Clamp includes:
   - 1X D0901904 Intermediate Wire Clamp Mount, Lower, HSTS
   - 1X D0901903 Intermediate Wire Clamp, Outside, HSTS
   - 2X SHCS, #4-40 X 0.375", Ag-Plated SSTL
   - 2X #4 Flat Washers

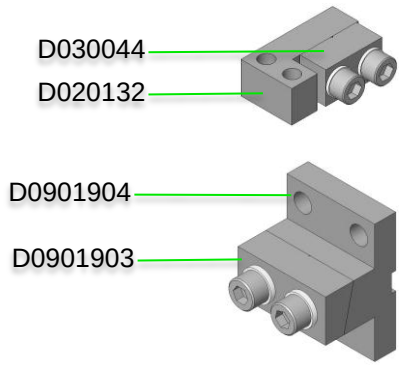


Fig 13: Clamps

5. On the Wire Jig, attach one Lower Blade Wire Clamp to the outboard side of the Blade Wire Clamp Bracket (D0902532) using:
   - 2X SHCS, #2-56 X 0.375", Ag-Plated SSTL

6. On the Wire Jig, attach one Intermediate Wire Clamp to the outboard side of the Mass Wire Clamp Bracket (D0902533), using:
   - 3X SHCS, #4-40 X 0.375", SSTL

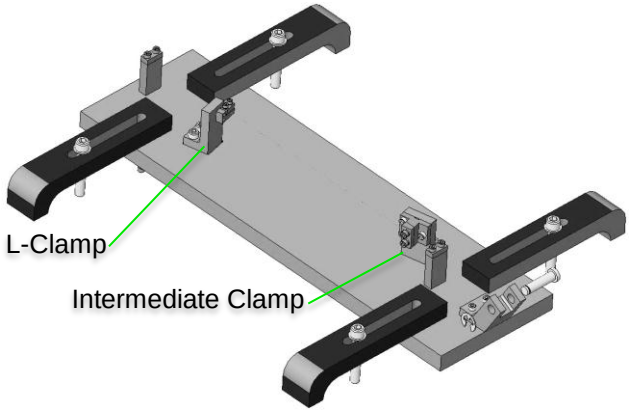


Fig 14: Clamps Mounted on Wire Jig

7. Unspool approximately 24" of 0.0079" diameter Steel Music Wire. Clean the Steel Music Wire as described in Section 12.4. Cut the Steel Music Wire from the spool using dirty wire cutters.
8. Feed the Steel Music Wire through theWire Jig and Clamps in the order shown:
   1) Over the Clevis Pin
   2) Through the first Wire Start Post (D1000628 and D1000583)
   3) Through the Intermediate Wire Clamp
   4) Through the Lower Blade Wire Clamp
   5) Through the second Wire Start Post
9. Tighten the SHCS in the second Wire Start Post after feeding approximately 0.5" of Steel Music Wire through the clamp.

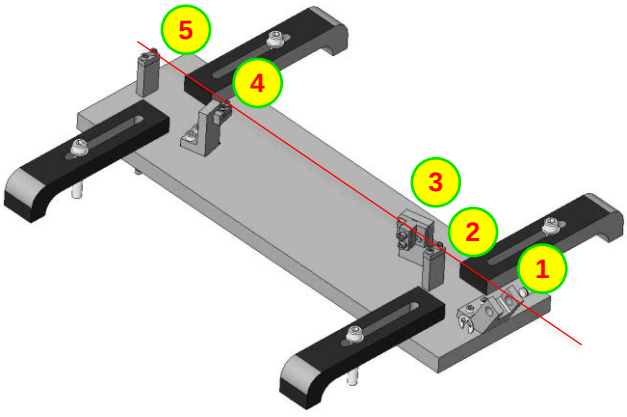


Fig 15: Wire Path

10. Using a Weight Hanger and a set of Small Test Weights, make up a hanging weight with a mass of 1.460 kg. Note that the Weight Hanger and Test Weights are not clean.
11. Tie the end of the Steel Music Wire hanging over the Clevis Pin around the hook on the Weight Hanger. The Steel Music Wire should now be taut, due to the hanging weight.
12. Allow the hanging weight to hang from the Steel Music Wire for at least 5 minutes. Be careful of hands and feet underneath the hanging weight.

Fig 16: Hanging Weight

13. Measure the length of the wire between the inboard sides of the Lower Blade Wire Clamp and the Intermediate Wire Clamp. The desired length is 167.02 mm.
14. Tighten the SHCS in the clamps in the order shown. The SHCS in clamp 2 (Lower Blade Wire Clamp) should be torqued to 4 in-lb, while the SHCS in clamp 3 should be torqued to 6 in-lb. When tightening the SHCS, ensure that the inboard surfaces of the two halves of each clamp are completely parallel.
15. Remove the hanging weight from the wire.
16. Using clean wire cutters, cut the Steel Music Wire in two locations as shown, as close to the outboard sides of the clamps as possible.

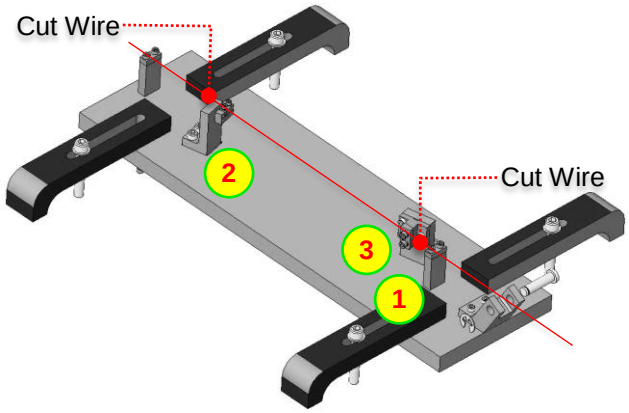


Fig 17: Clamping and Cutting the Wire (backwards)

17. Before removing the Wire Assembly from the Wire Jig, record part serial numbers, the measured wire length and the mass of the hanging weight to be included in the ICS assembly load.
18. Loosen the #2-56 X 0.375 and #4-40 X 0.375 SHCS holding the clamps to the Wire Jig (NOT the ones holding the clamps together) Loosen the SHCS in the Wire Start Posts and discard the leftover Steel Music Wire. The completed Intermediate Wire Assembly is shown in Figure 18.
19. Create an assembly load in ICS for the Intermediate Wire Assembly. Use the serial number of D0901904 as the serial number of the assembly (D0901905).

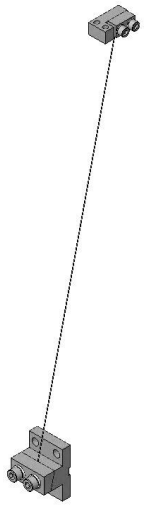


Fig 18: Intermediate Wire Assembly

NOTE: If a wire breaks, the Intermediate Wire Assembly can be disassembled and certain parts can be reused. Parts that can be reused include D020132, D0901904 and hardware. These parts can only be used if there is no damage caused to the part (grooves, nicks, etc.) caused by wire clamping.

Parts that CANNOT be reused include D030044 and D0901903. These parts must be marked as defective in ICS and quarantined from usable production parts.

11 Assembly of Lower Wires

11.1 Documents

E0900332 HSTS Assembly and Installation Hazard Analysis
D0901902 Lower Wire Assembly, HSTS
E960022 Vacuum Compatibility, Cleaning Methods and Qualification Procedures

11.2 Materials

Qty	Unit	Part Number	Description
1	Each	D0902524	Lower Wire Jig Assembly, HSTS
4	Each	D980184	LOS Clamp, Long
2	Each	D020202	Lower Wire Clamp Mount, HSTS
4	Each	D020203	Lower Wire Clamp, HSTS
2	Each	D1200108	Lower Wire Clamp Base, HSTS
2	Each	D1200188	Lower Wire Clamp Blank Top, HSTS
4	Each	N/A	SHCS, #8-32 X 0.625", Ag-Plated SSTL
4	Each	N/A	#8 Flat Washer
1	Spool	N/A	Steel Music Wire, 0.0047" Diameter
2	Each	N/A	Weight Hanger
2	Set	N/A	Test Weights (1g – 500g)
1	Bag	PNHS-99	Polynit Heatseal Wipes
1	Bottle	N/A	Methanol
1	Bottle	N/A	Acetone
1	Bottle	N/A	Isopropanol
1	Each	N/A	Vise Grip, 6", Needle Nose
1	Each	N/A	Electronic Microscope

11.3 Procedure

2 Lower Wire Assemblies are required per HSTS – one to hang the metal lower mass and one to hang the actual glass optic. Lower Wire Assemblies should only be assembled as needed (NOT assembled ahead of time and stored).

Wear safety glasses and glove liners per E0900332.

1. Ensure that all parts of the Lower Wire Jig Assembly (D0902524) have been processed to Class B per E960022.
2. Confirm that the Wire Jig is assembled completely and correctly per the drawing.
3. Attach the Jig to a corner of an Optical Table such that both ends of the Wire Jig extend beyond the edges of the Optical Table. Use 4X LOS Long Clamps (D980184) to clamp the Wire Jig to the Optical Table.

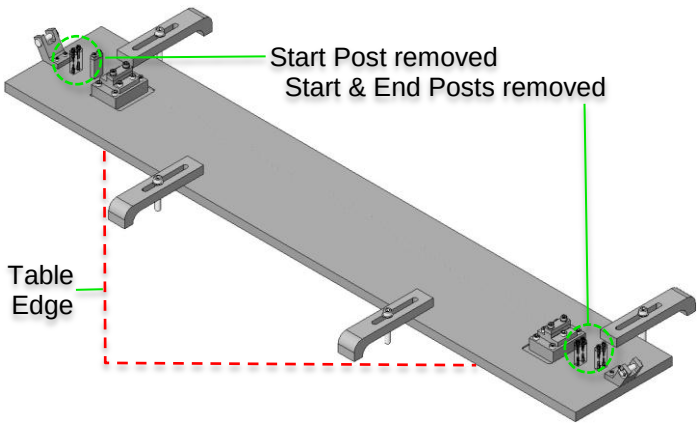


Fig 19: Lower Wire Assembly Jig

4. Assemble to the Jig:
   - 2 D1200108 Clamp Base
   - 4 (not 6) Socket Head Cap Screws 8/32 x 0.50" SSTL

   2 Screws are omitted to provide clearance for the Machinist's Square.

   Align the Clamp Mounts with the Jig Blocks using the Machinist's Square, and Torque to 20 in-lb.

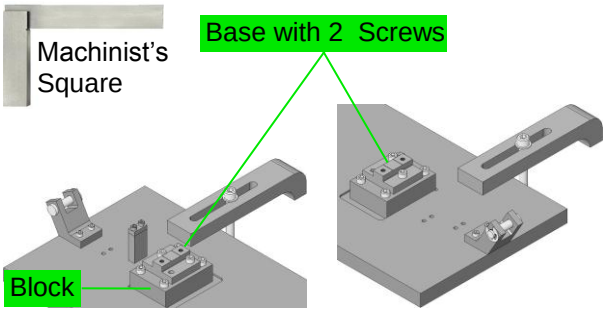


Fig 20: Clamps with 2 Screws each

Assemble the 1st Wire

5. Cut 2 48" pieces of .0047" Wire from the spool.
6. Clean the Wire per Section 12.4
7. Lay the 1st Wire down on the far-side Wire Grooves of the 2 Clamp Bases.
8. Feed the LH end of the Wire through the LH Start Clamp, leaving about ½" of Wire beyond the Clamp.
9. Drape the RH end of the Wire over the RH Clevis.
10. Lay out the wire in a straight line from the Start Clamp, across the Clamp Bases and over the Clevis.
11. Tighten the 2 Start Clamp Screws to 30 in-lb.
12. Create a small loop in the free end of the Wire and tie a Square Knot to secure the Loop.
13. Slide the Hang Weight hook through the Wire Loop and allow the Weight to pull the Wire taught.
14. Ensure the Wire lies smooth and straight from the Start Clamp, across the 2 Wire Grooves in the Clamp Bases, and across the Clevis.
15. Leave the Weight on the Wire for at least 5 minutes.

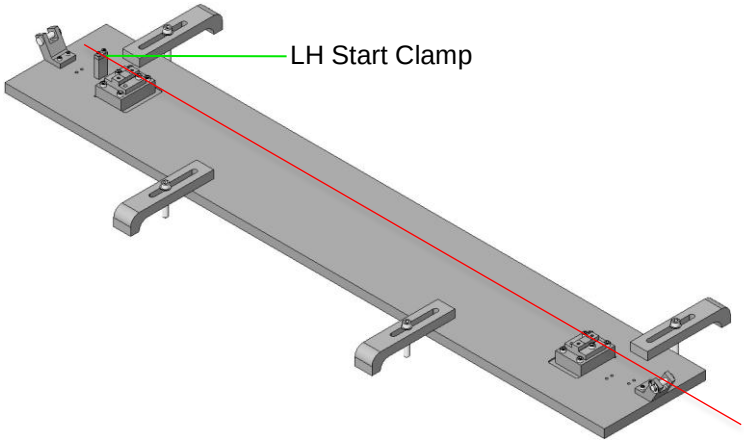


Fig 21: Installing 1st Wire

Fig 22: Hang Weight

Assemble the 2nd Wire

16. Lay the 2nd Wire down on the near-side Wire Grooves of the 2 Clamp Bases.
17. Drape the LH end of the Wire over the LH Clevis.
18. Ensure the Wire is lying in a straight line across the Clamp Bases and over the Clevis.
19. Lay the 2 D1200188 Clamp Tops on top of the Wires and Clamp Bases.
20. Assemble through the RH Clamp Base and Clamp Top:
    - 2 Socket Head Cap Screws 8/32 x .625" AgPlated
    - 2 Flat Washers

    Inspect the Clamps from the side, to verify the Wires are fully seated in the Grooves of each bottom Clamp.

    Align the Clamp Top with the Clamp Base using the Machinist's Square.

    Torque to 30 in-lb.

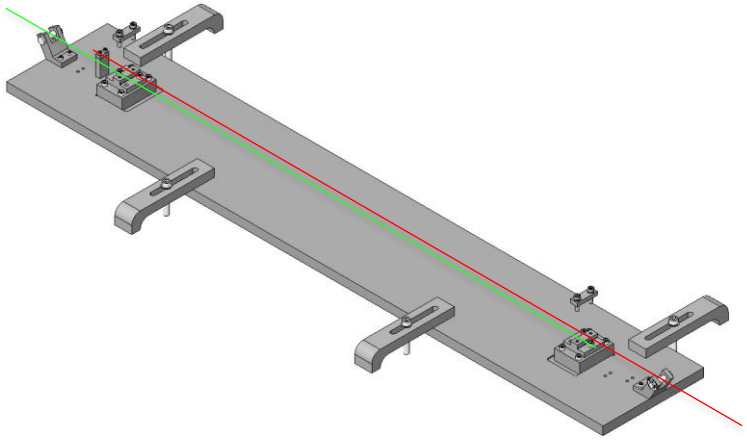


Fig 23: Installing the 2nd Wire

21. Ensure the Wire is lying in a smooth, straight line across the other Clamp Base and across the LH Clevis.
22. Leave the Weight on the Wire for at least 5 minutes.
23. Assemble through the LH Clamp Base and Clamp Top:
    - 2 Socket Head Cap Screws 8-32 x .625" AgPlated
    - 2 Flat Washers

    Inspect the Clamps from the side, to verify the Wires are fully seated in the Grooves of each bottom Clamp.

    Align the Clamp Top with the Clamp Base using the Machinist's Square.

    Torque to 30 in-lb.

24. Remove the Hang Weights from the Wires.
25. Cut the Wires just outboard of the 2 Lower Wire Clamps, making three cuts total.

    To avoid puncture injury, fold over the 4 cut ends of Wire on the final Assembly.
26. Remove the Assembly from the Fixture:
    - Loosen the 2 inboard Screws
    - Loosen the 4 outboard Screws

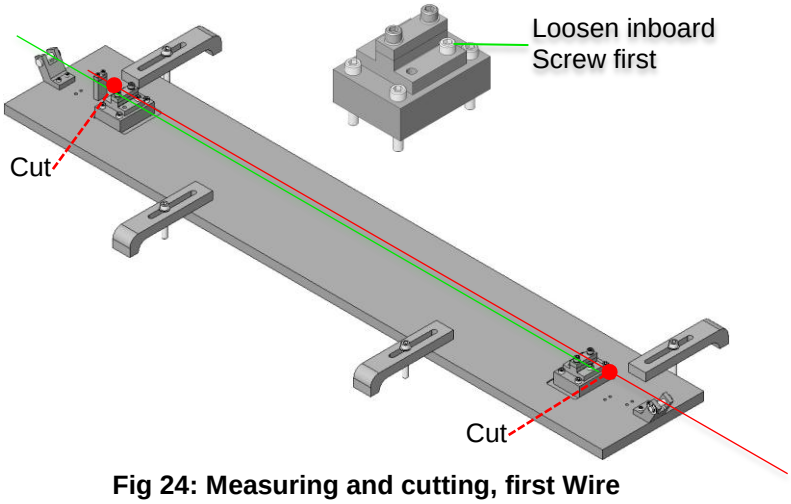


Fig 24: Measuring and cutting, first Wire

27. Finished lower wire, Clamp-Wire-Clamp assembly: 2 Wires, 2 Clamps.

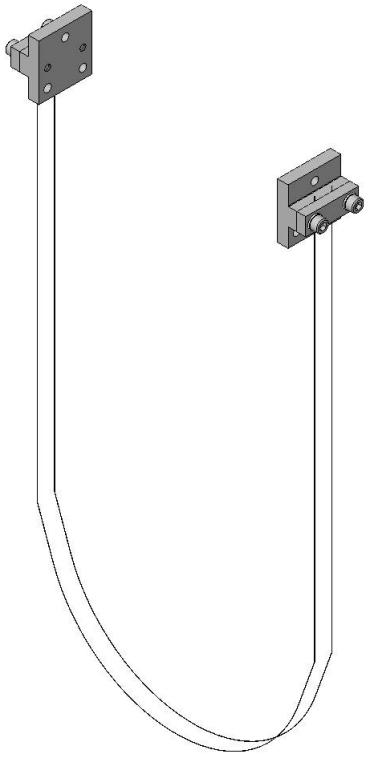


Fig 25: Lower Wire Assembly complete

12 Assembly of Top Blade Guards

12.1 Documents

D0901934 Top Blade Guard Assembly, HSTS

12.2 Materials

Qty	Unit	Part Number	Description
2	Each	D0901936	Blade Guard Riser, HSTS
1	Each	D0901935	Blade Guard Crossbeam, HSTS
4	Each	N/A	SHCS, #8-32 X 0.625", SSTL
2	Each	1185-4EN375	Helicoil, ¼-20 X 0.375", Nitronic 60
2	Each	D0900999	SHCS, ¼-20 x 2", Fully Threaded, Rounded End, SSTL
2	Each	N/A	Hex Nut, ¼-20, Ag-Plated SSTL

12.3 Procedure

2 Top Blade Guard Assemblies are required per HSTS.

1. Insert 2 Helicoils into the Blade Guard Crossbeam (D0901935). Before removing the tangs, thread an SHCS into each Helicoil to be sure that the Helicoil is threaded correctly.
2. Attach 2 Blade Guard Risers (D0901936) to the Blade Guard Crossbeam (D0901935) using 4 SHCS, #8-32 X 0.625". Torque the SHCS to 30 in-lb.
3. Thread 1 Ag-Plated Hex Nut onto each of 2 Rounded End SHCS, ¼-20 X 2" (D0900999). Thread the 2 Rounded End SHCS into the Blade Guard Crossbeam with the rounded ends facing down, as shown in Figure 26.

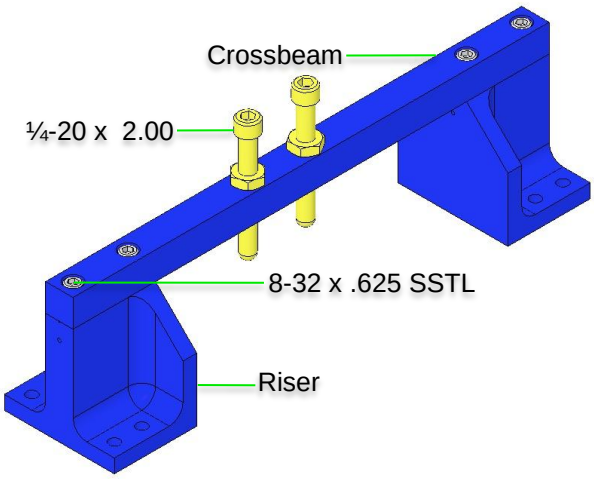


Fig 26: Top Blade Guard Assembly

13 Assembling Upper Blade Rotational Adjusters

13.1 Documents

D1000045 HSTS Rotational Adjuster Assembly
E1000169 Blade Characterization Spreadsheet
T0900559 Blade Pairings Spreadsheet

13.2 Materials

Qty	U	ID	Description
2	Ea	D020660	**Blade Pulldown Device**
2	Ea	D0901815	Upper Clamp Inside
2	Ea	D0901813	Upper Clamp Outside
4	Ea	NA	2 Socket Head Cap Screw 4-40 x 0.375” AgPlated
2	Ea	NA	Flat Washer #4 Vented, SSTL
2	Ea	NA	Socket Head Cap Screw 4-40 x 0.25” AgPlated
1	Ea	NA	4.483 kg in weight
2	Ft	NA	Music Wire .024” dia. min.
1	Ea	D020677	**Library of Clamps**
2	Ea	D1000045	**HSTS Rotational Adjuster Assembly**
1	Ea	D030448	Base Plate
1	Ea	D030447	Rotating Plate
2	Ea	D1001812	HSTS Upper Blades
1	Ea	DXXXXXX	Upper Blade Clamp, Upper Side, 0-3.5°
1	Ea	DXXXXXX	Upper Blade Clamp, Lower Side, 0-3.5°
1	Ea	DXXXXXX	Upper Blade Clamp, Lower Shim
1	Ea	D030449	Push Plate
1	Ea	D030450	Pull Plate
2	Ea	NA	Flat Washer, ¼” SSTL
3	Ea	NA	Socket Head Cap Screw, ¼-20 x .375”, SSTL
2	Ea	NA	Socket Head Cap Screw, 8-32 x 1.00”, SSTL
2	Ea	NA	Socket Head Cap Screw, 8-32 x 0.75”, AgPlated
1	Ea	NA	Socket Head Cap Screw, 8-32 x 1.00”, AgPlated
1	Ea	NA	Socket Head Cap Screw, 8-32 x 1.00” Round Tip AgPlated
3	Ea	D1100785-472	Flat Washer, ¼” x .472 OD, N-60
1	Ea	D1100785-359	Flat Washer, .20 x .359 OD, N-60
2	Ea	NA	Socket Head Cap Screw, ¼-20 x 1.375”, AgPlated
1	Ea	D1002440	**HSTS Upper Blade Bake Fixture**

13.3 Procedure

Use Safety Glasses and Glove Liners per E0900332.

1. Prepare 2 D020660 Blade Pulldown Devices per Materials List above.

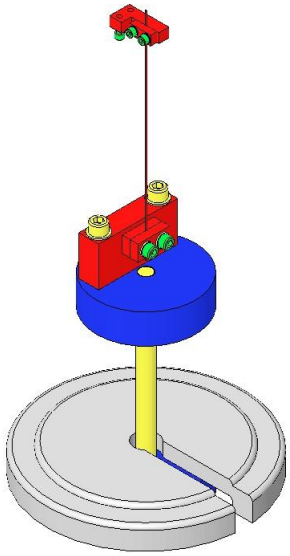


Fig 27: Blade Pulldown Device

2. Select pairs of D1001812 Blades and Blade Clamps per the T0900559 Blade Pairings Spreadsheet.
3. Correlate each Blade to a location within the Suspension:
   - The Blade with the higher tip goes to the +X, -Y corner (meaning that the blade with the higher tip is installed in the Rotational Adjuster that is mounted on the +X, -Y corner).
   - The Blade with the lower tip goes to the -X, +Y corner (meaning that the blade with the lower tip is installed in the Rotational Adjuster that is mounted on the –X, +Y corner).
   - Blade launch angle is set by Blade Clamps. These range from 0-3.5 deg. in .5 deg. increments.
   - Select Clamps from the D020677 HSTS Library of Clamps
   - Select Clamps according to Blade Characterization data for stiffness and expected load.
   - Select Blades in pairs according to Blade Characterization data.
   - Record the Blade serial numbers and Blade clamp angles and orientations within ICS.

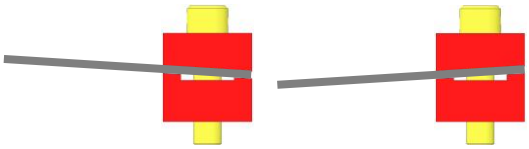


Fig 28: Clamps Control Launch Angle

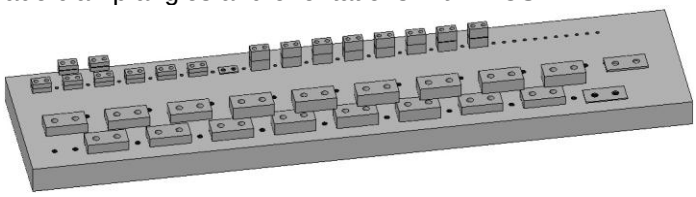


Fig 29: HSTS Library of Clamps

4. Mount the D1002440 Baking Fixture to an Optics Table, aligning the Crossbar side with the Table edge to allow clearance for the Blade Pulldown Device.
5. Remove a D1002443 Crossbar from the Baking Fixture.
6. Assemble to the Baking Fixture:
   - 2 D030447 Rotating Plates
     Beveled-side-down
   - 4 Socket Head Cap Screws
     ¼-20 x 0.375" SSTL
   - 4 D1100785-472 Flat Washers
     Tighten the Screws firmly

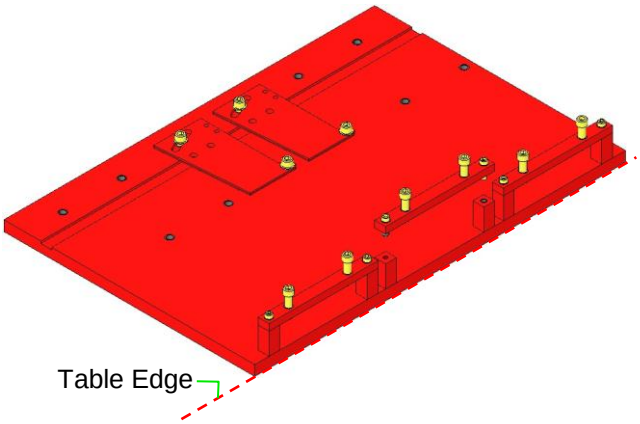


Fig 30: Base Plates in Baking Fixture

7. Assemble to each Rotating Plate:
   - 1 DXXXXXX Shim, Upper Blade Clamp
     Each Weldment is packaged with 2 Rotational Adjuster Shim's, each marked with the Weldment Serial Number
   - 1 DXXXXXX Lower Clamp
   - 1 D1001812 Upper Blade
   - 1 DXXXXXX Upper Clamp
   - 2 Socket Head Cap Screws
     ¼-20 x 1.375" SSTL
   - Flat Washer ¼" SSTL
     Hand-tighten the 2 Screws

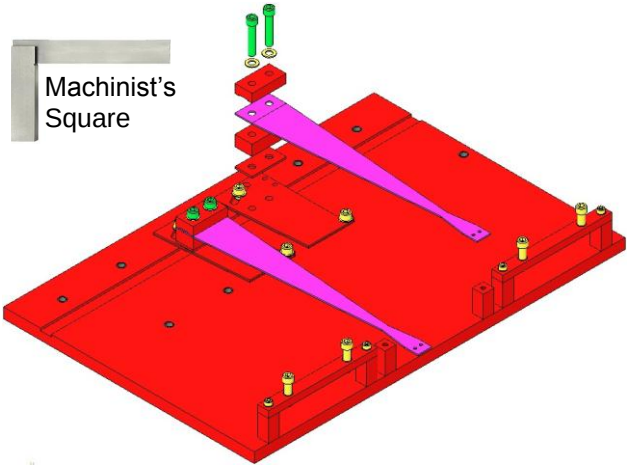


Fig 31: Shim, Clamps, Blade, Screws, Washers

8. Attach a Pulldown Device from each Upper Blade Tip to flatten the Blades.
9. Assemble to the Bake Fixture:
   - 1 D1002443 Bake Fixture Crossbar
   - 2 Socket Head Cap Screws 8-32 x 0.625" SSTL
   - 2 Flat Washers #8 SSTL
     Tighten the Screws firmly
   - 2 Socket Head Cap Screws ¼-20 x 1.0 Full-Thread, Round-Tip SSTL
10. Turn down the Round-Tip Screws until the weighted Blade tip is level with the Blade root.
    Be careful not to damage the nickel plating on the blade
11. Leaving the Wire Clamp attached to the Blade, remove the rest of the Blade Pulldown Device.
12. Using the Machinist's Square, square the Blade, Clamps, and Shim to each other and to the Rotating Plate.
13. Tighten the ¼-20 Screws that clamp the Blade, to 100 in-lb.
14. Re-attach the Blade Pulldown Device to the Wire Clamp.
15. Turn back the Rounded-End Screws and remove the D1002443 Crossbar again.
16. Slowly lift and then disconnect the Blade Pulldown Device, allowing each Blade to curve fully upward.
17. Disassemble the Rotational Adjuster(s) from the Upper Blade Baking Fixture.

18. Assemble to a D030448 Base Plate:
    - A just-assembled Rotational Adjuster
    - 3 Socket Head Cap Screw
      ¼-20 x 0.375" SSTL
    - 3 D1100785-472 N-60 Flat Washers
      Hand-tighten only
    - D030450 Pull Plate
    - 2 Socket Head Cap Screw
      8-32 x 0.75" AgPlated
      Torque to 30 in-lb

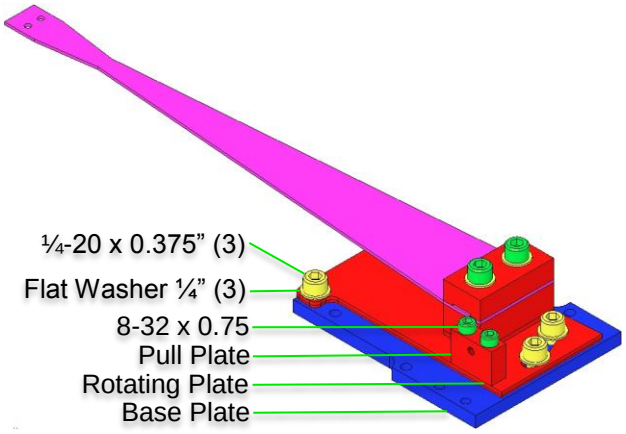


Fig 32: Base Plate and Pull Plate added

19. Assemble to the Base Plate:
    - D030449 Push Plate
    - 2 Socket Head Cap Screws
      8-32 x 1.00" SSTL
      Torque to 20 in-lb
20. Assemble through the Push Plate, into the Pull Plate:
    - 1 Socket Head Cap Screw
      8-32 x 1.00" AgPlated
    - 1 D1100785-359 N-60 Flat Washer
    - 1 Socket Head Cap Screw
      8-32 x 1.00" Round Tip AgPlated

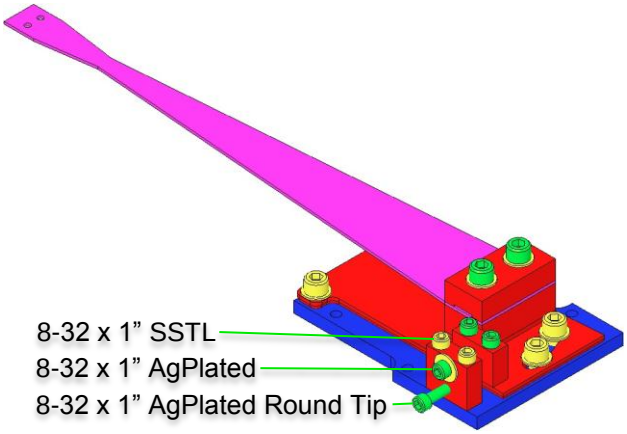


Fig 33: Adding Push Plate

14 Assembling Barrel Earthquake Stops

2 Assemblies for Intermediate Mass / Upper Side

14.1 Documents

D0902203 Barrel Earthquake Stop Assembly / Intermediate Wire

14.2 Materials

Qty	U	ID	Description
4	Ea	D0902009	Barrel EQ Stop Base
4	Ea	D0902008	Barrel EQ Stop Top
8	Ea	NA	Socket Head Cap Screw 4-40 x 0.375" SSTL
2	Ea	D0901925	Barrel EQ Stop Crossbar, Intermediate Wire
8	Ea	NA	Socket Head Cap Screw ¼-20 x 0.875" SSTL
8	Ea	NA	Flat Washer, ¼" SSTL
4	Ea	NA	Socket Head Cap Screw ¼-20 x 2.25" SSTL Round Tip
4	Ea	NA	Hex Nut ¼-20 AgPlated

14.3 Procedure

Repeat these steps to build 2 Assemblies.
Used above the Intermediate Mass.

1. Assemble:
   - 2 D0902009 Barrel EQ Stop Base
   - 2 D0902008 Barrel EQ Stop Top
   - 2 Socket Head Cap Screws
     4-40 x 0.375" SSTL
     Torque to 5 in-lb

     Ensure the Vent Holes of each D0902008 are facing outboard.

     Ensure the Bases and Tops are aligned with a Precision Square.
2. Assemble 1 D0901925 Barrel EQ Stop Crossbar to the previous assemblies, using:
   - Socket Head Cap Screw
     ¼-20 0.875" SSTL
   - Flat Washer ¼" SSTL
     Assemble Bolts loosely.
3. Assemble to the Crossbar:
   - 2 Socket Head Cap Screw
     ¼-20 2.25" SSTL Rounded Tip
   - 2 Hex Nuts ¼-20 AgPlated
     Note the orientation of the bolts relative to the Crossbar.

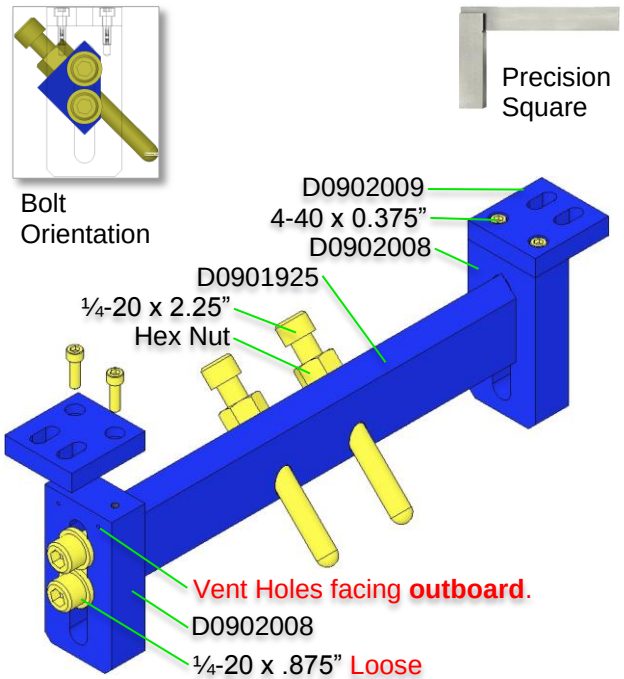


Fig 34: Build 2 Assemblies

2 Assemblies for Intermediate Mass / Lower Side
4 Assemblies for Lower Mass

14.4 Documents

D0902201 HSTS Barrel EQ Stop Assembly, Lower Wire

14.5 Materials

Qty	U	ID	Description
12	Ea	D0902009	Barrel EQ Stop Base
12	Ea	D0902008	Barrel EQ Stop Top
24	Ea	NA	Socket Head Cap Screw 4-40 x 0.375" SSTL
6	Ea	D0902202	Barrel EQ Stop Crossbar
24	Ea	NA	Socket Head Cap Screw ¼-20 x 0.875" SSTL
24	Ea	NA	Flat Washer, ¼" SSTL
12	Ea	NA	Socket Head Cap Screw ¼-20 x 2.25" Round-Tip SSTL
8	Ea	D0900932	EQ Stop for Glass
12	Ea	NA	Hex Nut ¼-20 AgPlated
1	Ea	NA	Machinist's Square

14.6 Procedure

6 Assemblies; 2 beneath Intermediate Mass; 4 for Bottom Mass or Optic. For Optic, use EQ Stops for Glass; for Intermediate and Bottom Mass, use ¼-20 x 2.25" SHCS Round Tip.

1. Assemble:
   - 2 D0902009 Barrel EQ Stop Bases
   - 2 D0902008 Barrel EQ Stop Tops
   - 2 Socket Head Cap Screws 4-40 x 0.375" SSTL Torque to 5 in-lb

     Ensure the vent holes of the D0902008 are facing outboard relative to the D0902009.

     Ensure the Bases and Tops are aligned with a Machinist's Square.
2. Assemble 1 D0902202 Barrel EQ Stop Crossbar, Lower Wire, to the previous assemblies, using:
   - Socket Head Cap Screw ¼-20 x 0.875" SSTL
   - Flat Washer ¼" SSTL

     Assemble Bolts loosely.
3. Assemble to the Crossbar:
   - 2 Socket Head Cap Screw ¼-20 x 2.25" SSTL Round Tip
   - Hex Nuts ¼-20 AgPlated

     Note the orientation of the bolts relative to the Crossbar.

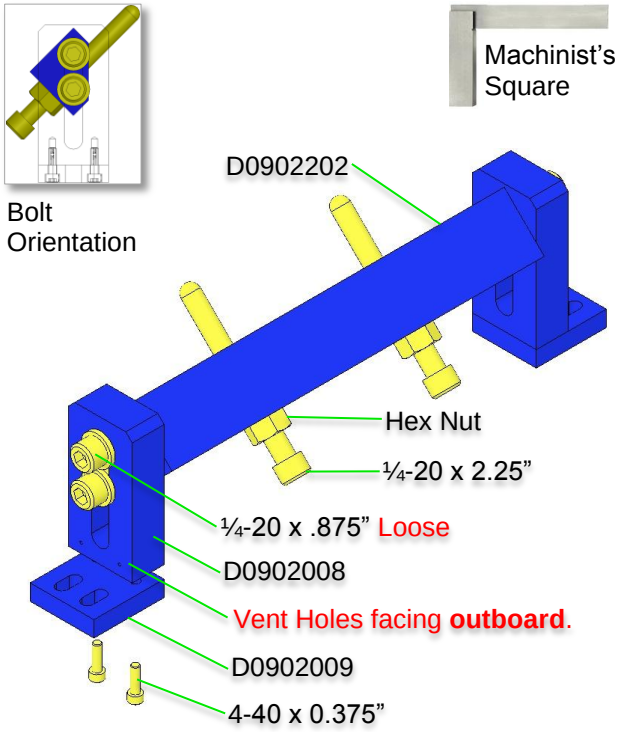


Fig 35: Build 6 Assemblies

15 Assembling Face EQ Stops

2 Assemblies for Intermediate Mass

15.1 Documents

D0902413 Face EQ Stop Assembly, Intermediate Mass

15.2 Materials

Qty	U	ID	Description
2	Ea	D0902204	HSTS Face EQ Stop Bracket, Intermediate Mass
2	Ea	D0901923	HSTS Face EQ Stop Base
4	Ea	NA	Socket Head Cap Screw 8-32 x 0.625" SSTL
4	Ea	NA	Socket Head Cap Screw ¼-20 x 2.25" SSTL Round Tip
4	Ea	NA	Hex Nut ¼-20 AgPlated
4	Ea	1185-4EN375	Helicoil ¼-20 x 0.375"

15.3 Procedure

Repeat steps to build 2 Assemblies:

1. Assemble:
   - 1 D0901923 Base
   - 1 D0902204 Bracket
   - 2 Socket Head Cap Screws 8-32 x 0.625" SSTL Torque to 20 in-lb
   - 2 Socket Head Cap Screws ¼-20 x 2.25" SSTL Round-Tip
   - 2 Hex Nuts ¼-20 AgPlated

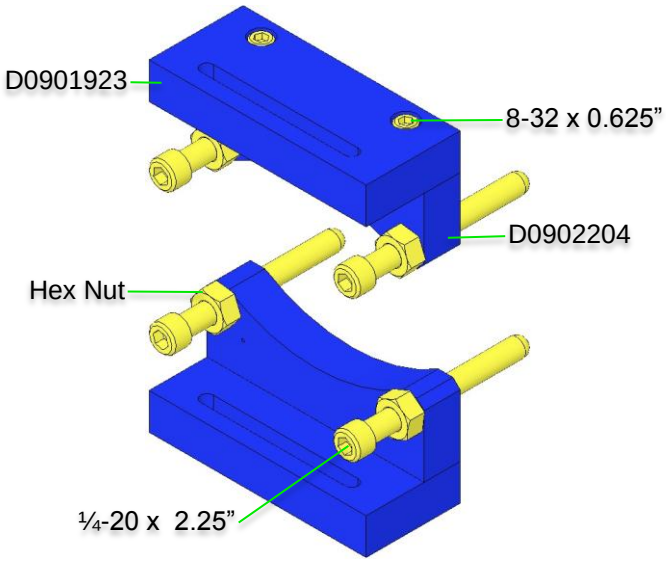


Fig 36: 2 Assemblies

2 Assemblies for Lower Mass

15.4 Documents

D0902205 Face EQ Stop Assembly, Bottom Mass

15.5 Materials

Qty	U	ID	Description
2	Ea	D0901922	HSTS Face EQ Stop Bracket, Lower Mass
2	Ea	D0901923	HSTS Face EQ Stop Base
4	Ea	NA	Socket Head Cap Screw 8-32 x 0.625" SSTL
4	Ea	NA	Socket Head Cap Screw ¼-20 x 2.25" Round-Tip SSTL (for Mass)
4	Ea	D0900932	EQ Stop for Glass, 2" (for Optic)
4	Ea	NA	Hex Nut ¼-20 AgPlated
4	Ea	1185-4EN375	Helicoil ¼-20 x 0.375"

15.6 Procedure

1. Create 2 Assemblies, each with:
   - 1 D0901923 Base
   - 1 D0901922 Bracket
   - 2 Socket Head Cap Screws 8-32 x 0.625" SSTL Torque to 20 in-lb

   For Mass:
   - 2 Socket Head Cap Screws ¼-20 x 2.25" Round-Tip SSTL
   - 2 Hex Nuts ¼-20 AgPlated

   For Optic:
   - 2 D0900932 EQ Stop for Glass
   - 2 Hex Nuts ¼-20 AgPlated

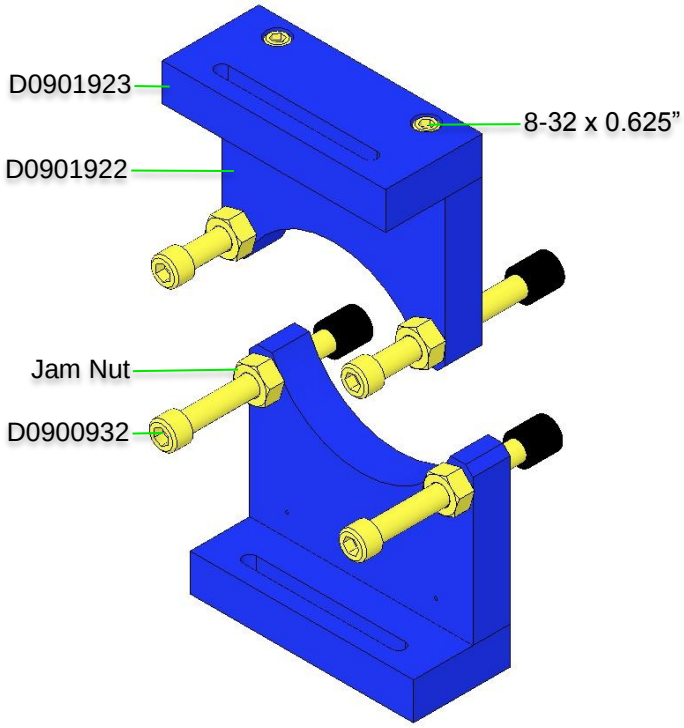


Fig 37: 2 Assemblies

16 Assembling AOSEM Alignment Assemblies

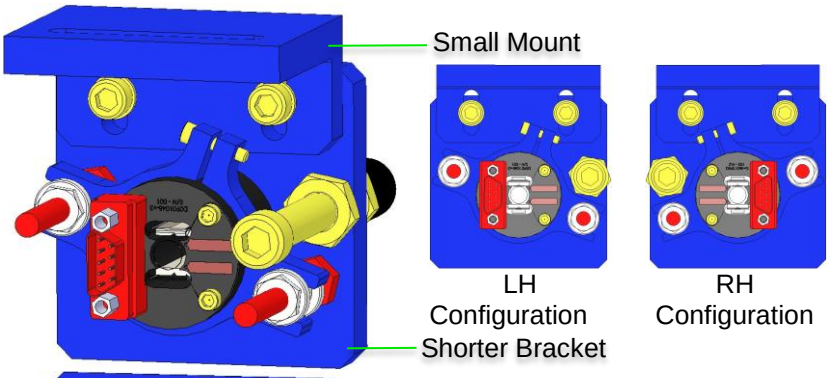
These assemblies are identical, with 3 exceptions:

- Intermediate Mass assemblies have a shorter Alignment Bracket;
- LH / RH versions (Alignment Bracket is reversed);
- 3 heights of Alignment Bracket Mounts, depending on PN.

Brackets are shown with A OSEMs in place, but A OSEMs are actually installed later on.

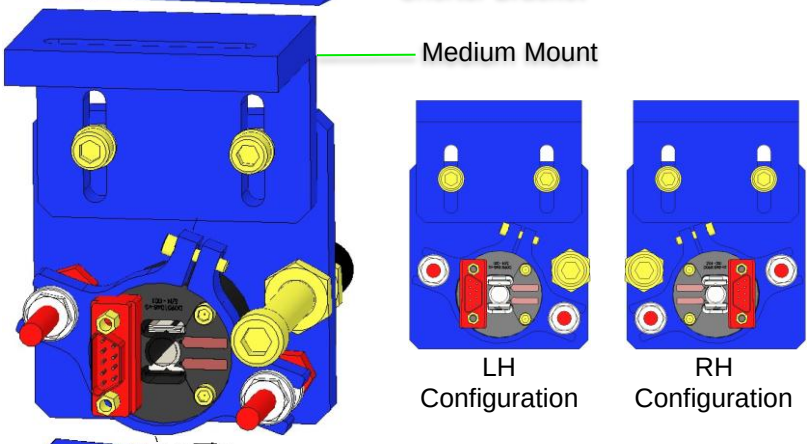
D0901924 (4)
A OSEM Alignment Assy
Intermediate Mass

Used in all 4 locations at the Intermediate Mass.



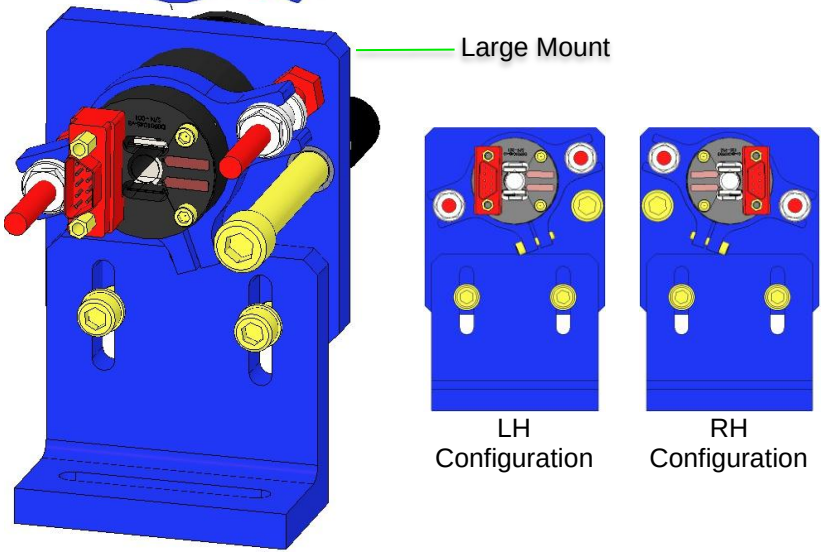
D0902207 (2)
Upper A OSEM Alignment Assy
Lower Mass

Used in the top 2 positions at the Lower Mass.



D0902208 (2)
Lower A OSEM Alignment Assy
Lower Mass

Used in the lower 2 positions at the Lower Mass.



16.1 Materials

D0901924

Qty	U	ID	Description
1	Ea	D0902206	A OSEM Alignment Bracket Mount, Intermediate Mass
1	Ea	D0902414	A OSEM Alignment Bracket, Intermediate Mass
1	Ea	D0901065	A OSEM Assembly
1	Ea	D0901548	A OSEM Adjustment Collar
2	Ea	D1000660	Adjustment Nut
2	Ea	D1000659	Adjustment Shaft
1	Ea	NA	Socket Head Cap Screw ¼-20 x 2.25” Round-Tip SSTL
1	Ea	1185-4EN250	Helicoil ¼-20 x 0.25”
2	Ea	1185-2EN246	Helicoil 8-32 x 0.246”
2	Ea	NA	Socket Head Cap Screw 8-32 x 0.625”
2	Ea	NA	Flat Washer #8 SSTL
1	Ea	NA	Socket Head Cap Screw 2-56 x 0.375”
1	Ea	NA	Hex Nut ¼-20 AgPlated

D0902207

Qty	U	ID	Description
1	Ea	D0902417	A OSEM Alignment Bracket
1	Ea	D0902416	A OSEM Alignment Bracket Mount, Intermediate Mass
1	Ea	D0901065	A OSEM Assembly
1	Ea	D0901548	A OSEM Adjustment Collar
2	Ea	D1000660	Adjustment Nut
2	Ea	D1000659	Adjustment Shaft
1	Ea	NA	Socket Head Cap Screw ¼-20 x 2.25” Round-Tip SSTL (for Mass)
1	Ea	D0900932	EQ Stop for Glass 2” (for Optic)
1	Ea	1185-4EN250	Helicoil ¼-20 x 0.25”
2	Ea	1185-2EN246	Helicoil 8-32 x 0.246”
2	Ea	NA	Socket Head Cap Screw 8-32 x 0.625”
2	Ea	NA	Flat Washer #8 SSTL
1	Ea	NA	Socket Head Cap Screw 2-56 x 0.375”
1	Ea	NA	Hex Nut ¼-20 AgPlated

D0902208

Qty	U	ID	Description
1	Ea	D0902417	A OSEM Alignment Bracket
1	Ea	D0902415	A OSEM Alignment Bracket Mount, Intermediate Mass
1	Ea	D0901065	A OSEM Assembly
1	Ea	D0901548	A OSEM Adjustment Collar
2	Ea	D1000660	Adjustment Nut
2	Ea	D1000659	Adjustment Shaft
1	Ea	NA	Socket Head Cap Screw ¼-20 x 2.25” Round-Tip SSTL (for Mass)
1	Ea	D0900932	EQ Stop for Glass 2” (for Optic)
1	Ea	1185-4EN250	Helicoil ¼-20 x 0.25”
2	Ea	1185-2EN246	Helicoil 8-32 x 0.246”
2	Ea	NA	Socket Head Cap Screw 8-32 x 0.500”
2	Ea	NA	Flat Washer #8 SSTL
1	Ea	NA	Socket Head Cap Screw 2-56 x 0.375” SSTL
1	Ea	NA	Hex Nut ¼-20 AgPlated

16.2 Procedure

Assembly procedure is nearly identical for all 3 units, but varies by the part number and orientation of the Alignment Bracket, and Mount.

1. Assemble D1000659 Adjustment Shafts to an Alignment Bracket, ensuring you have the correct Alignment Bracket and ensuring the correct orientation of the Shafts to the Bracket to enable the LH/RH configuration.
2. Assemble to the D0901548 Adjustment Collar:
   - 1 Socket Head Cap Screw
     2-56 x 0.375" SSTL
     Do not tighten Screw
3. Assemble the Adjustment Collar to the D1000659 Adjustment Shafts using D1000660 Adjustment Nuts

   The Adjustment Nut threads MUST be tapped; as is, the Nuts are tight and will seize

   Be extremely careful to not strip the Heads of the Nuts
4. Assemble the correct Bracket Mount to the Alignment Bracket using:
   - Correct Socket Head Cap Screw 8-32
   - Flat Washer #8
5. Assemble EQ Stop to Alignment Bracket with Hex Nuts

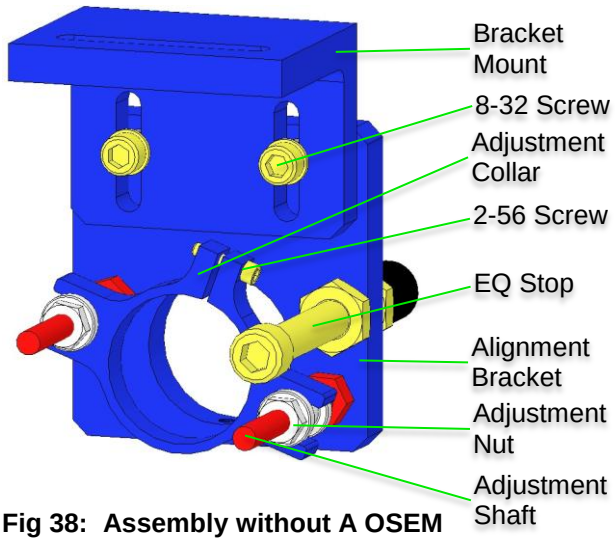


Fig 38: Assembly without A OSEM

17 Overall Assembly

The following document sections encompass installation into the main D020023 Weldment of:

- All aforementioned Subassemblies;
- Other individual components.

Each Subassembly must be weighed and documented in ICS, correlated to a specific overall assembly.

17.1 Subassemblies

Qty	U	ID	Description
2	Ea	D1000045	Rotational Adjuster
2	Ea	D0901934	Upper Blade Guard
1	Ea	D020534	Upper Mass
2	Ea	D0901854	Upper Wire
2	Ea	D0901905	Intermediate Wire
2	Ea	D0901902	Lower Wire
1	Ea	D0901873	Intermediate Mass
1	Ea	D0901791	Metal Lower Mass MC
1	Ea	D0902333	Metal Lower Mass PR/RS
2	Ea	D0902201	Earthquake Barrel Stop, Lower Wire
1	Ea	D0902413	Face EQ Stop, Intermediate Mass
1	Ea	D0902205	Face EQ Stop, Test Mass
6	Ea	D060218	BOSEM
4	Ea	D0901924	Upper AOSEM Alignment, Intermediate Mass
2	Ea	D0902207	Upper AOSEM Alignment, Test Mass
2	Ea	D0902208	Lower AOSEM Alignment, Test Mass

17.2 Individual Components

Qty	U	ID	Description
8	Ea	D980184	LOS Clamps
8	Ea	NA	Socket Head Cap Screw ¼-20 x 1.5” AgPlated
4	Ea	D020346	Tablecloth Bracket
1	Ea	D020239	Tablecloth

18 Preparing the Weldment

18.1 Procedure

1. Verify usability of ALL tapped holes.
2. Install at the base of the Weldment:
   - 6 1185-2EN492 Helicoils 8-32 x 3.0D

     Install these BEFORE securing the Weldment to the Optical Table!
3. Install in the top plate of the Weldment:
   - 4 1185-4EN250 Helicoils ¼-20 x 1.0D
4. Identify the Front vs Rear of the Weldment by examining the hole patterns on the top surfaces of the bottom crossmembers.

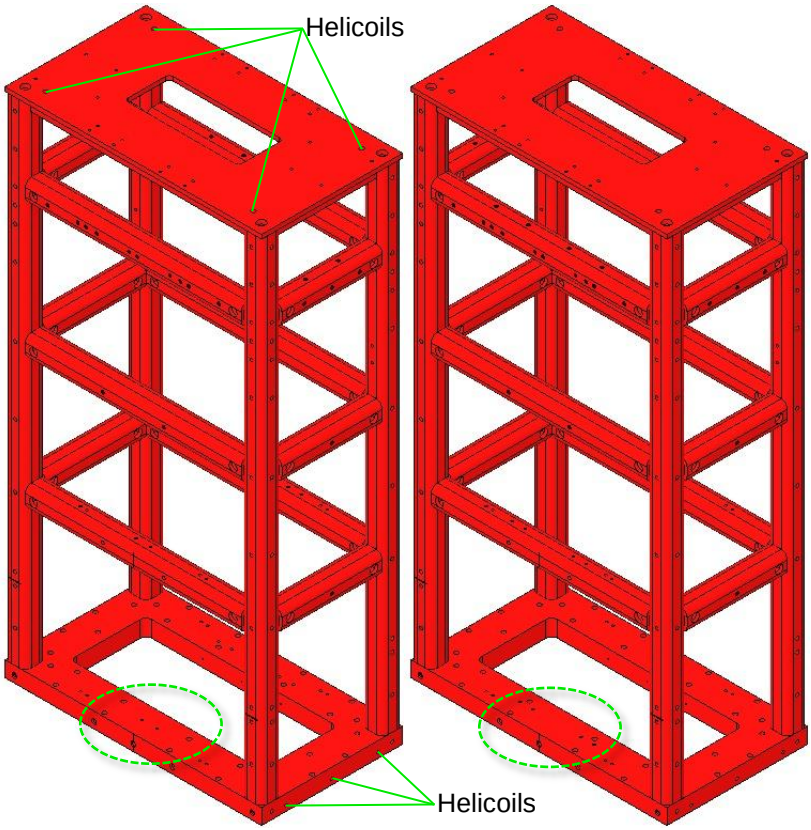


Fig 39: Front of Weldment **Fig 40: Rear of Weldment**

5. Secure the Weldment to an Optics Table with
   - 8 D980184 LOS Clamps, 2 per corner
   - 8 ¼-20 x 1.5" Screws AgPlated

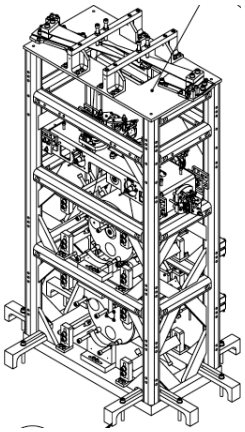


Fig 41: Clamping Weldment to Optics Table

19 Installing the Rotational Adjusters

19.1 Documents

D020023 HSTS Weldment Assembly

19.2 Materials

Qty	U	ID	Description
2	Ea	D020660	**Blade Pulldown Device**
2	Ea	D0901815	Upper Clamp Inside
2	Ea	D0901813	Upper Clamp Outside
4	Ea	NA	2 Socket Head Cap Screw 4-40 x 0.375" AgPlated
4	Ea	NA	Flat Washer #4 Vented, SSTL
4	Ea	NA	Socket Head Cap Screw 4-40 x 0.25" AgPlated
1	Kg	NA	4.483 kg in weight
2	Ft	NA	Music Wire .024" dia. min.
2	Ea	D1102119	**Blade Pulldown Support** Class B cleaned
2	Ea	D1000045	**Upper Blade Rotational Adjustment Assemblies**
2	Ea	D0901934	**Blade Guard Assembly**
24	Ea	NA	Socket Head Cap Screw 8-32 x .625" AgPlated SSTL
24	Ea	NA	Washer, Flat #8 SSTL
1	Roll	NA	UHV Foil

19.3 Process

Wear Safety Glasses and Glove Liners per E1000043.

1. Prepare 2 D020660 Blade Pulldown Devices per Materials List.

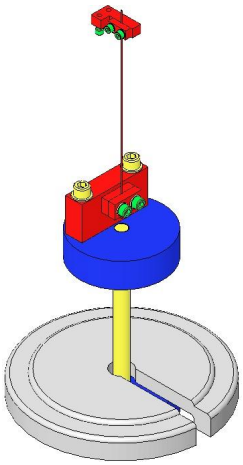


Fig 42: Blade Pulldown Device

2. Attach 2 D0901934 Upper Blade Guard Assemblies to the Weldment using:
   - 16 Socket Head Cap Screws 8-32 x 0.625" AgPlated SSTL
   - 16 Washers, Flat #8 SSTL
     Torque to 30 in-lb

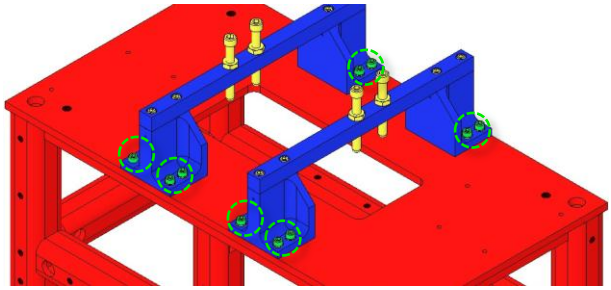


Fig 43: Base Plates and Blade Guards

3. Remove the 2 D0901935 Blade Guard Bars
4. Attach the Rotational Adjusters to the Weldment with:
   - 8 Socket Head Cap Screws 8-32 x 0.625" AgPlated SSTL
   - 8 Washers, Flat #8 SSTL

   Torque to 20 in-lb.

   Blades are shown flat but are actually curved upward at this point.

   Record the serial number and location of both Upper Blades in ICS in the RA assembly load.

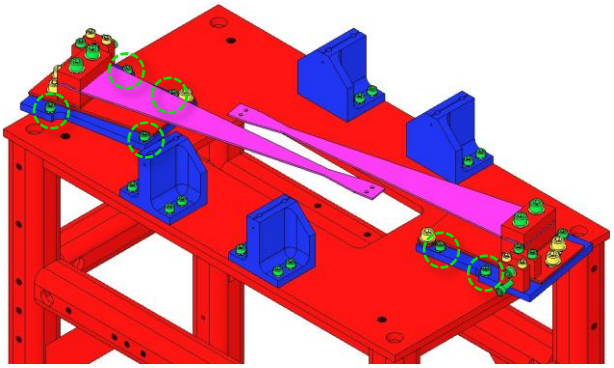


Fig 44: Crossbars removed

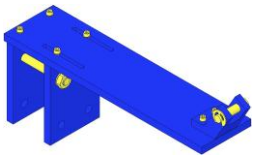


Fig 45: Blade Pulldown Support

5. Ensure the 2 D1102119 Blade Pulldown Supports are Class B clean.
6. Attach the Blade Pulldown Supports to the center of the Weldment cross member shown, Clevis extending outboard.
7. Cover each end of the Weldment Structure and surrounding Optical Table areas with UHV Aluminum Foil, to protect them from the dirty Pulldown Device.

   2 workers required:
8. 1st person holds the Pulldown Weight.
9. 2nd person passes Wire Clamp of the Pulldown Device through the Weldment side opening, up toward the Upper Blade Tip, then attaches the Clamp to the Blade tip with:
   - 2 Socket Head Cap Screws 4-40 x .375" AgPlated SSTL
10. 1st person gently drapes the wire over the Clevis, and slowly releases the Weight.
11. Repeat Steps 11-13 for the second Pulldown Device.

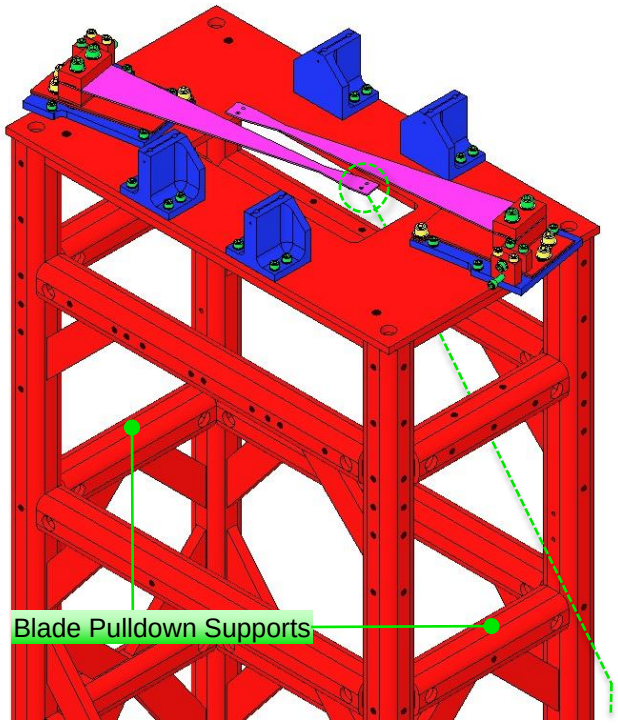


Fig 46: Location of Blade Pulldown Support

12. Re-Assemble the 2 D0901935 Blade Guard Bars to the Risers, using the original:
    - 4 Socket Head Cap Screws
      8-32 x .625" SSTL
      Torque to 20 in-lb

    Ensure the Bars are oriented with the EQ Stop Screws directly over the Blades.

    The EQ Stop Screws should be adjusted so the Blades are flat. Once adjusted, the Screws should be secured with the Hex Nuts.
13. Carefully remove the 2 Blade Pulldown Devices.
14. Remove the 2 Blade Pulldown Supports.

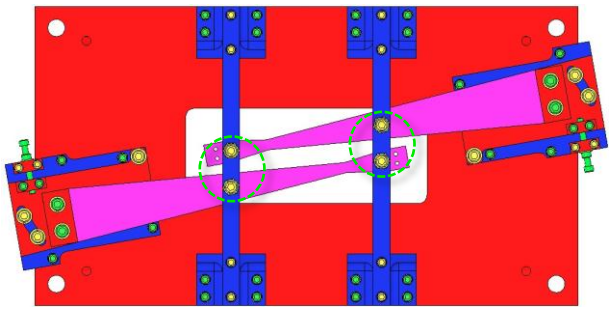


Fig 47: Bar orientation

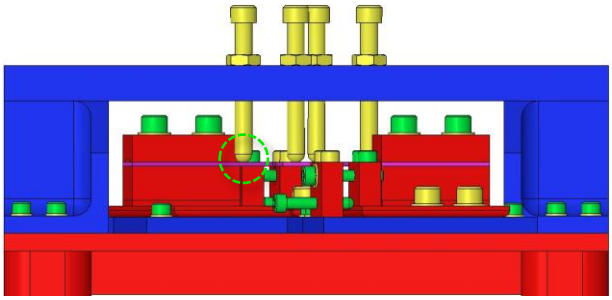


Fig 48: EQ Stops turned to flatten Blades

20 Installing Barrel EQ Stops

20.1 Materials

Qty	U	ID	Description
2	Ea	D0902203	Barrel EQ Stop, Intermediate Wire
6	Ea	D0902201	Barrel EQ Stop, Lower Wire
32	Ea	NA	Socket Head Cap Screw 8-32 x 0.5” AgPlated
32	Ea	NA	Flat Washer #8
1	Ea	NA	Machinist’s Square

20.2 Procedure

1. Assemble to the Weldment:
   - 2 D0902203 Assemblies above the Intermediate Mass
     Raise Crossbars
     Retract Stop Screws
   - 2 D0902201 Assemblies beneath the Intermediate Mass
     Lower Crossbars
     Extend Stop Screws to support the Mass
   - 2 D0902201 Assemblies above Bottom Mass / Optic
     Crossbars at midpoint
     Stop Screws at midpoint
   - 2 D0902201 Assemblies beneath Bottom Mass / Optic
     Raise Crossbars
     Extend Stop Screws
   - 32 Socket Head Cap Screw 8-32 x 0.675” AgPlated
   - 32 Flat Washer #8
     Torque to 30 in-lb

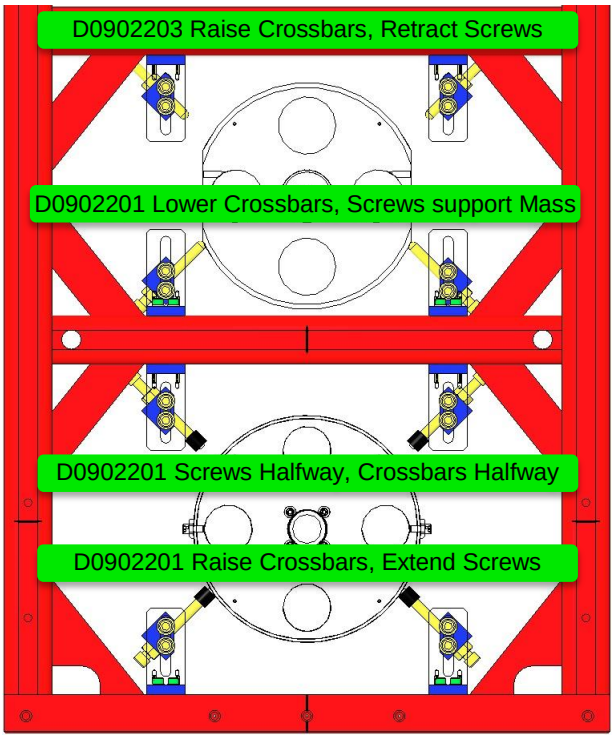


Fig 49: Weldment / Front View

21 Assembling the Intermediate Mass (M2)

21.1 Documents

D0901873 HSTS Intermediate Mass Assembly

21.2 Materials

Qty	U	ID	Description
1	Ea	D0901792	**HSTS Intermediate Mass**
2	Ea	NA	Socket Head Cap Screw ¼-20 x .875" Vented
2	Ea	Several	Add-On Masses
2	Ea	D020202	Lower Wire Clamp, Inside
4	Ea	D020203	Lower Wire Clamp, Outside
6	Ea	NA	Socket Head Cap Screw, 8-32 x .5" SSTL
4	Ea	NA	Socket Head Cap Screw, 8-32 x .625" AgPlated
10	Ea	NA	Flat Washer #8 SSTL
4	Ea	D0901904	Intermediate Wire Clamp Mount
4	Ea	D0901903	Intermediate Wire Clamp, Lower
8	Ea	NA	Socket Head Cap Screw 4-40 x .375" AgPlated
12	Ea	NA	Socket Head Cap Screw 4-40 x .375" SSTL
20	Ea	NA	Flat Washer #4 SSTL

21.3 Procedure

1. Weigh the following items, selecting Add-On Weights to arrive at 2963.30 total:
   - Intermediate Mass
   - Lower Wire Clamps per list above
   - Intermediate Wire Clamps per list above
   - Add-On Masses for the Intermediate Mass

     D1100894 2g
     D1100863 5g
     D1100855 10g
     D030078 20g
     D020351 50g
     D020350 100g

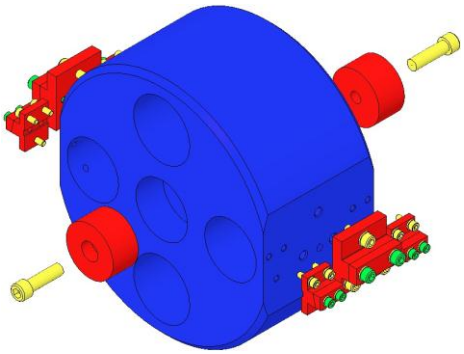


Fig 50: Add-On Weights and Wire Clamps

2. Assemble the Add-On Masses to the Intermediate Mass.

   The grooves on the Add-On Masses must face inboard

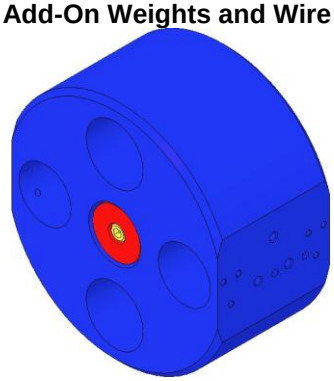


Fig 51: Intermediate Mass with Add-On Masses

22 Assembling the Lower Mass (M3)

22.1 Documents

D0901791 HSTS Metal Lower Mass Assembly (MC)

22.2 Materials

Qty	U	ID	Description
1	Ea	D0902658	Optic Holder
4	Ea	D980184	LOS Clamps
4	Ea	NA	Socket Head Cap Screw ¼-20 x 1.5” AgPlated
1	Ea	D020234	**HSTS Metal Lower Mass**
2	Ea	Y1-1037-0	Laser Mirror
8	Ea	NA	Socket Head Cap Screw 4-40 x .375” SSTL
8	Ea	NA	Flat Washer #4 SSTL
8	Ea	NA	Flat Washer #8 SSTL
2	Ea	D0901790	Primary Metal Breakoff Prism
4	Ea	NA	Socket Head Cap Screw 8-32 x .375” SSTL
4	Ea	NA	Flat Washer #8 SSTL
2	Ea	D0901278	Secondary Metal Breakoff Prism

22.3 Procedure

1. Mount the D0902658 Optic Holder to an Optic Table using 4 D980184 Clamps and 4 Socket Head Cap Screws, ¼-20 x 1.5” AgPlated.
2. Place the D0901792 Intermediate Mass into the D0902658 Optic Holder.

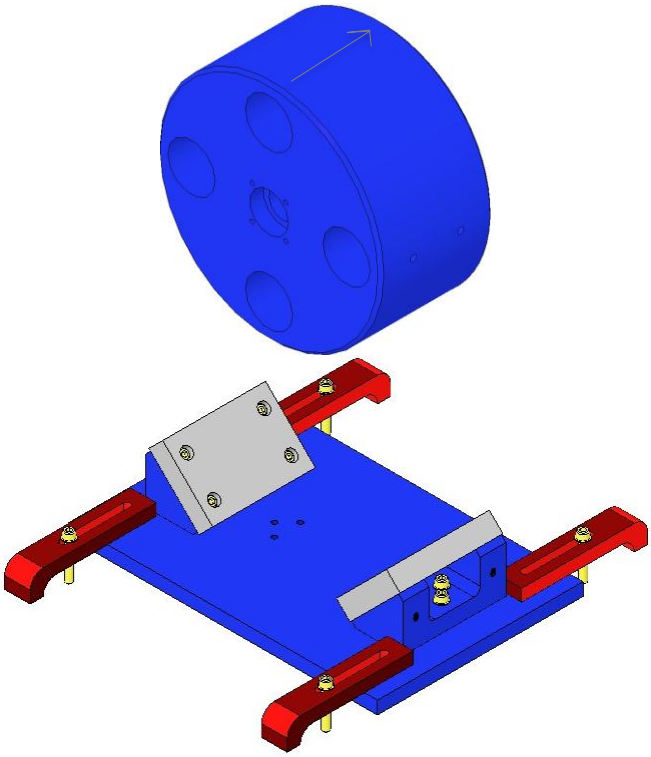
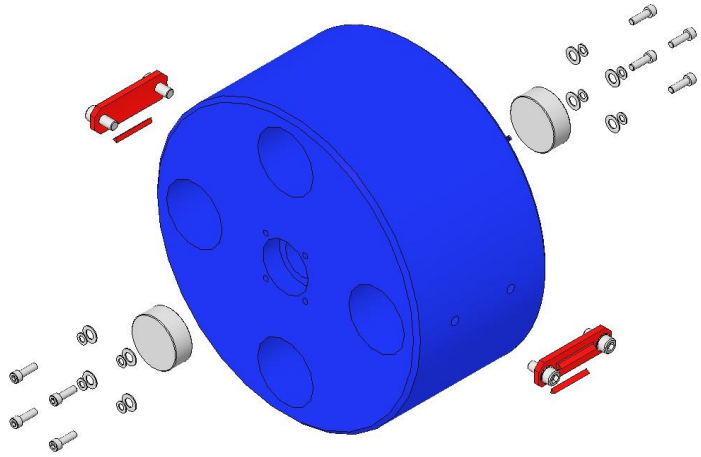


Fig 52: Optic Holder and Bottom Mass

3. Assemble to the Lower Mass:
   - 2 Y1-1037-0 Laser Mirrors
   - 8 Socket Head Cap Screws 4-40 x 0. 375" SSTL
   - 4 Flat Washers #4 SSTL
   - 4 Flat Washers #8 SSTL
     Torque to 5 in-lb
     Mirror Arrow must face outwards.
   - 2 D0901790 Prism Breakoffs
   - 4 Socket Head Cap Screws 8-32 x 0.375 SSTL
   - 4 Flat Washers #8 SSTL
     Torque to 20 in-lb



4. With the assembly process complete, weigh the Bottom Mass Assembly, including the D0901278 Secondary Metal Prism Breakoffs; the combined weight should be 2888.695g. Record this value in ICS. The Lower Mass is not designed to be weight-adjusted; weight is added to or subtracted from the Intermediate Mass. So adjusting Lower Mass weight is actually adjusting the combined weight of the Intermediate and Lower Masses, a total of 2963.30g + 2888.69g = 5851.99g.

23 Installing Intermediate and Lower Masses and Face EQ Stops

23.1 Materials

Qty	U	ID	Description
1	Ea	D0901873	Intermediate Mass Assembly
1	Ea	D0901791	Lower Mass Assembly

23.2 Procedure

1. Place a 0901873 Intermediate Mass Assembly on top of the 4 Barrel EQ Stop Screws at the Intermediate Mass level.
   - Magnets on the Mass face the rear of the Weldment.
   - Top/Bottom of the Mass is identified per the Screw hole pattern in the side of the Mass.
2. Level the Mass (flat sides vertical) by adjusting the 4 EQ Stop Screws such that the lower four corners of the Mass are equidistant from the Optic Table surface.

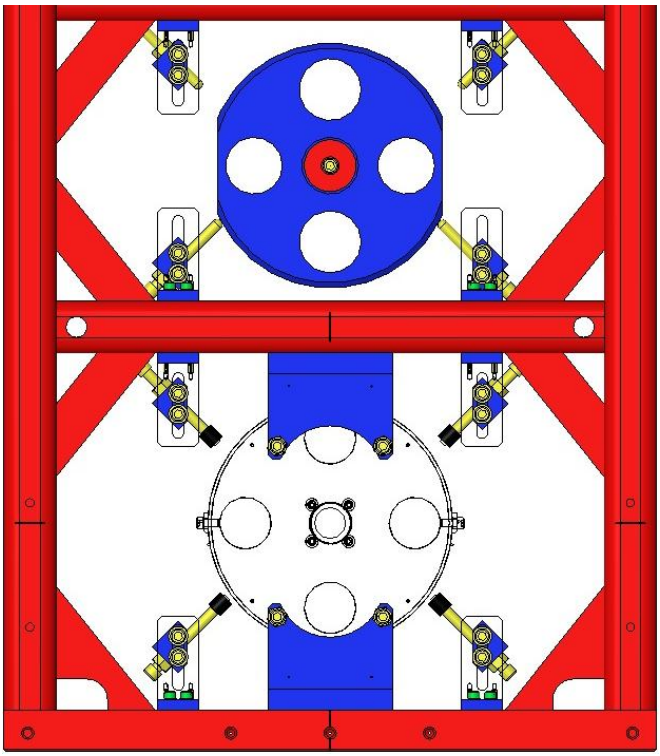


Fig 53: Intermediate Mass on Stops

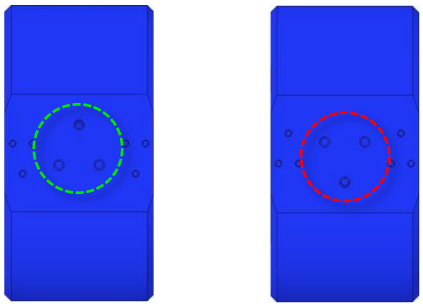


Fig 54: Right-Hand View of Mass

3. Assemble 2 D0902413 Face EQ Stops to the Weldment in front of the Mass, using:
   - 4 Socket Head Cap Screws 8-32 UHC x .75" AgPlated
   - 4 Flat Washers #8 SSTL Torque to 30 in-lb

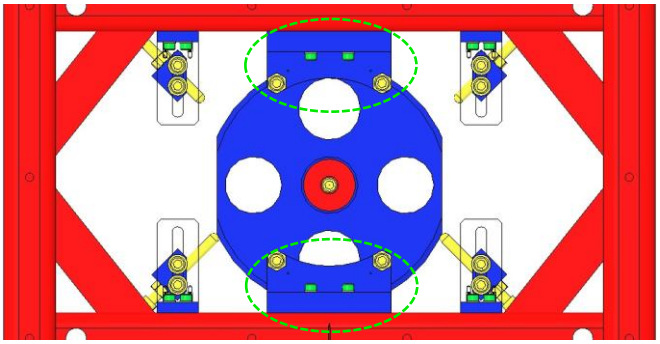


Fig 55: Face EQ Stops

4. Assemble both ends of the D0901902 Lower Wire Assembly to the Intermediate Mass with:
   - 6 Socket Head Cap Screws 8-32 x 0.5" SSTL
   - 6 Flat Washers #8 SSTL Torque to 20 in-lbs
5. Use the Machinist's Square to square the Wire Clamps with the front side of the Mass.

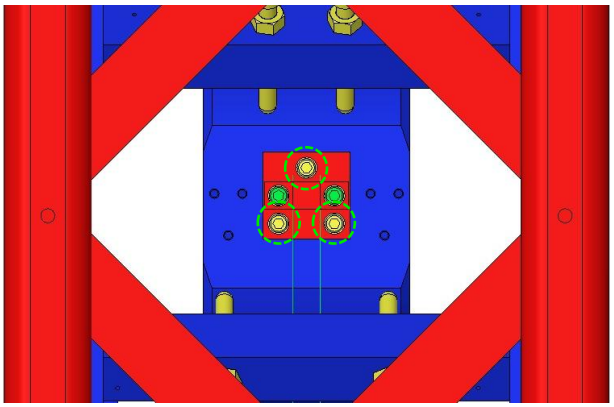


Fig 56: Lower Wire Assembly / Side View

6. Place a D0901791 Lower Mass within the twin wires of the D0901902 Lower Wire Assembly, but resting on the lower Stop Screws. Ensure:
   - The 2 Crossbeams are raised fully;
   - The 4 Stop Screws are extended fully.
   - Each wire is seated in a Prism notch.
7. Retract the 4 Stop Screws until the Lower Wires are almost taught. *Retract the Screws equally, turning each no more than 1 revolution at a time.*
8. Level the Mass by adjusting the 4 Stop Screws such that both ends of each Prism are equidistant from the Optic Table surface.

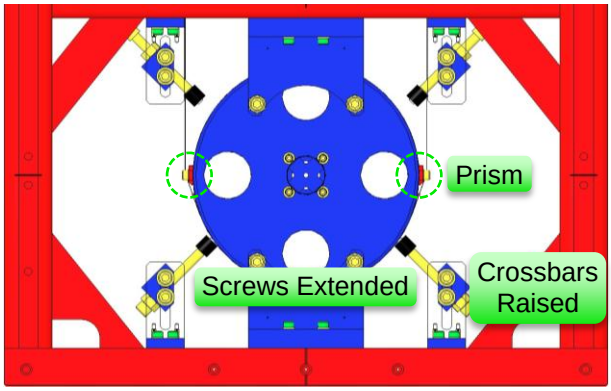


Fig 57: Lower Mass installed

9. Seat the 2 Lower Wires within the tiny grooves in the 2 Prisms. Adjust the 2 Wire loops such that they are equally spaced beneath the Mass.
10. Retract the 4 Stop Screws to lower the Mass until it is fully supported by the Lower Wires. Adjust the Screws equally, turning each Screw no more than 1 revolution at a time.
11. Level the Lower Mass: Raise the Mass evenly on the 4 Stop Screws until the wire is slack but does not leave the Prism Grooves.
12. Reposition the 2 Wires to achieve leveling. If leveling is not possible, then the Lower Wire Assembly is defective and must be replaced (the 2 wires likely are of different lengths).

13. Install 2 D0902205 Face EQ Stops in front of the Lower Mass, using:
    - 4 Socket Head Cap Screws ¼-20 UHC x 0.375" SSTL
    - 4 Flat Washers ¼" SSTL
    Torque to 75 in-lb
14. Back off the lower Stop Screws (4) so that the Mass hangs free and the Lower Wires (2) are therefore taught.

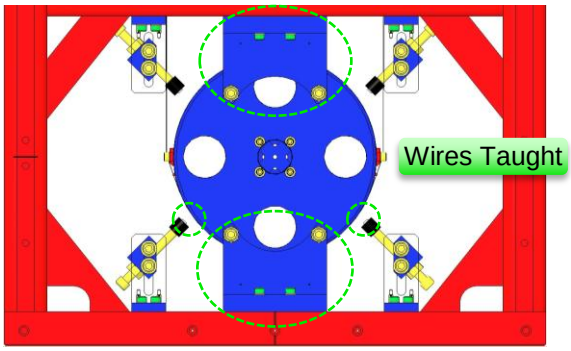


Fig 58: Lower Mass and Face EQ Stops

24 Assembling Magnets – Upper Mass

24.1 Materials – Upper Mass Magnets

Qty	U	ID	Description
9	Ea	D1100573	BOSEM Flat Magnet Flag
9	Ea	D1100574	BOSEM Flat Magnet Flag Disk
9	Ea	94518A108	Screw, Countersunk
9	Ea	D394197N35UHP	Sintered NdFeB Magnet, Ni Plated, 10mm x 5mm
18	Ea	D1001534	BOSEM Magnetic Plug
3	Ea	D0902494	BOSEM Magnet Holder, Short
6	Ea	D0902423	BOSEM Magnet Holder, Long

24.2 Assembly Procedure – Upper Mass Magnets

1. Assemble 3 D0902492 BOSEM Magnet / Flag Assemblies, Short, each with (shown left-to-right, at right):
   - D1100573 BOSEM Flat Magnet Flag
   - D1100574 BOSEM Flat Magnet Flag Disk
   - 94518A108 Screw, Countersunk
   - Magnet DCNI 00626/N Sintered NdFeB Ni-Plated 10 mm x 5 mm
   - D1001534 BOSEM Magnetic Plug
     See Plug Insertion procedure, below
   - D0902494 BOSEM Magnet Holder, Short
     Handle with care; thin sidewalls are easily damaged.

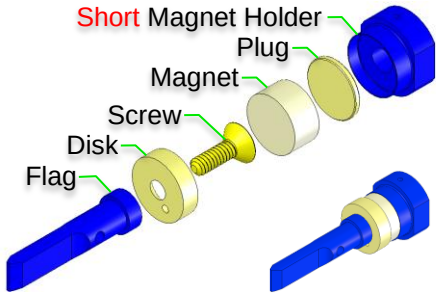


Fig 59: Short Magnet Assembly

2. Assemble 6 D0902418 BOSEM Magnet / Flag Assemblies, Long, each with (shown left-to-right, at right):
   - D1100573 BOSEM Flat Magnet Flag
   - D1100574 BOSEM Flat Magnet Flag Disk
   - 94518A108 Screw, Countersunk
   - Magnet DCNI 00626/N Sintered NdFeB Ni-Plated 10 mm x 5 mm
   - D1001534 BOSEM Magnetic Plug
     See Plug Insertion procedure, below
   - D0902423 Magnet Holder, Long
     Handle with care; thin sidewalls are easily damaged.

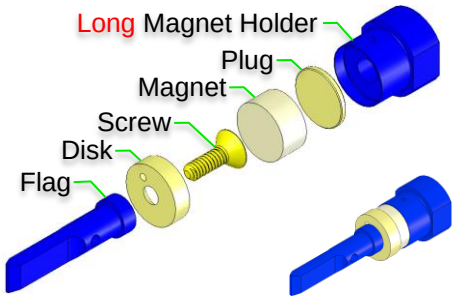


Fig 60: Long Magnet Assembly

24.3 Procedure – Plug Insertion

Procedure for assembling D1001534 Plug to Magnet Holder:

1. Heat Air Bake Oven to 70°C;
2. Attach Magnet Holders to Heating Fixture with:
   - Socket Head Cap Screw
     8-32 x 0.3125" SSTL
     Screws must be Class A or B clean
3. Place Heating Fixture in Oven for 10 min. minimum;
4. Remove Heating Fixture from Oven and inspect Magnet Holders for out-of-round condition, using tapered end of the Disk Insertion Tool to address any out-of-round conditions.
5. Place Disk on a Magnet Holder, Place non-tapered end of Disk Insertion Tool on Disk, and tap Insertion Tool until Disk is fully seated within Holder.
6. Return Heating Fixture to Oven for another 5 minutes, minimum.
7. Remove Heating Fixture from Oven, and repeat Step 5, above.
8. Remove Magnet Holders from Heating Fixture.

Fig 61: Heating Fixture with Holders

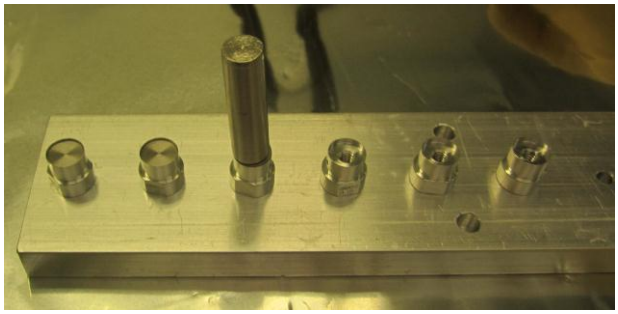


Fig 62: Insertion Tool in position
Note: Tapered end of Tool is up
Note: Seated Disks on left 2 Holders

25 Assembling the Upper Mass (M1)

25.1 Documents

D020534	HSTS Upper Mass Assembly
E0900023	Maraging Steel Blade Specification
E1000169	Blade Characterization Spreadsheet
T0900559	Blade Pairings Spreadsheet

25.2 Materials

Qty	U	ID	Description
1	Ea	D040259	**HSTS Jig, Upper Mass and Coil Holder**
1	Ea	D020534	**HSTS Upper Mass Assembly**
1	Ea	D020134	HSTS Upper Mass Main Section
4	Ea	D080761	HSTS Lower Blades
2	Ea	0902030	HSTS Blade Guards, Upper Mass
4	Ea	NA	Socket Head Cap Screws 4-40 x .5” SSTL
4	Ea	NA	Socket Set Screw 4-40 x .625 SSTL
4	Ea	D020482	Screw Drive Body
8	Ea	NA	Socket Head Cap Screw 8-32 x .625 SSTL
4	Ea	NA	Socket Head Cap Screw 8-32 x .75” Fully-Threaded SSTL
7	Ea	D0902493	Base Plate, Long
2	Ea	D020199	Base Plate, Short
4	Ea	NA	Socket Head Cap Screw 4-40 x .625” Vented AgPlated
2	Ea	NA	Socket Head Cap Screw 4-40 x .625” AgPlated
4	Ea	NA	Socket Head Cap Screw 4-40 x .625” SSTL
7	Ea	NA	Socket Head Cap Screw 8-32 x .3125” SSTL 2
2	Ea	NA	Socket Head Cap Screw 8-32 x .5” SSTL
4	Ea	D0902492	BOSEM Magnet Holder, Short
6	Ea	D0902418	BOSEM Magnet Holder, Long 4
4	Ea	D020211	Magnet Holder Brace
8	Ea	NA	Socket Head Cap Screw 4-40 x 1.25” AgPlated
18	Ea	NA	Flat Washer #4
8	Ea	NA	Socket Head Cap Screw 2-56 x 0.25” AgPlated
8	Ea	NA	Flat Washer #2 SSTL
1	Ea	D020136	HSTS Upper Mass T-Section
1	Ea	D020137	HSTS Pitch Insert for T-Section
1	Ea	NA	Socket Set Screw ½”-20 x 2.00” AgPlated
1	Ea	D020676	HSTS Roll Insert for T-Section
4	Ea	NA	Socket Set Screw 8-32 x .25” AgPlated SSTL
2	Ea	NA	Socket Head Cap Screw ¼-20 x .375 AgPlated SSTL
10	Ea	NA	Flat Washers #8
1	Ea	D020677	**HSTS/OMC Library of Clamps**
4	Ea	D0XXXXX	HSTS Lower Blade Clamp, Upper Side
4	Ea	D0XXXXX	HSTS Lower Blade Clamp, Lower Side
1	Ea	D020239	**HSTS Coil Holder**
2	Ea	NA	Socket Head Cap Screw ¼-20 x 1.125” AgPlated
2	Ea	NA	Hex Nut ¼-20 SSTL
12	Ea	NA	Socket Head Cap Screw 8-32 x 1.00” Round Tip, AgPlated
12	Ea	NA	Hex Nut 8-32 SSTL

2	Ea	D020660	**Blade Pulldown Device**
2	Ea	D020132	Lower Blade Wire Clamp
2	Ea	D0901855	Intermediate Wire Upper Clamp, Outside
8	Ea	NA	Socket Head Cap Screw 2-56 x 0.25" AgPlated
4	Ea	NA	Flat Washer #2 Vented SSTL
1	Kg	NA	1.4595 kg in weight
2	Ft	NA	Music Wire .024" dia.
1	Ea	NA	Machinist's Square

25.3 Procedure – Main Section & T Section

1. Assemble to the T-Section D020136:
   - Roll Insert D020676
   - Pitch Insert D020137
   - 4 Socket Set Screws 8-32 x .25" AgPlated Torque to 30 in-lb

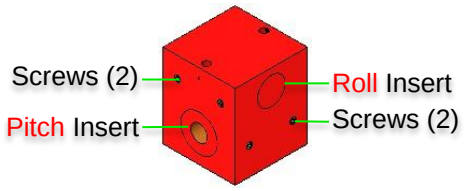


Fig 63: Upper Mass T-Section

2. Attach the D040259 Upper Mass Jig to an Optics Table with a ¼-20 Ag-Plated Bolt.
3. Thread the T-Section onto the ¼-20 stud at the top of the Jig.

The Jig will not be shown for the remainder of the assembly steps, but is necessary to secure the Upper Mass during the assembly process.

Fig 64: Upper Mass Jig and T-Section

4. Assemble the D020134 Upper Mass Main Section to the T-Section using:
   - 2 Socket Head Cap Screws ¼-20 x .375" AgPlated Torque to 100 in-lb

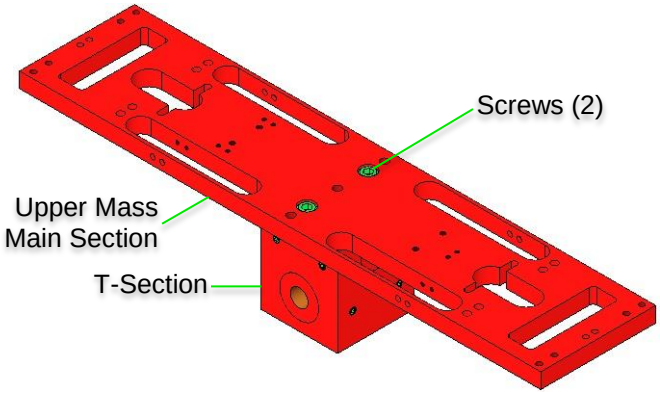


Fig 65: Main Section assembled to T-Section

25.4 Procedure – Lower Blades & Screw Drives

Wear Safety Glasses and Glove Liners per E1000043.

Blades are shown flattened but are curved upward until weighted.

5. Prepare 2 D020660 Blade Pulldown Devices per Materials List.
6. Per the data in T0900559 Blade Pairings, retrieve:
   - A matched set of 4 D080761 Lower Blades.
   - 4 sets of Blade Clamps from the D020677 Library of Clamps, each with an Angle corresponding to a specific Blade.
7. Identify the Blades for installation in the Upper Mass as follows:
   - Blade with highest tip in +X, +Y corner
   - Blade with next to highest tip in –X, +Y corner
   - Blade with next to lowest tip in +X, -Y corner
   - Blade with lowest tip in –X, -Y corner

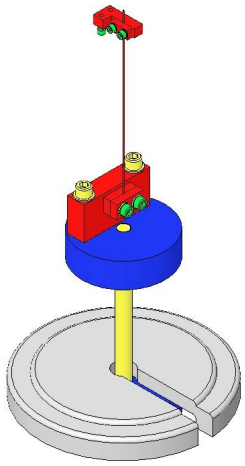


Fig 66: Blade Pulldown Device

8. Assemble Blade Assemblies with:
   - 2 Socket Head Cap Screws 8-32 x 1” AgPlated
   - 2 #8 Flat Washers SSTL
   - 1 D0XXXXX Blade Clamp, Lower
   - 1 D080761 Lower Blade
   - 1 D0XXXXX Blade Clamp, Upper

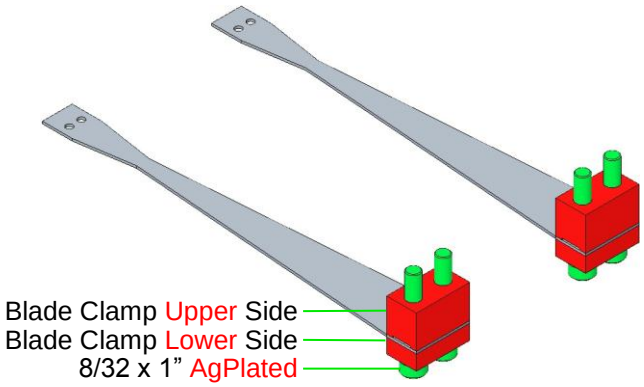


Fig 67: Lower Blade Assemblies

The Upper Mass remains on the Upper Mass Jig, as shown in Step 2.

9. Attach each Blade assembly to the Main Section in the location specified in the T0900559 Blade Pairings file; snug the Screws tight.

   Square Blades and Clamps with the Main Section using the Machinist’s Square. Ensure the Blade tips won’t touch the oval cutout walls.

10. Attach the Blade Pulldown Device to the tip of each Blade. The Blade tips will pass through the cutouts until the Blades are essentially flat.
11. Torque the Blade Clamp Screws to 30 in-lb AFTER the Blades are flattened.

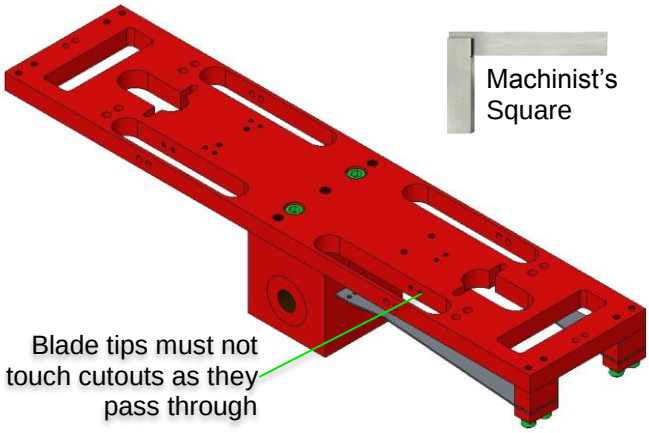


Fig 68: Attaching the Blades to the Main Section

12. When using Blade Clamp pairs other than 0° ensure the orientation of Upper Clamp to Lower Clamp is such that the bolt holes are concentric (visibly, the Clamp sidewalls must be parallel).

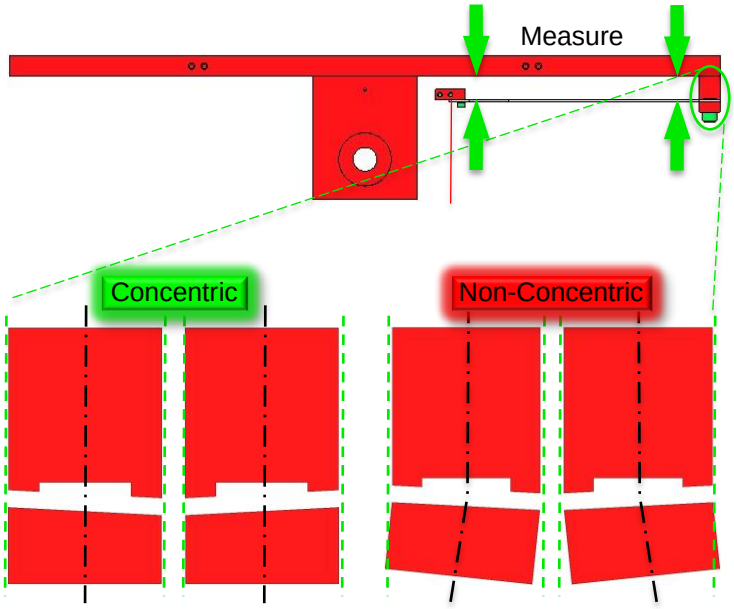


Fig 69: Profile Matching & Blade Clamp Alignment

13. Assemble a 0902030 Blade Guard to the Main Section with:
    - 2 Socket Head Cap Screw 4-40 x .5" SSTL Torque to 5 in-lb
14. Assemble to the Blade Guard:
    - 2 Socket Set Screws 4-40 x .625" SSTL

    Diagram shows SHC Screws; ½" Set Screws are being used as a temporary deviation as of 2/12. Turn the Screws down as far as possible.
15. Disconnect the Pulldown Devices from the Blade tips.

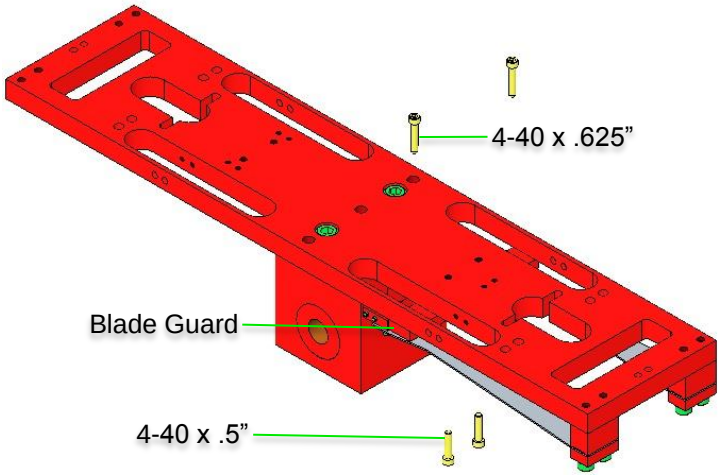


Fig 70: Adding Blade Guards

16. Repeat steps 7–14 to assemble the 2nd pair of Lower Blades and Blade Guards.

17. Assemble to Pitch Insert:
    - 1 Socket Set Screw ½”-20 x 2.00” AgPlated
18. Assemble 4 D020482 Screw Drive bodies to Main Section with:
    - 8 Socket Head Cap Screws 8-32 x .625” SSTL
    - 8 Flat Washers #8
    - Torque to 20 in-lb

    Use a Machinist’s Square to ensure Screw Drive bodies are square with the Upper Mass Main Section.
19. Assemble to Screw Drive System bodies:
    - 4 SHCS 8-32 x .75” Fully-Threaded SSTL

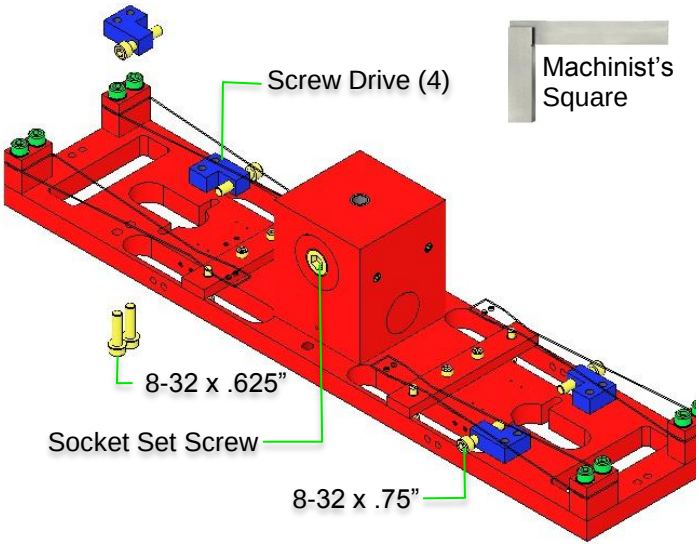


Fig 71: Adding Screw Drives

25.5 Procedure – Magnets

The Magnet Holders and Wires that follow, are vulnerable to damage and therefore must ONLY be added JUST PRIOR to the Upper Mass being assembled (with the Coil Holder) to the Weldment. The Magnet/Flag Assemblies are left off until all Masses and Wires are installed and suspended.

The Upper Mass continues to be mounted on the Upper Mass Jig, as shown in Section 24.3 Step 2.

20. Assemble:
    - 2 D0902492 Magnet Holder, Short
    - 2 D0902493 Base Plates, Long
    - 2 SHCS 8-32 x .3125" SSTL s to 20 in-lb
21. Assemble these to the top of the Main Section with:
    - 4 SHCS 4-40 x .625" Vented AgPlated
    - 4 Flat Washers #4 Torque to 7 in-lb

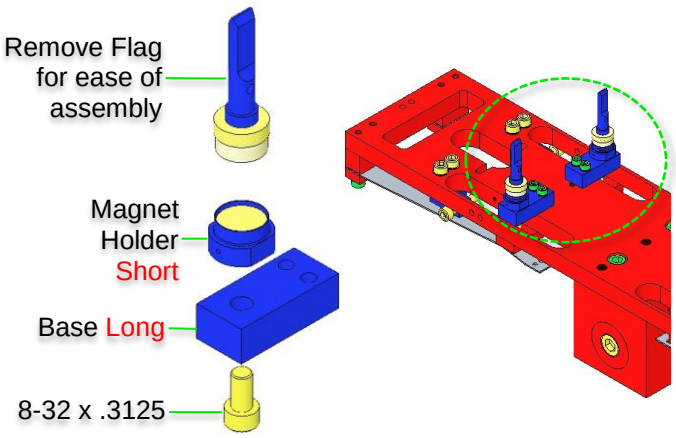


Fig 72: 2 Short Assemblies attached to Main Section

22. Assemble:
    - 1 D0902492 Magnet Holder Short
    - 1 D0902493 Base Long
    - 1 SHCS 8-32 x .3125" SSTL Torque to 20 in-lb

    Remove Magnet Flag for ease of assembly.
23. Assemble the Base to the top of the Main Section with:
    - 2 SHCS 4-40 x .625" AgPlated
    - 2 Flat Washer #4 Torque to 6 in-lb

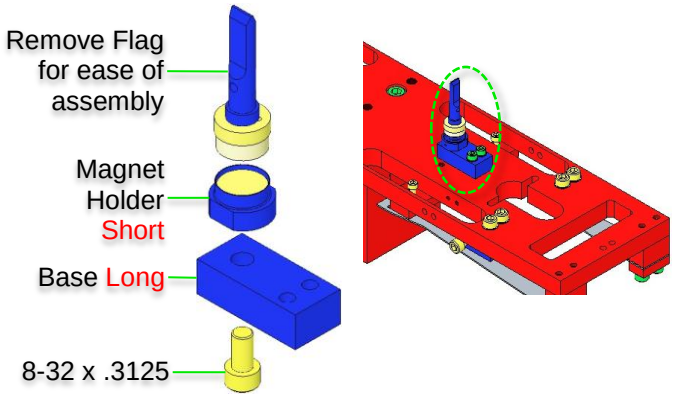


Fig 73: 1 Short Assembly attached to Main Section

24. Assemble:
    - 4 D0902418 Magnet Holder, Long
    - 4 D0902493 Base Plate, Long
    - 4 SHCS 8-32 x .3125" SSTL Torque to 20 in-lb

    Remove Magnet Flag for ease of assembly.

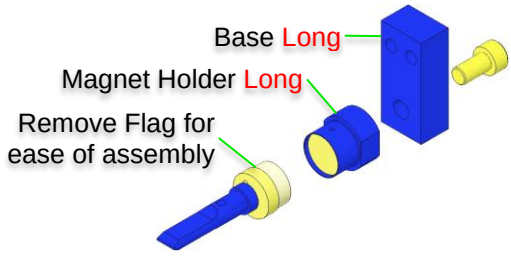


Fig 74: 5 Long Assemblies

25. Assemble these 4 Assemblies to the sides of the Main Section with:
    - 4 D020211 Magnet Holder Brace
    - 8 SHCS 4-40 x 1.25" AgPlated
    - 8 Flat Washer #4
      Torque to 30 in-lb

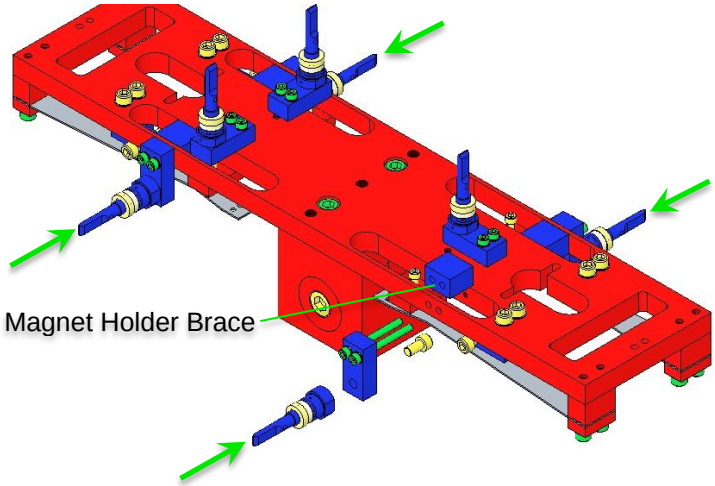


Fig 75: 4-7 of 9 Magnet Assemblies

26. Assemble:
    - 2 D020199 Base Plate Short
    - 2 D0902418 Magnet Holder Long
    - 2 SHCS 8-32 x .5" SSTL
      Torque to 20 in-lb

      Remove the Flag portion of the M/F Assembly when attaching the

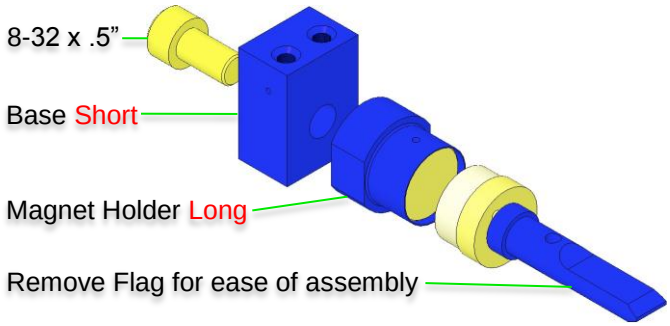


Fig 76: 2 Short Assemblies

27. Assemble one of these Assemblies to each end of the Main Section using:
    - 4 SHCS 4-40 x .625" SSTL
    - 4 Flat Washer #4
      Torque the -Y assembly to 5 in-lb

      Hand-tighten +Y Assembly; it will be dis-assembled and re-assembled during assembly to the Weldment.

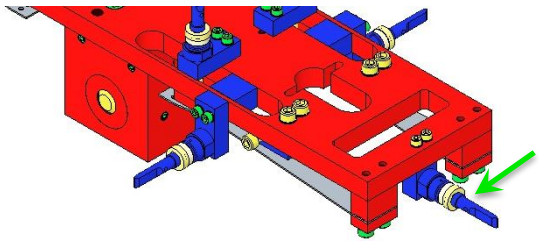


Fig 77: LH end of Main Section; 8 of 9 Magnet Assys

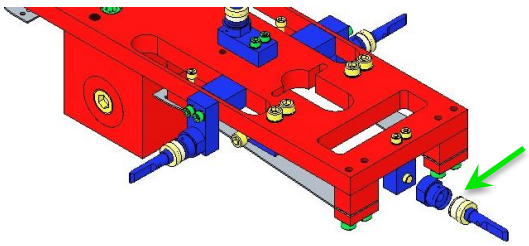


Fig 78: RH end of Main Section; 9 of 9 Magnet Assys

28. Weigh the following items to arrive at the Upper Mass total weight of 3115 gm., and record with the Upper Mass Serial Number in ICS:

    1 Upper Mass assembly just completed, including the 9 Magnet Flags

    2 Lower Clamps (with bolts) from the Upper Wire Assembly:
    - 2 D020481 Upper Mass C-Clamp
    - 2 D0901999 Upper Mass Wire Clamp, Inside
    - 2 D0901998 Upper Mass Wire Clamp, Outside
    - 4 Socket Head Cap Screws 2-56 x .375" AgPlated SSTL
    - 4 Flat Washers, #2 SSTL
    - 4 Socket Head Cap Screws 8-32 x 1.00" AgPlated SSTL
    - 4 Flat Washer, #8, D1100785-281

    4 Upper Clamps (with bolts) from the Lower Wire Assembly:
    - 4 D020132 Lower Blade Wire Clamp
    - 4 D030044 Lower Blade Wire Clamp Plate, angled
    - 8 Socket Head Cap Screws 2-56 x .375" AgPlated SSTL
    - 8 Washers, Flat, #2
    - 8 Socket Head Cap Screws 2-56 x 0.25" AgPlated SSTL
    - 8 Washers, Flat #2, SSTL Hand-tighten the Screws.

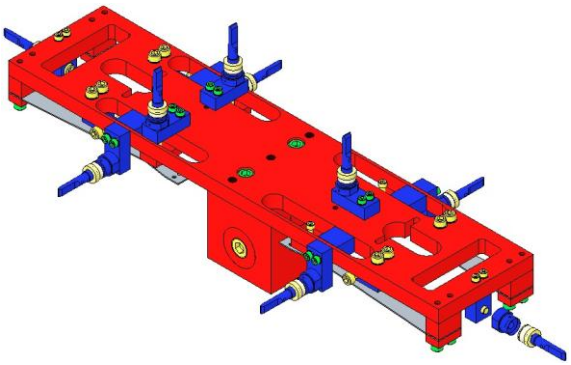


Fig 79: Upper Mass subassembly

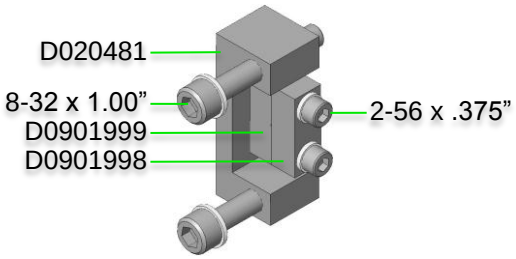


Fig 80: Lower Clamp from Upper Wire Assy

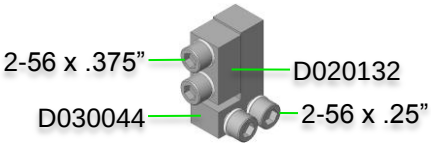


Fig 81: Upper Clamp from Lower Wire Assy

25.6 Procedure – Lower Wires

The Upper Mass continues to be mounted on the Upper Mass Jig, as shown in Section 24.3 Step 2.

29. Assemble the L-Clamps of the 4 D0901905 Lower Wire Assemblies to the tips of the 4 Lower Blades, using:
    - 8 Socket Head Cap Screws 2-56 x 0.25" AgPlated
    - 8 Flat Washers #2, SSTL

    Hand-tighten the Screws.

    Note that the Clamp mounts *above* the Blade and the Screw assembles from *beneath* the Blade.

    Note the orientation of each Clamp is the same relative to each Blade tip.

    If any Wire becomes kinked during assembly, replace with another Wire Assembly.

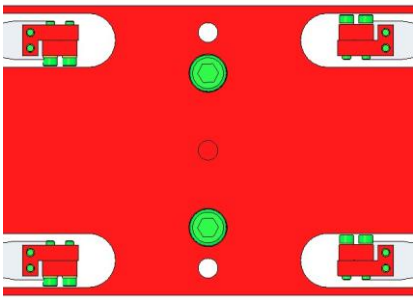


Fig 82: Top View of Clamps

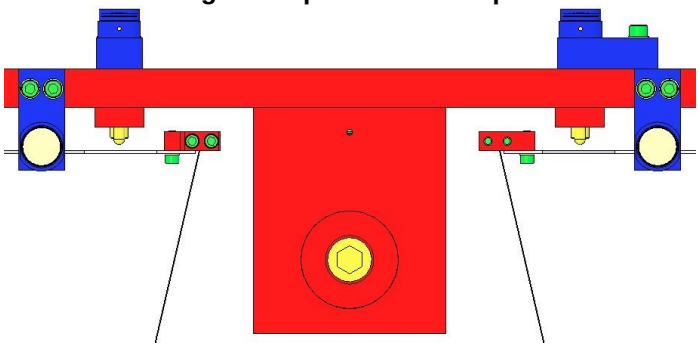


Fig 83: Lower Wire Assemblies added

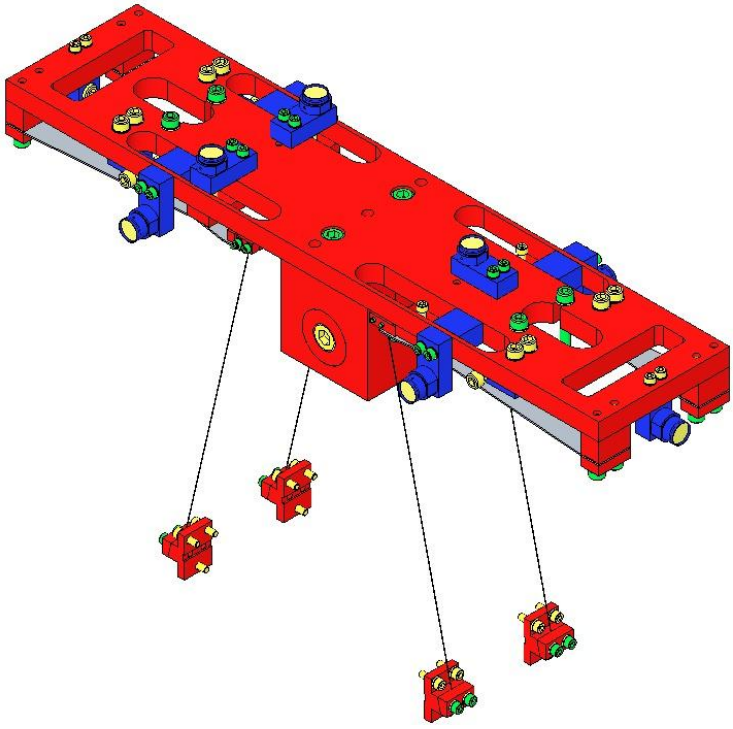


Fig 84: Upper Mass (Magnet Flags removed) with Lower Wires

25.7 Procedure – Coil Holder

The Upper Mass continues to be mounted on the Upper Mass Jig, as shown in Section 24.3 Step 2.

30. Remove the previously hand-tightened Magnet Holder at the +Y side of the Upper Mass, to allow assembly clearance for the Coil Holder.
31. Place the D020239 Coil Holder over the Upper Mass and secure with:
    - 2 Socket Head Cap Screws ¼-20 x 1.125" AgPlated
    - 2 Hex Nuts ¼-20 SSTL

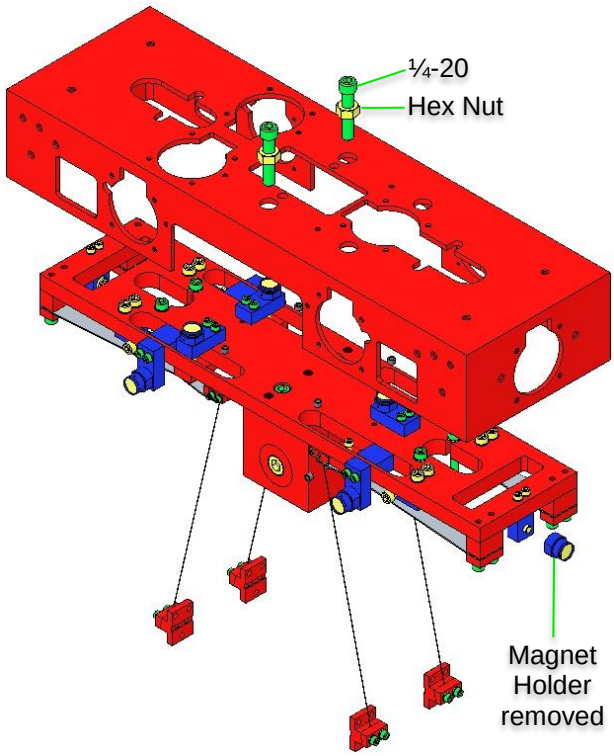


Fig 85: Assembling Upper Mass to Coil Holder

32. Using the 2 ¼-20 Screws, draw the Upper Mass fully upwards into the Coil Holder, to optimize later assembly steps.
33. Re-attach the end Magnet Holder. Torque to 30 in-lb
34. Assemble into the Coil Holder:
    - 12 Socket Head Cap Screws 8-32 x 1.00" Round Tip, AgPlated
    - 12 Hex Nuts 8-32 SSTL
      Diagram will be updated to show Hex Nuts.

Adjust the Screws to protrude 10 mm inside the Coil Holder.

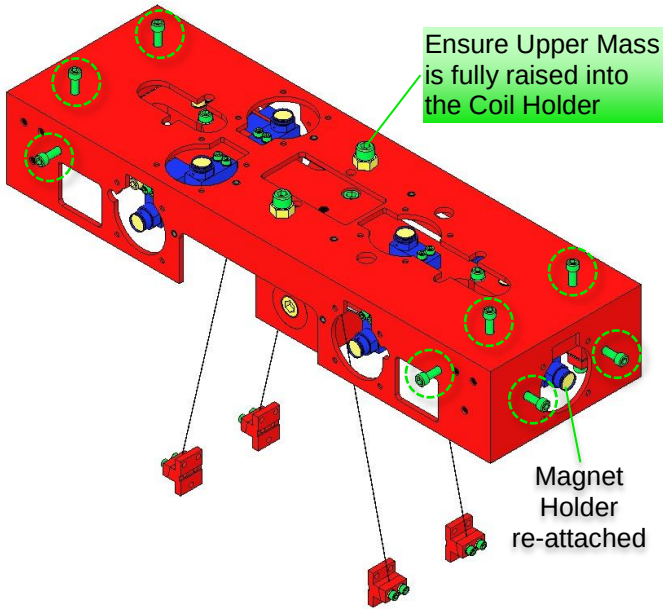


Fig 86: 12 Screws added

26 Installing the Upper Mass and Coil Holder

26.1 Materials

Qty	U	ID	Description
1	Ea	D040259	**Upper Mass Jig**
1	Ea	D020239	**HSTS Coil Holder**
4	Ea	D020346	HSTS Coil Holder Bracket
16	Ea	NA	Socket Head Cap Screw 8-32 x .375” AgPlated
16	Ea	NA	Flat Washer #8 SSTL
12	Ea	D030025	Socket Head Cap Screw, 8-32 x 1.00”, Round Tip, AgPlated
1	Ea	D020534	**HSTS Upper Mass Assembly**
4	Ea	D020482	HSTS Screw Drive System
9	Ea	D0902418	Magnet/Flag Assembly Long
7	Ea	D0902493	Magnet/Flag Assembly Base
2	Ea	D020199	Magnet/Flag Assembly Base Short
4	Ea	D020211	HSTS Magnet Holder Brace
8	Ea	NA	Socket Head Cap Screw 4-40 x 1.25” AgPlated
4	Ea	NA	Socket Head Cap Screw 4-40 x .625” Vented AgPlated
6	Ea	NA	Socket Head Cap Screw 4-40 x .625” AgPlated
18	Ea	NA	Flat Washer #4
4	Ea	NA	Socket Head Cap Screw 4-40 x 0.375” AgPlated SSTL
1	Ea	NA	Allen Head Wrench #4 T-Handle

It is important that the Upper Wires NOT be assembled to the Upper Mass / Coil Holder until it is ready to be installed in the Weldment.

26.2 Procedure – Assembling Upper Mass & Coil Holder to Weldment

Coil Holder brackets are made to match each Weldment.

1. Assemble loosely to one end of the Weldment (LH end of Weldment shown):
   - 2 D020346 Coil Holder Brackets
   - 4 Socket Head Cap Screws 8-32 x .375" AgPlated SSTL
   - 4 Flat Washers #8 SSTL

   Attach Bracket to the Weldment through the horizontal Screw Slots.

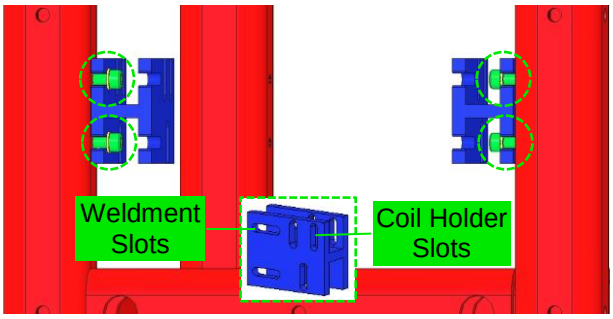


Fig 87: 1st pair of Coil Holder Brackets

2. Assemble loosely to the 2 Brackets:
   - The D020239 Coil Holder
   - 4 Socket Head Cap Screws 8-32 x .375" AgPlated SSTL (2 shown)
   - 4 Flat Washers #8 SSTL

   Although each Coil Holder Bracket has 3 Screw slots for the Coil Holder, only 2 Screw slots are usable due to clearance issues with the Weldment.

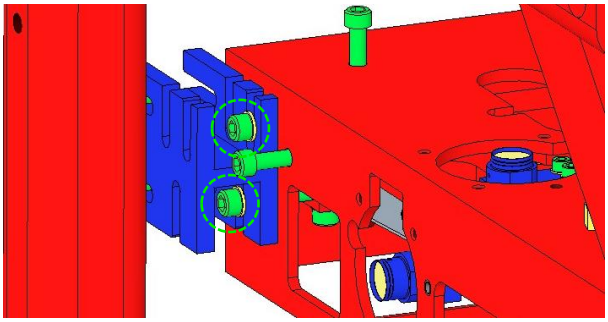


Fig 88: Assemble Coil Holder to 2 Brackets

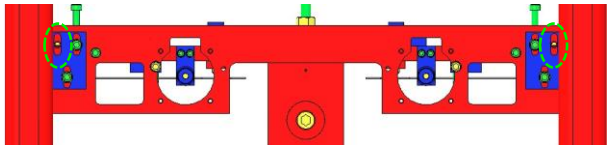


Fig 89: Unusable Screw locations

3. Assemble loosely to the other end of the Weldment:
   - 2 D020346 Coil Holder Brackets
   - 4 Socket Head Cap Screws 8-32 x .375" AgPlated SSTL
   - 4 Flat Washers #8 SSTL
4. Assemble loosely to the 2 Brackets:
   - The D020239 Coil Holder
   - 4 Socket Head Cap Screws 8-32 x .375" AgPlated SSTL
   - 4 Flat Washers #8 SSTL
5. Align Coil Holder to Weldment and with the 4 Coil Holder Brackets:
   - **Horizontally**: Visually centered
   - **Vertically**: Low in the Bracket Slots
6. Torque all 8 Screws that connect the Brackets to the Weldment to 30 in-lb. Leave the 8 Screws that connect the Brackets to the Coil Holder loose.

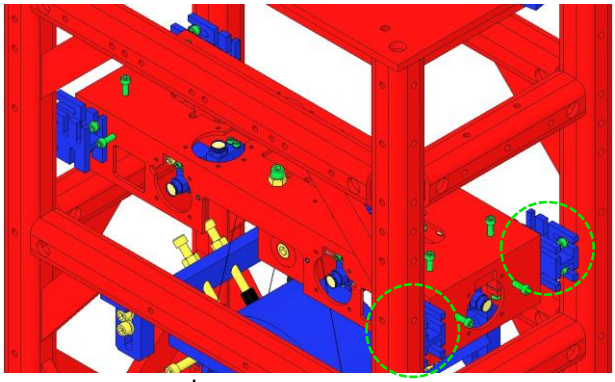


Fig 90: 2nd pair of Coil Holder Brackets

26.3 Procedure – Assembling Intermediate Wires to Intermediate Mass

7. Extend the Intermediate Mass lower Barrel EQ Stop screws (4) as far as possible. These will raise both the Intermediate and Lower Masses.
   While extending these screws, observe the 8 screws within the 4 upper Barrel EQ Stops, and retract those screws if it appears either Mass will come in contact with any of them.

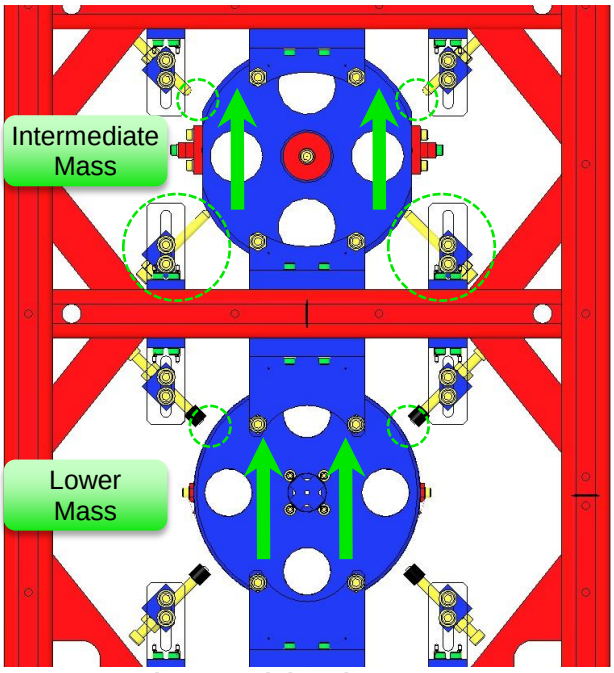


Fig 91: Raising the Masses

8. Ensure the Coil Holder is fully raised within the Coil Holder Brackets. The Screws may be left loose at this point.
9. Using the 2 center ¼-20 Screws, lower the Upper Mass fully, within the Coil Holder (shown transparent here).

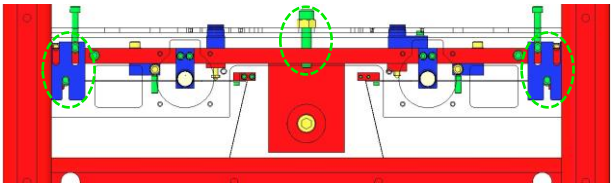


Fig 92: Coil Holder lowered

10. Assemble the 4 Intermediate Clamps of the D0901905 Intermediate Wire Assemblies to the Intermediate Mass with:
    - 12 Socket Head Cap Screws 4-40 x 0.375" SSTL
    - Flat Washer #4 SSTL
      Torque to 5 in-lb

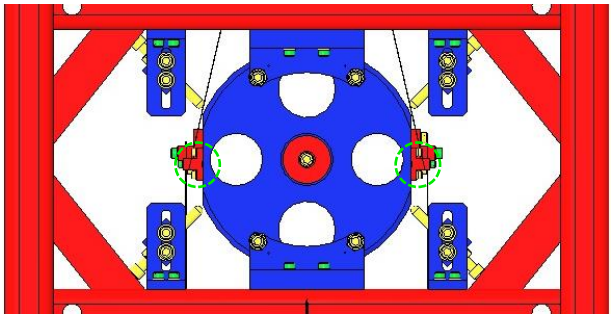


Fig 93: Intermediate Mass and Face EQ Stops

11. Raise the Coil Holder fully within the Coil Holder Brackets and then tighten the Screws.
12. Using the 2 center ¼-20 Screws, raise the Upper Mass fully, within the Coil Holder (shown transparent here).

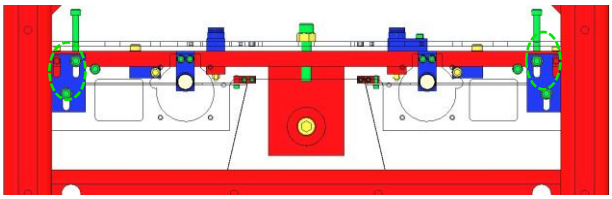


Fig 94: Coil Holder raised

26.4 Procedure – Assembling Upper Wires to Upper Mass

To improve clarity, the diagrams for this procedure do not show the Weldment.

13. Grasp the L-Clamp end of each D0901854 Upper Wire Assembly and feed the Assemblies upwards through the oval openings in the Upper Mass and Coil Holder.

    If any Wire becomes kinked during assembly, replace with another Wire Assembly.

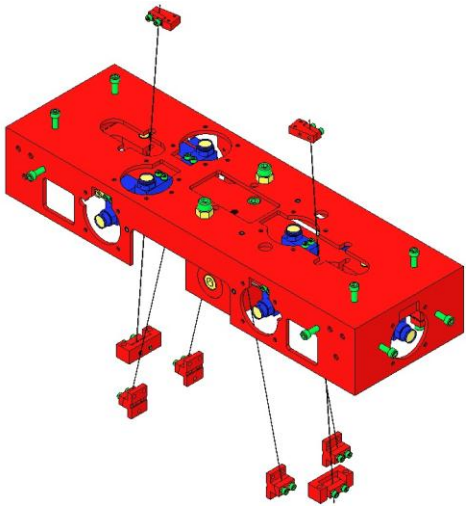


Fig 95: Upper Wires fed through Upper Mass

14. Assemble the C-Clamps of the Upper Wire Assemblies to the Upper Mass, using:
    - 4 Socket Head Cap Screws 8-32 x 1.00" AgPlated SSTL
      Use Screws that have only ½" of shaft threaded; fully-threaded Screws will not fit in the slots.
    - 4 Washers Flat, #8, SSTL
      Torque to 30 in-lb

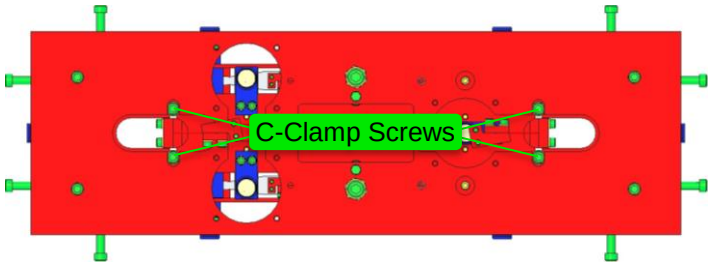


Fig 96: Attaching Upper Wires to Upper Mass

15. Use the 4 Screws from the Screw Drive Systems to center the C-Clamps on the oval openings.

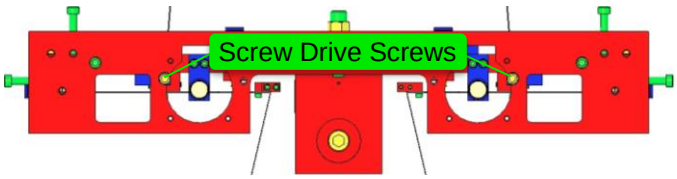


Fig 97: Centering the C-Clamps with the Screw Drives

26.5 Procedure – Assembling Upper Wires to Upper Blades

16. Fasten the 2 L-Clamps of the Upper Wire Assemblies to the Upper Blades using:
    - 4 Socket Head Cap Screws 4-40 x .375" AgPlated SSTL

    When assembling the Screws, use a T-Handle Allen Wrench, approaching the Screws from below. Hand-tighten only; do not use a Torque Wrench.

    The L-Clamps are mounted ON TOP OF each Upper Blade.

    Note the orientation of the L-Clamps, relative to each Blade.

    If any Wire becomes kinked during assembly, replace with another Wire Assembly.

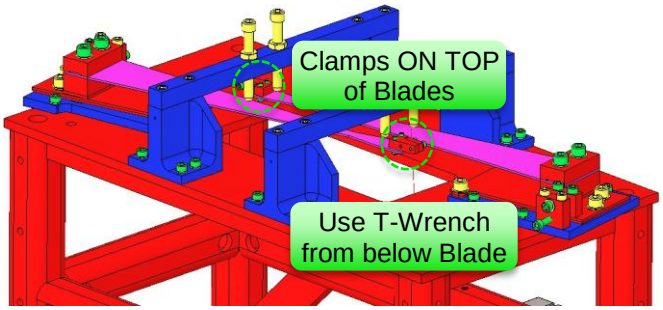


Fig 98: Upper Wire L-Clamps

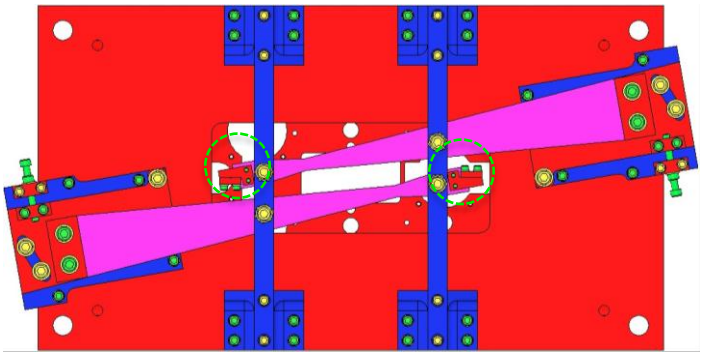


Fig 99: Orientation of Clamps

27 Suspending the Masses

27.1 Procedure

1. Lower the Coil Holder halfway within the Coil Holder Brackets and then tighten the 8 Screws.
2. Using the 2 center ¼-20 Screws, lower the Upper Mass halfway within the Coil Holder (shown transparent here).

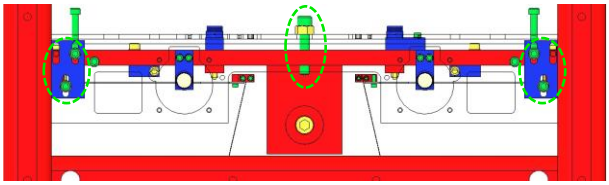


Fig 100: Coil Holder & Upper Mass lowered

3. Retract the 4 screws of the Intermediate Mass lower Barrel EQ Stops until the Intermediate Wires are taught (until the Intermediate and Lower Masses are supported by the Upper Mass, and not the EQ Stops). *The EQ screws should barely contact the Mass.*

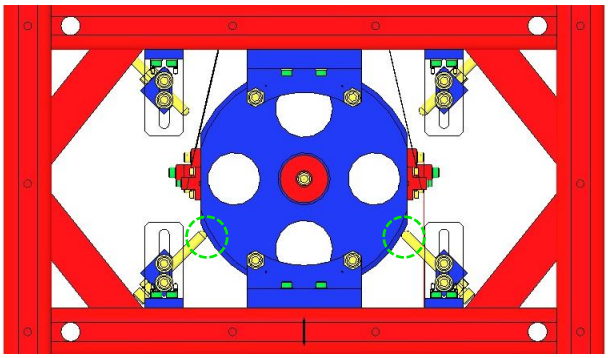


Fig 101: Lower Screws retracted

4. Adjust all 24 EQ Stop Screws so they contact the 2 Masses, but with no pressure.
5. Turn these Screws ¾ turn counterclockwise to leave a 1 mm gap at the 2 Masses:

   Adjust Lower Mass Screws first:
   - 8 Barrel EQ Stop Screws
   - 4 Face EQ Stop Screws

   Adjust Intermediate Mass last:
   - 8 Barrel EQ Stop Screws
   - 4 Face EQ Stop Screws
6. Tighten each Hex Nut at all 24 of the above Screws, to ensure each Screw is locked in the 1 mm gap position.

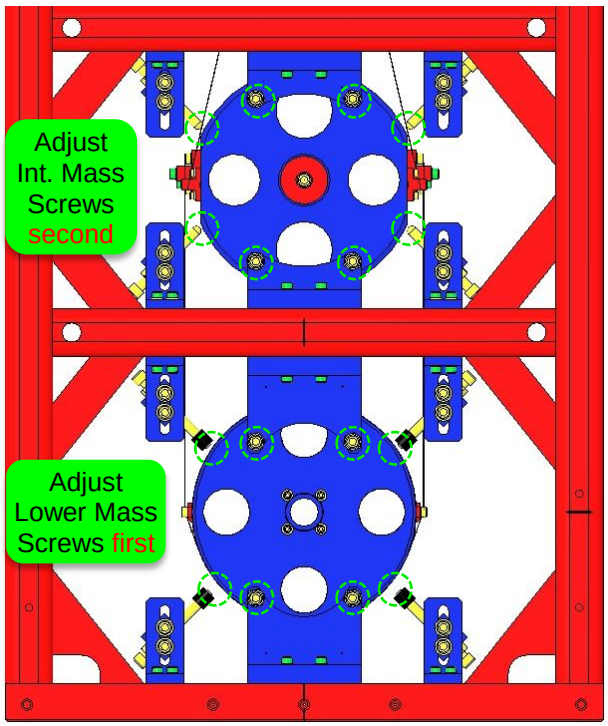


Fig 102: Adjusting Screws to 1 mm gaps

7. Separate the Upper Mass from the Coil Holder by completely removing the 2 ¼-20 Screws and Hex Nuts (the Upper Mass is then supported by the Upper Blades).
8. Adjust the 12 8-32 round-tipped Coil Holder Screws so that they contact the Upper Mass, but with no pressure.
9. Turn the 8-32 Screws counterclockwise 1 ¼ turns, to leave a 1 mm gap with the Upper Mass.

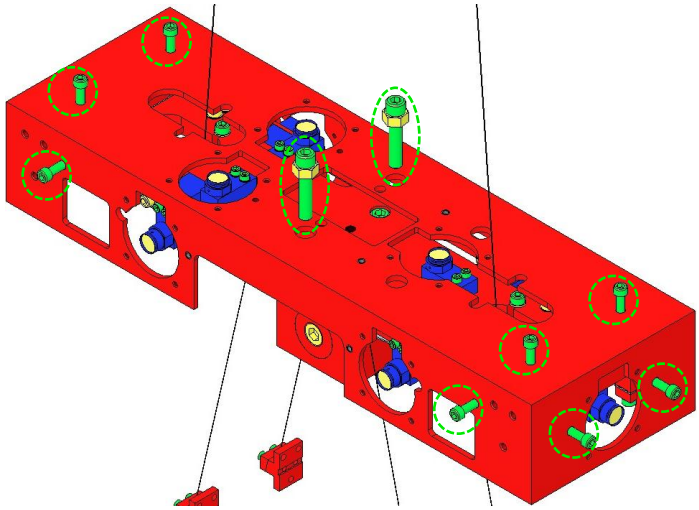


Fig 103: Suspending the Upper Mass

10. Adjust the 4 Lower Blade Guard Screws so they contact the Blades, but with no pressure.

    2 Magnet Holder Assemblies will need to be removed to access 2 of the Screws.
11. Turn the 4 Screws counterclockwise 1 ½ turns each, to leave a 1 mm gap at the Lower Blades.

    Replace the 2 Magnet Holders when finished.

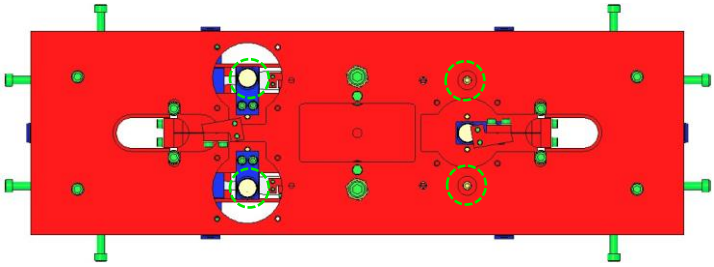


Fig 104: Top View / Adjusting Blade Guard Screws

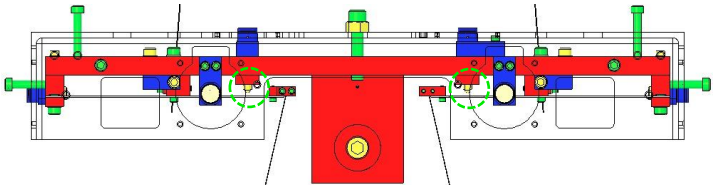


Fig 105: Side View / Adjusting Blade Guard Screws

12. Turn the 4 Upper Blade Guard Screws down until they contact the Upper Blades, but apply no pressure.
13. Turn Screws counterclockwise ¾ turn, to leave a 1 mm gap with the Blades.
14. Tighten each Hex Nut to ensure each Screw is locked in the new position.

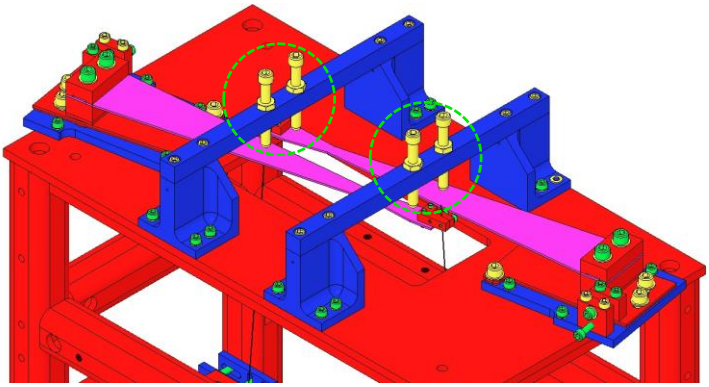


Fig 106: Suspending the Upper Blades

28 Creep Bake

All Blades (2 Upper, 4 Lower) are exposed to 120°C @ 168 hr., accelerating the microscopic yielding of the Blade material, to reduce mechanical noise of the Suspension when in operation.

28.1 Documents

T1100289 Notes on Creep/Creak Bakes for Blades

E0900023 Process for Manufacturing Cantilever Spring Blades

28.2 Materials

Qty	U	ID	Description
1	Ea	D1002440	**Upper Blade Baking Fixture**
2	Ea	D020660	**Blade Pulldown Device**
2	Ea	D0901815	Upper Clamp Inside
2	Ea	D0901813	Upper Clamp Outside
4	Ea	NA	2 Socket Head Cap Screw 4-40 x 0.375" AgPlated
4	Ea	NA	Flat Washer #4 Vented SSTL
4	Ea	NA	Socket Head Cap Screw 4-40 x 0.25" AgPlated
1	Kg	NA	4.483 kg in weight
2	Ft	NA	Music Wire .024" dia. min.

28.3 Procedure

Wear Safety Glasses and Glove Liners per E1000043.

1. Prepare 2 D020660 Blade Pulldown Devices per Materials List.

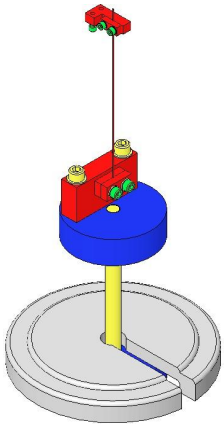


Fig 107: Blade Pulldown Device

2. Lock down the 2 Upper Blades by extending the 4 EQ Stop Screws until they just contact the Blades.
3. Disconnect the 2 Upper Clamps from the Upper Blade tips. Handle the Wire Assemblies carefully to ensure they are not kinked.

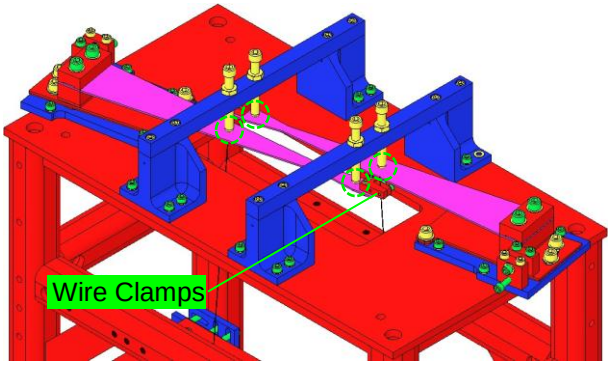


Fig 108: EQ Stop Screws contact Blades

4. Ensure the 2 D1102119 Blade Pulldown Supports are Class B clean.
5. Attach the Blade Pulldown Supports to the center of the Weldment cross member shown, Clevis extending outboard.
6. Cover each end of the Weldment Structure and surrounding Optical Table areas with UHV Aluminum Foil, to protect them from the dirty Pulldown Device.

2 workers required:

7. 1st person holds the Pulldown Weight.
8. 2nd person passes Wire Clamp of the Pulldown Device through the Weldment side opening, up toward the Upper Blade Tip, then attaches the Clamp to the Blade tip with:
   - 2 Socket Head Cap Screws 4-40 x .375" AgPlated SSTL
9. 1st person gently drapes the wire over the Clevis, and slowly releases the Weight.
10. Repeat Steps 7-9 for the second Pulldown Device.

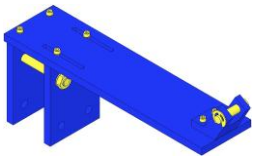


Fig 109: Blade Pulldown Support

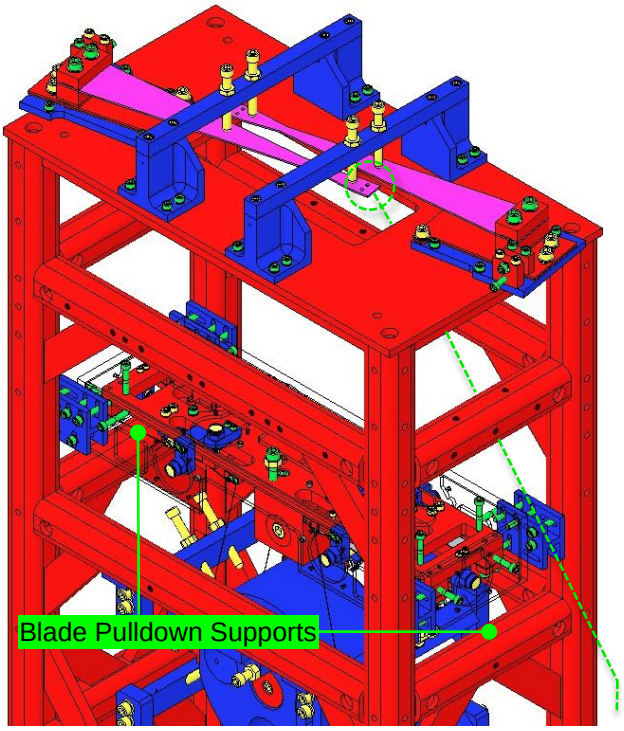


Fig 110: Location of Blade Pulldown Support

11. Remove the 2 D0901935 Blade Guard Bars.
12. Slowly lift the Pulldown Devices and then disconnect the Wire Clamps from the Blade tips. The Blades will be left curving upward.
13. Remove the Rotational Adjusters from the Weldment, down to the Rotating Plate (leaving the Base Plate attached to the Weldment).

    Record the serial number and location of both Upper Blades in ICS in the RA assembly load.

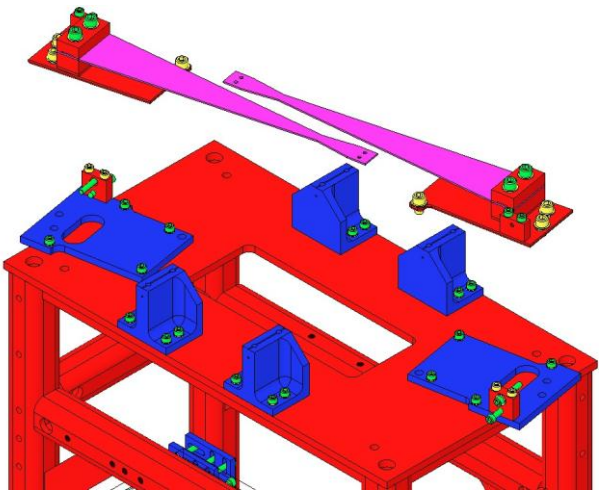


Fig 111: Rotational Adjusters removed

14. Ensure the D1002440 Baking Fixture is Class B clean.
15. Mount the Baking Fixture to an Optics Table, aligning the Crossbar side with the Table edge to allow clearance for the Blade Pulldown Device.
16. Remove a D1002443 Crossbar from the Baking Fixture.

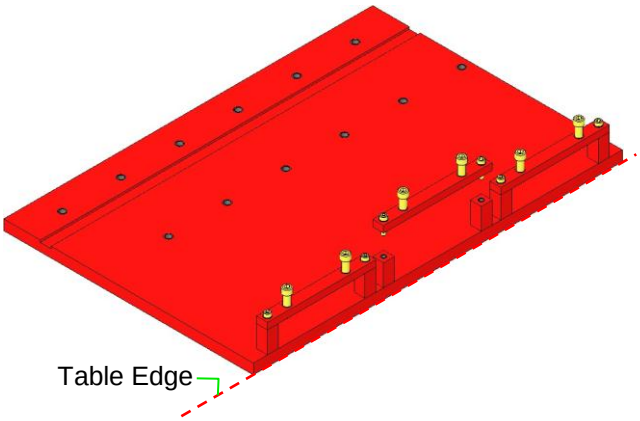


Fig 112: Base Plates in Baking Fixture

17. Assemble to the Baking Fixture the 2 Rotational Adjuster assemblies using the same Screws from the Suspension:
    - 4 Socket Head Cap Screws ¼-20 x 0.375" SSTL
    - 4 D1100785-472 Flat Washers

    Tighten the Screws firmly

    The Blades are shown here as flat, but are actually curved upward at this point.

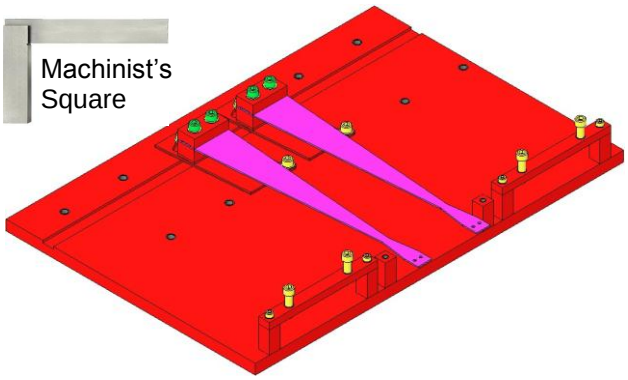


Fig 113: Shim, Clamps, Blade, Screws, Washers

18. Attach a Pulldown Device to each Upper Blade Tip to flatten the Blades.
19. Re-assemble the Crossbar to the Bake Fixture:
    - 1 D1002443 Bake Fixture Crossbar
    - 2 Socket Head Cap Screws 8-32 x 0.625" SSTL
    - 2 Flat Washers #8 SSTL

      Tighten the Screws firmly
    - 2 Socket Head Cap Screws ¼-20 x 1.0 Full-Thread, Round-Tip SSTL
20. Turn down the Round-Tip Screws until the weighted Blade tip is level with the Blade root.
    Be careful not to damage the nickel plating on the blade
21. Remove the Blade Pulldown Devices.

    The Rotational Adjusters and Baking Fixture are now ready for the Creep Bake.

22. Fully retract the 8 Screws in the 4 Upper Barrel EQ Stops.

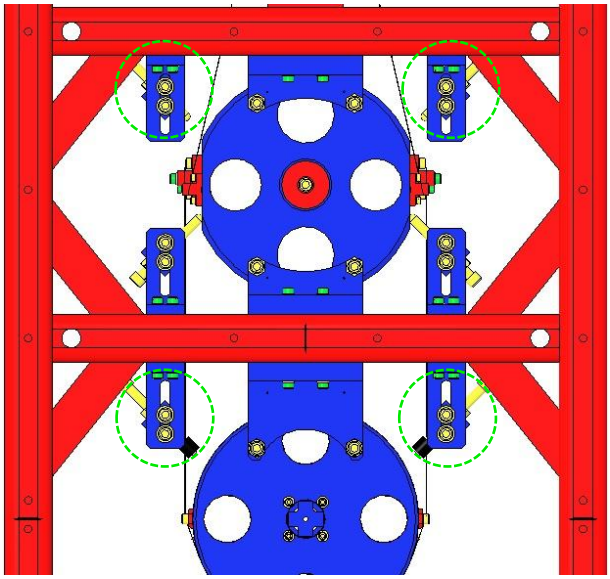


Fig 114: 8 Screws in Upper Barrel EQ Stops

23. Fully raise the Coil Holder within it's 4 corner Brackets (The Screws will be at the top of their Bracket slots).

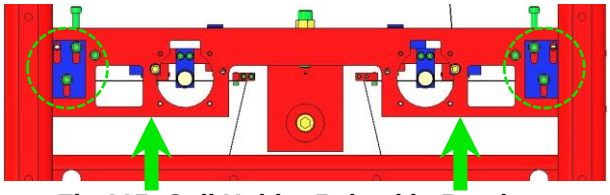


Fig 115: Coil Holder Raised in Brackets

24. Using the two ¼-20 Screws, fully raise the Upper Mass within the Coil Holder.
    The Upper Wires will go slack at this point.

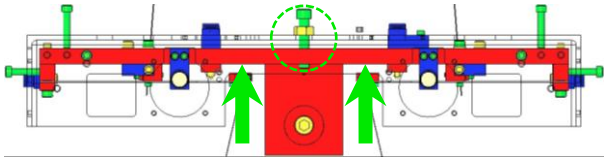


Fig 116: Upper Mass raised within Coil Holder

25. Fully retract the 4 Adjustment Screws within the 4 Screw Drives.

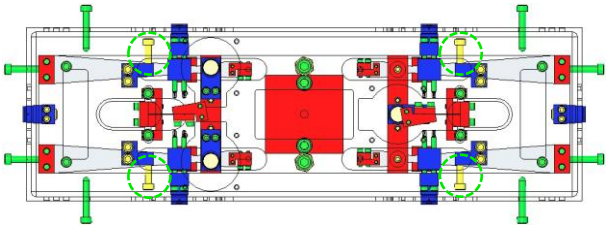


Fig 117: Top View – 4 Screws Retracted

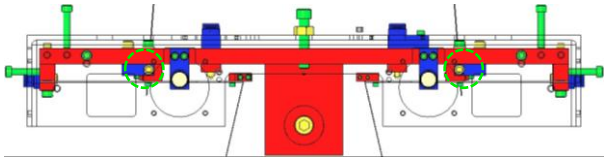


Fig 118: Side View – 4 Screws retracted

26. Disconnect the Upper Wire Assemblies:
    - Remove the 4 C-Clamp Screws at the Upper Mass

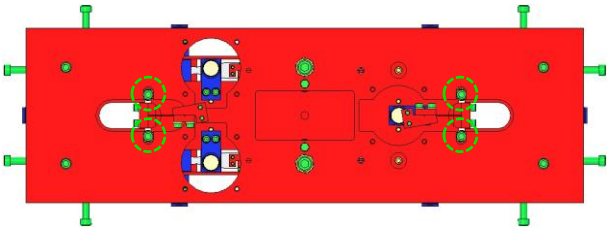


Fig 119: Top View – 4 C-Clamp Screws

27. Remove the Upper Wire Assemblies completely by grasping the L-Clamps and lowering the Assemblies down through the openings in the Coil Holder and Upper Mass.

    Record in ICS, which Wire Assembly correlates to which Upper Blade.

    Handle the Wire Assemblies with great care and store them in a protected container until the Creep Bake process is complete.

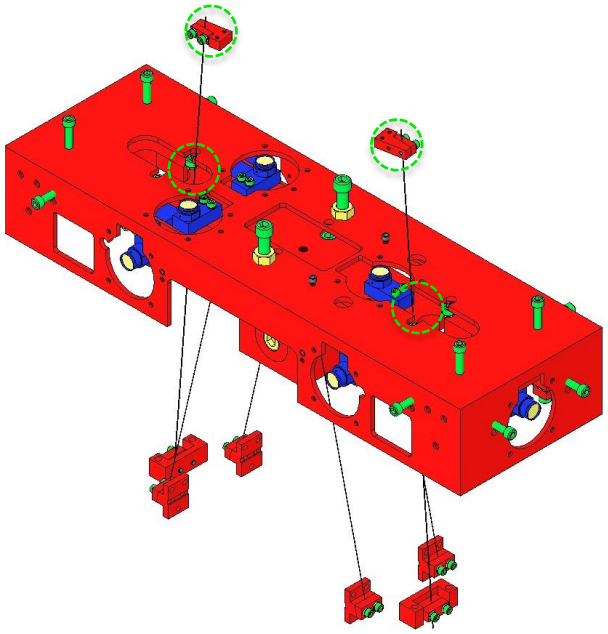


Fig 120: Upper Wires fed downward

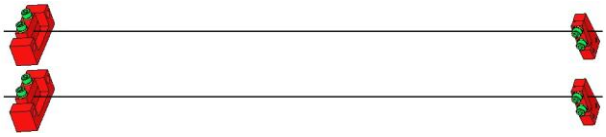


Fig 121: 2 Upper Wire Assemblies removed

28. Fully extend the 8 Screws within the lower 4 Barrel EQ Stops.

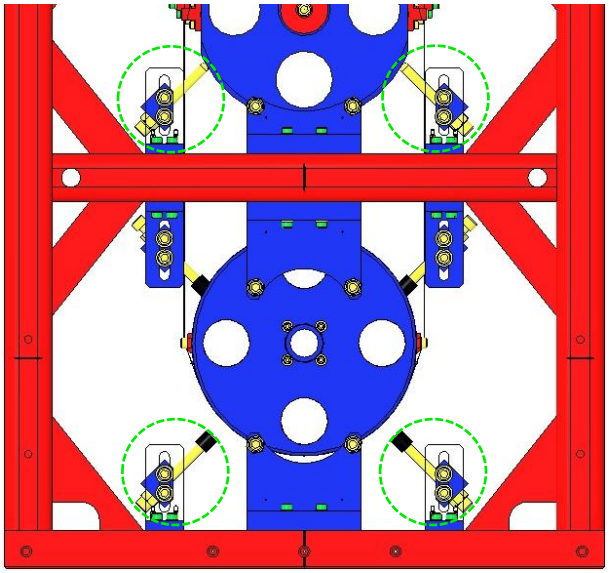


Fig 122: 8 Screws extended

29. Remove the 4 Screws that attach the pair of Magnet Holders on top of the Upper Mass.
30. Remove the 2 Magnet Holders.

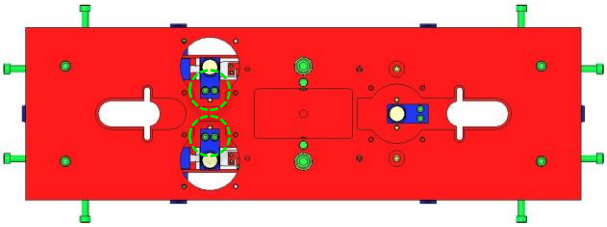


Fig 123: 4 Screws to remove

31. Extend the 4 Blade Guard Screws until they just touch the Lower Blades.

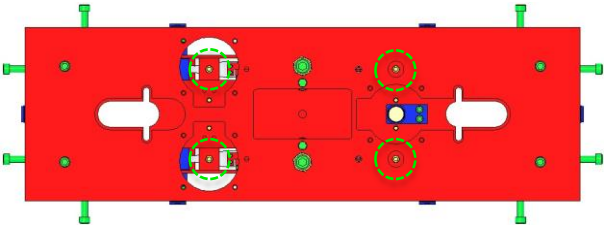


Fig 124: Top View - 4 Blade Guard Screws

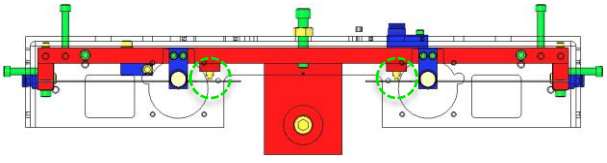


Fig 125: Side View – 4 Screws extended

32. Using the 2 ¼-20 Screws, lower the Upper Mass within the Coil Holder.

The Intermediate Wires will go slack at this point.

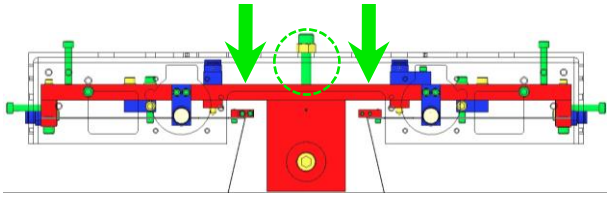


Fig 126: Upper Mass lowered within Coil Holder

33. Disconnect the Intermediate Wires from the Intermediate Mass by removing the 12 Screws from the 4 Lower Clamps of the Intermediate Wire Assemblies.

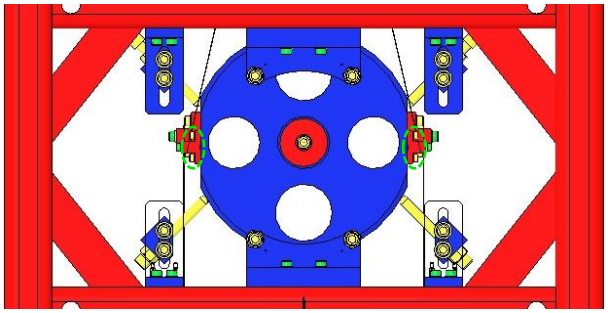


Fig 127: Lower Clamps of Intermediate Wires

34. Remove the Upper Face EQ Stop from in front of the Intermediate Mass.

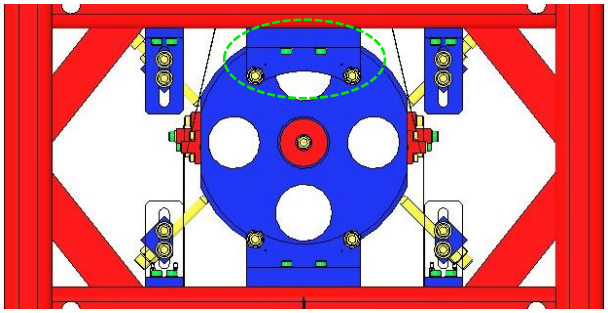


Fig 128: Upper Face EQ Stop

35. Remove the 8 Screws attaching the L-Clamps of the Intermediate Wire Assemblies to the 4 Lower Blades.
36. Remove the 4 Intermediate Wire Assemblies.
    Record in ICS, which Wire Assembly correlates to which Lower Blade.

    Handle the Wire Assemblies with great care and store them in a protected container until the Creep Bake process is complete.

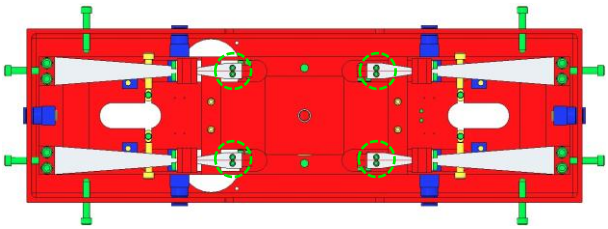


Fig 129: Bottom View – L-Clamp Screws

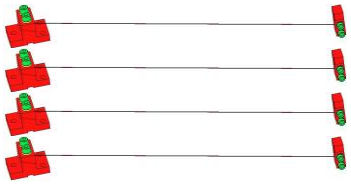


Fig 130: Intermediate Wire Assemblies

37. Remove the 8 Screws from the 4 Coil Holder Brackets.
38. Remove the Coil Holder / Upper Mass Assembly from either short side opening in the Weldment.

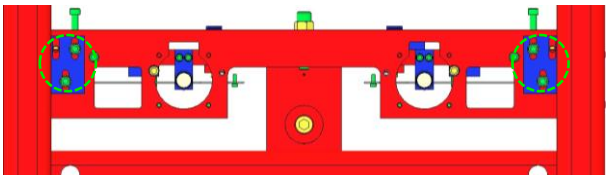


Fig 131: Coil Holder Screws

39. From one of the two Magnet Holders assembled to the ends of the Upper Mass, remove 1 Magnet Holder from it's Base. This will provide clearance for separation of the Upper Mass from the Coil Holder.
40. Remove the 2 ¼-20 Screws from the Coil Holder.
41. Separate the Upper Mass Assembly from the Coil Holder.
42. Re-attach the Magnet Holder to its Base.

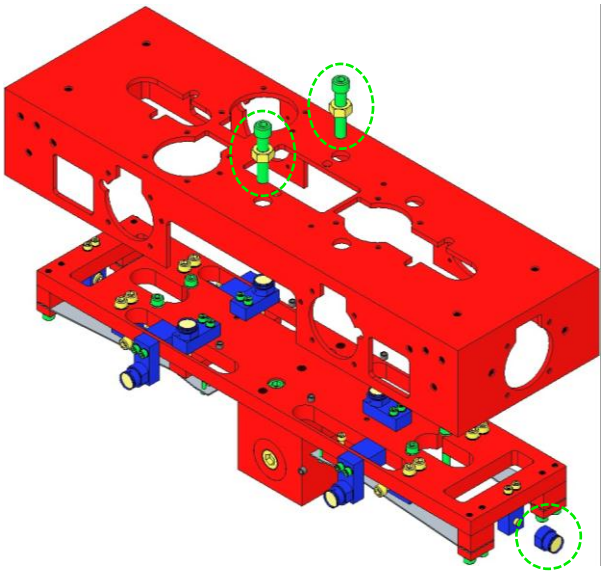


Fig 132: Upper Mass and Coil Holder seperated

43. Remove all 9 Magnet Holder / Base Assemblies from the Upper Mass. This includes the 4 Braces for the Magnet Assemblies attached to the sides of the Upper Mass.
44. Remove all 4 Screw Drives from the Upper Mass.
45. Remove the T-Section from the Upper Mass Main Section.

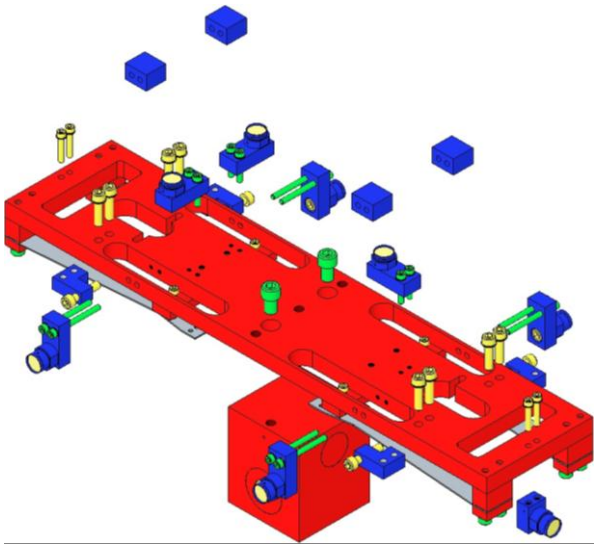


Fig 133: Disassembled Upper Mass

The remaining Assembly, ready for Creep Bake, consists only of:

- *1 Main Section;*
- *4 clamped Lower Blades;*
- *2 Blade Guards with 4 Screws each.*

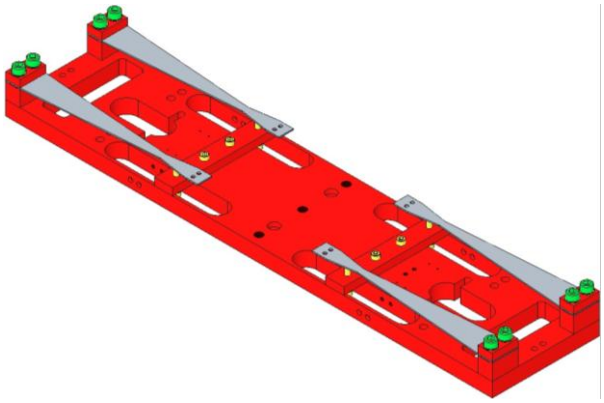


Fig 134: Assembly Ready for Creep Bake

46. Follow the process outlined in E0900023 for baking all 6 Blades for 120°C @ 168 hr.
    - 2 Upper Blades (2 Rotational Adjusters);
    - 4 Lower Blades (clamped in 1 Main Section);
47. Re-assemble and install in the Weldment:
    - The Upper Blades in their Rotational Adjusters, per the section, “Installing the Rotational Adjusters”;
    - The Upper Mass per the sections, “Assembling the Upper Mass” and “Installing the Upper Mass and Coil Holder”.

29 Bonding Magnet Assemblies to Intermediate Mass

29.1 Documents

M0900034 Use of Magnets in Suspensions
E990196 HSTS HLTS Magnet/Standoff Assembly Preparation
E960022 Vacuum Compatibility, Cleaning Methods and Qualification Procedures

29.2 Materials

Qty	U	ID	Description
1	Ea	D1100356	**Triple Optic Base Assembly**
4	Ea	D980184	LOS Clamps
4	Ea	NA	Socket Head Cap Screw ¼-20 x 1.5” AgPlated
1	Ea	D0901873	**HSTS Intermediate Mass Assembly**
2	Ea	D020661	North magnet/dumbbell assembly, Intermediate Mass
2	Ea	D020661	South magnet/dumbbell assembly, Intermediate Mass
1	Ea	D1002606	**Intermediate Mass Ring Fixture Assembly**
1	Ea	TBD	Gun Applicator, MasterBond
1	Ea	EP30-2	Epoxy, Double Barrel Cartridge with Mix Tube, MasterBond
1	Ea	NA	Machinist Square, approx. 6” in length
1	Ea	NA	Depth Gage; either Vernier Calipers or Spring-Type Needle Gage
1	Ea	NA	Tweezers
1	Btl	NA	Isopropanol
X	Ea	NA	Lint Free Wipes
X	Ea	TBD	Sewing Needle
X	Ea	TBD	Razor Blade
X	Roll	NA	UHV Aluminum Foil
1	Ea	NA	Heat Lamp, 120w Bulb

29.3 Procedure

1. Mount the D1100356 Base Assembly to an Optics Table with the 4 D980184 LOS Clamps and ¼-20 x 1.5" AgPlated Screws.
2. Place the D0901873 Intermediate Mass Assembly on the Base Plate.
3. Place the D1002606 Intermediate Mass Ring Fixture Assembly on top of the Intermediate Mass.

   For clarity, the Base Plate is not shown after this point.

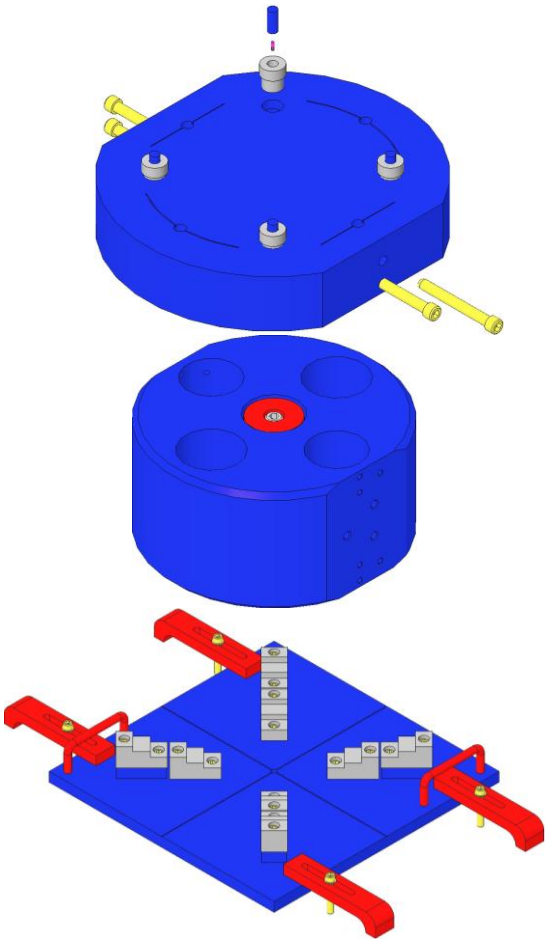


Fig 135: Ring Fixture, Mass, Base Plate

Align the Ring Fixture and Mass

4. Center the Ring Fixture on the Mass by obtaining equidistant readings between opposing parallel sides of the Fixture and Mass, using a Depth Gage. The Ring Fixture Screw tips must barely contact and not "clamp" the Mass.

   Note the locations of the 4 Magnet Plungers.

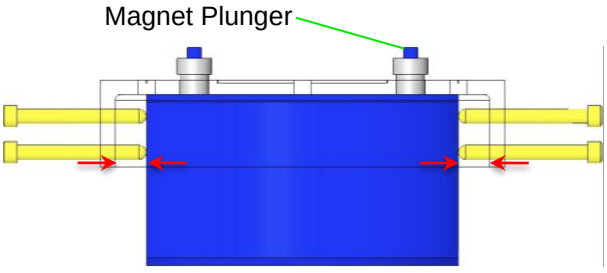


Fig 136: Ring Fixture Aligned with Mass

5. Prepare 2 "N" and 2 "S" D020661 Magnet/Standoff assemblies per the E990196 Preparation procedure.

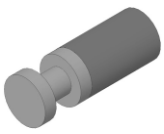


Fig 137: D020661 Magnet/Standoff Assembly

Load Plungers

6. Remove the 4 Magnet Plungers from the Fixture and wipe the counterbore end of each plunger with Isopropanol and a Wipe.
7. Using the Tweezers, load 4 Magnet/Standoff assemblies into the 4 Plungers, 2 North Magnets and 2 South Magnets. The Magnet end of each assembly rests within the Plunger counterbore.

   The Magnet/Standoffs are held to the Plungers magnetically.

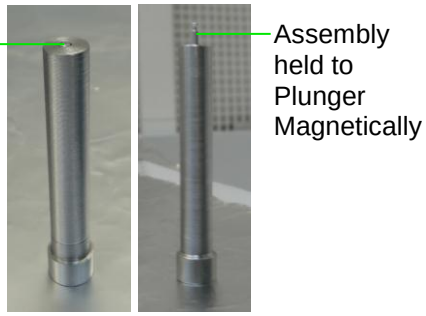


Fig 138: Plungers Empty and Loaded

8. Determine the correct Magnet Polarity Layout by identifying the in-use top of the Mass. The Wire Assembly Clamp Hole patterns on the sides of the Mass identify the top of the Mass.

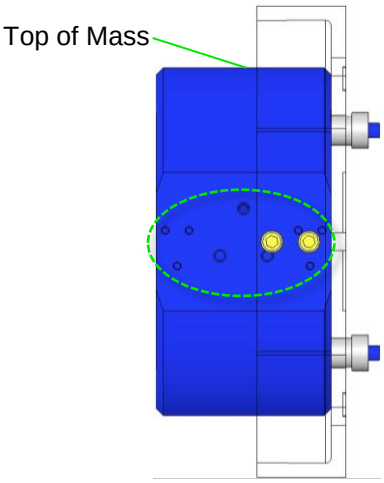


Fig 139: Top of Mass identified by Hole Pattern

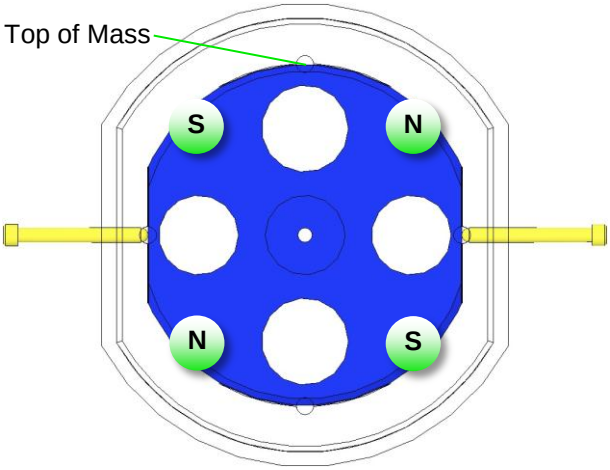


Fig 140: Magnet Polarity Layout

Bond Magnets to Mass/Optic

9. Load the EP30-2 Cartridge with Mix Tube attached, into the Gun Applicator.
10. Pull the trigger on the Gun Applicator 1 full stroke, to purge the Mix Tube of under-mixed adhesive.
11. Dispense a “quarter-sized” pool of Adhesive onto a small piece of clean UHV aluminum foil.
12. Pick up a Plunger loaded with a Magnet/Standoff assembly and hold it vertically, with the Magnet/Standoff end facing up. Clean the Standoff with Isopropanol and a Wipe.
13. Dip the end of a Sewing Needle in the pool of Epoxy and withdraw it, leaving a tiny drop on the Needle tip. Apply approximately ½ mm of Epoxy to the center of the Standoff end.
14. Load the Plunger, Magnet/Standoff down, into the appropriate Bushing in the Ring Fixture. Slide the Plunger down within the Bushing until the Standoff contacts the Mass/Optic. Press down on the Plunger lightly with one finger for about 2 seconds, then release.
15. Repeat steps 13-15 to load all 4 Plungers into the Placement Fixture.
16. Allow the Epoxy to cure within the Fixture at room temperature for 24 hours.
17. Carefully remove the 4 Plungers from their Bushings, and remove the Fixture from the Mass/Optic.
18. Center the Heat Lamp over the Fixture and adjust the height such that the Fixture surface is receiving 60°C, then allow the adhesive to cure for 4hr. The assembly process is complete.

30 Bonding Magnet Assemblies to Lower Masses

30.1 Documents

M0900034	Use of Magnets in Suspensions
E990196	HSTS HLTS Magnet/Standoff Assembly Preparation
D020234	HSTS Metal Lower Mass, 0.5 Degree Wedge
D0902332	HSTS Metal Lower Mass, 1.0 Degree Wedge
E0900342	HSTS Optic Orientations
E960022	Vacuum Compatibility, Cleaning Methods and Qualification Procedures

30.2 Materials

Qty	U	ID	Description
1	Ea	D1100356	**Triple Optic Base Assembly**
4	Ea	D980184	LOS Clamps
4	Ea	NA	Socket Head Cap Screw ¼-20 x 1.5" AgPlated
1	Ea	D020427	**HSTS Magnet Gluing Ring Fixture, Lower Mass**
1	Ea	D0901791	HSTS Lower Mass Assembly
1	Ea	Various	Optic, HSTS
4	Ea	D0902432	Magnet/Standoff Assemblies, 2 N and 2 S configurations
1	Ea	NA	Machinist Square, approx. 6" in length
1	Ea	NA	Depth Gage; either Vernier Calipers or Spring-Type Needle Gage
1	Ea	EP30-2	Epoxy, Double Barrel Cartridge with Mix Tube, MasterBond
1	Ea	TBD	Gun Applicator, MasterBond
1	Ea	NA	Generic Compass mounted on non-magnetic isolation post
1	Ea	NA	Tweezers
1	Btl	NA	Isopropanol
X	Ea	NA	Lint Free Wipes
X	Ea	TBD	Sewing Needle
X	Ea	TBD	Razor Blade
X	Ea	NA	UHV Aluminum Foil
1	Ea	NA	Heat Lamp, 120w Bulb

30.3 Procedure

Notes:

- The D020427 Fixture is being modified as of 3/12. Major modifications include:
  - The Fixture as shown will be inverted, and a Base for the Mass/Optic has been added.
  - The Stop Screw design will change.
  - The Magnet placement bushings will change.
- Glass Optics and Metal Masses will not be Air Baked.
- Glue Magnets before gluing Prisms (primary and secondary).
- Ensure the Main Section of the Mass has been cleaned and baked before attaching the Magnet/Dumbbell assemblies.
- Thoroughly Class B clean all parts of the Magnet Gluing Ring Fixture.
- Magnet/Standoff Assemblies are produced per E990196 HSTS HLTS Magnet/Standoff Assembly Preparation.

1. Prepare 2 “N” and 2 “S” D0902432 Magnet/Standoff assemblies per E990196 Preparation procedure.

Fig 141: D0902432 Assembly

2. Mount the D1100356 Base Assembly to an Optics Table with the 4 D980184 LOS Clamps and ¼-20 x 1.5” AgPlated Screws.
3. Place the Mass/Optic Assembly on the Base Plate with arrows pointing down.
4. Place theD020427 Magnet Gluing Fixture Assembly on top of the Mass/Optic.

   Note the Scribe Lines on both the Fixture and the Mass / Optic.

   For clarity, the Base Plate is not shown after this point.

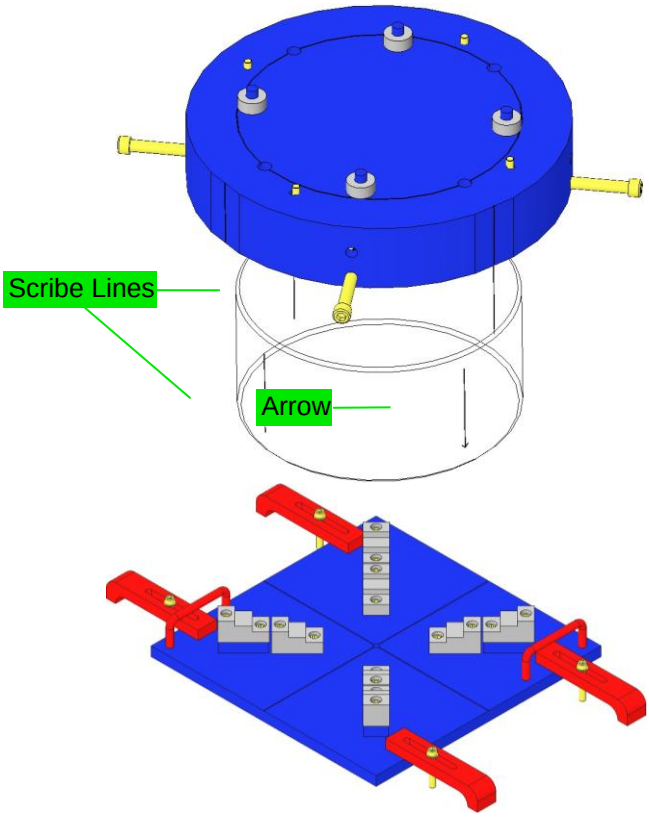


Fig 142: Magnet Gluing Ring Fixture

5. Center the Mass / Optic within the Fixture by using the 4 Stop Screws. Use a Depth Gage to obtain equidistant readings at opposing pairs of Mass / Optic Scribe Lines, between the Fixture and Mass / Optic perimeters. The Screw tips must barely contact and not "clamp" the Mass/Optic.

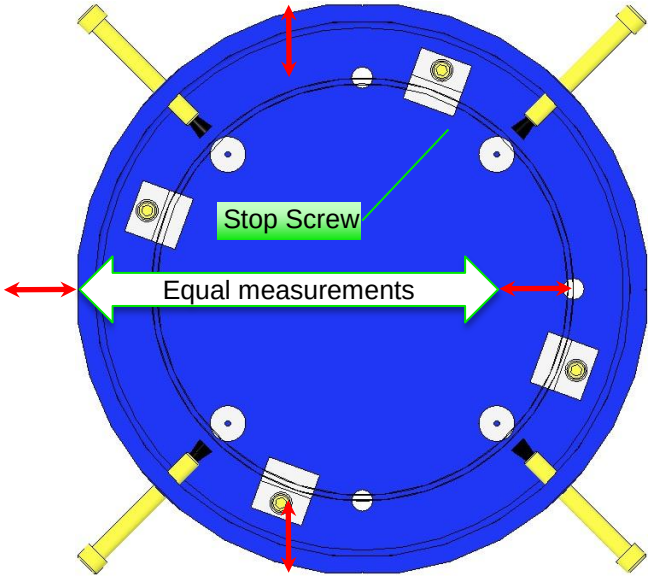


Fig 143: Top View of Centering

6. For a Metal Mass, rotate the Gluing Fixture while aligning the Mass and Fixture Scribe Lines with a Machinist's Square. Align at 2 Line positions 90° apart.

   For an Optic, sight across (through) the glass through 2 opposing Scribe Lines, then rotate the Gluing Fixture to align the Optic and Fixture scribe lines with a Machinist's Square.

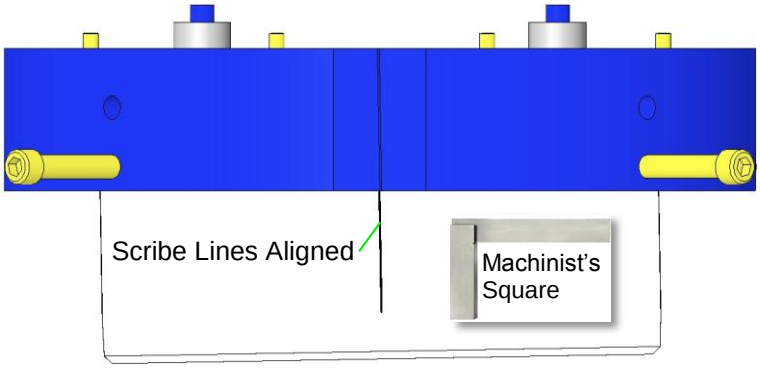


Fig 144: Centering the Mass / Optic in the Fixture

Load Plungers

7. Remove the 4 Magnet Plungers from the Fixture and wipe the counterbore end of each plunger with Isopropanol and a Wipe.
8. Using the Tweezers, load 4 Magnet/Standoff assemblies into the 4 Plungers, 2 North Magnets and 2 South Magnets. The Magnet end of each assembly rests within the Plunger counterbore.

   The Magnet/Standoffs are held to the Plungers magnetically.

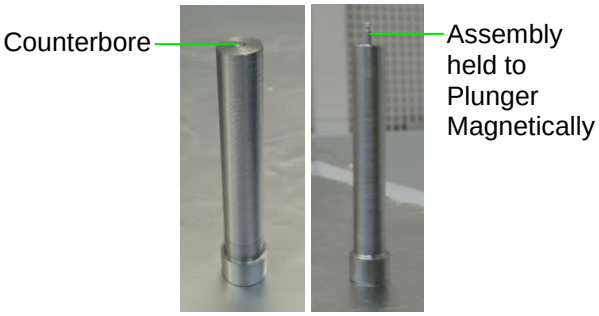


Fig 145: Plungers Empty and Loaded

9. Determine the correct Magnet Polarity Layout by identifying the in-use top of the Mass/Optic. The prisms on the sides of the Mass and the arrow on the Optic and the identify the top of the Mass.

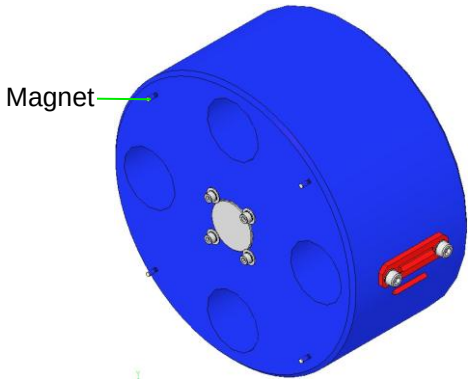


Fig 146: HSTS Lower Mass Assembly

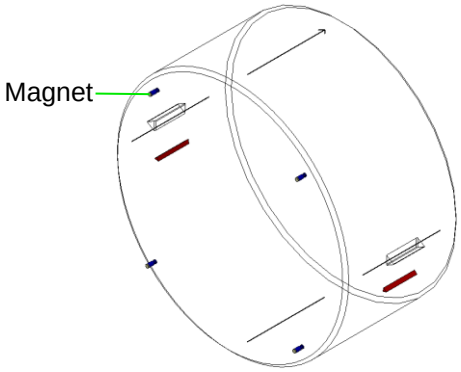


Fig 147: HSTS Optic Assembly

Bond Magnets to Mass/Optic

10. Load the EP30-2 Cartridge with Mix Tube attached, into the Gun Applicator.
11. Pull the trigger on the Gun Applicator 1 full stroke, to purge the Mix Tube of under-mixed adhesive.
12. Dispense a “quarter-sized” pool of Adhesive onto a small piece of clean UHV aluminum foil.
13. Pick up a Plunger loaded with a Magnet/Standoff assembly and hold it vertically, with the Magnet/Standoff end facing up. Clean the Standoff with Isopropanol and a Wipe.
14. Dip the end of a Sewing Needle in the pool of Epoxy and withdraw it, leaving a tiny drop on the Needle tip. Apply approximately ½ mm of Epoxy to the center of the Standoff end.
15. Load the Plunger, Magnet/Standoff down, into the appropriate Bushing in the Ring Fixture. Slide the Plunger down within the Bushing until the Standoff contacts the Mass/Optic. Press down on the Plunger lightly with one finger for about 2 seconds, then release.
16. Repeat steps 11-13 to load all 4 Plungers into the Placement Fixture.
17. Allow the Epoxy to cure within the Fixture at room temperature for 24 hours.
18. Carefully remove the 4 Plungers from their Bushings, and remove the Fixture from the Mass/Optic.
19. Center the Heat Lamp over the Fixture and adjust the height such that the Fixture surface is receiving 60°C, then allow the adhesive to cure for 4hr. The assembly process is complete.

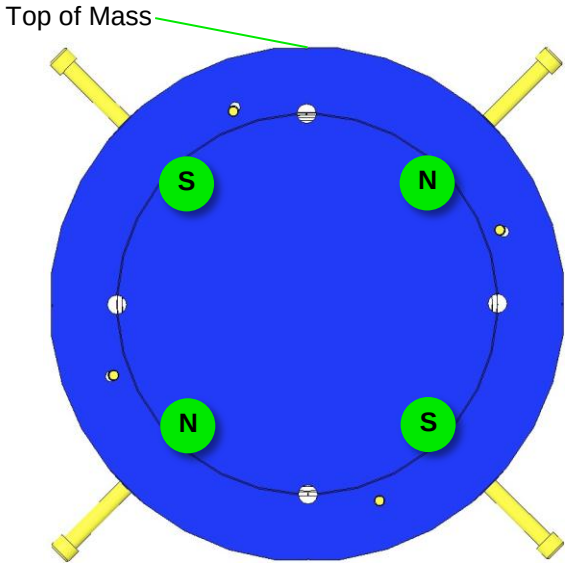


Fig 148: Magnet Polarity Layout

31 Installing AOSEM Brackets

31.1 Materials

Qty	U	ID	Description
4	Ea	D0901924	A OSEM Alignment Assemblies
2	Ea	D0902207	A OSEM Alignment Assemblies
2	Ea	D0902208	A OSEM Alignment Assemblies
16	Ea	NA	Socket Head Cap Screws 8-32 x 0.5 AgPlated
16	Ea	NA	Flat Washer #8 SSTL

31.2 Procedure

A OSEMS are assembled in LH and RH configurations per section 16. Note the configuration at each location within the Weldment.

The A OSEM Assemblies are attached using:

- 16 Socket Head Cap Screws 8-32 x 0.5" AgPlated
- 16 Flat Washers #8 SSTL Torque to 30 in-lb

1. Assemble 4 **D0901924** A OSEM Alignment Assemblies into the Intermediate Mass section of the Weldment.
2. Assemble 2 **D0902207** A OSEM Alignment Assemblies into the upper half of the Lower Mass section of the Weldment.

   Assemble 2 **D0902208** A OSEM Alignment Assemblies into the lower half of the Lower Mass section of the Weldment.

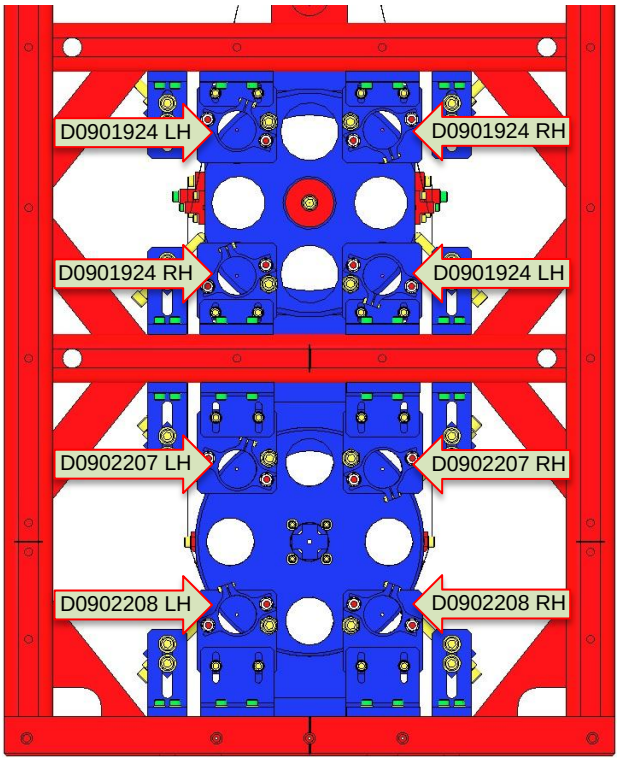


Fig 149: Rear view of Weldment

32 Installing AOSEMs and BOSEMs

32.1 Documents

D060218 BOSEM Assembly

D0901065 AOSEM Assembly

32.2 Materials

Qty	U	ID	Description
8	Ea	D0901065	**AOSEM Assembly**
6	Ea	D060218	**BOSEM Assembly**
24	Ea	NA	Socket Head Cap Screw 4-40 x 1.0 AgPlated
24	Ea	NA	Flat Washer #4 SSTL

32.3 Procedure

1. Review the test data that comes with the BOSEMs & the AOSEMs.

2. Position each BOSEM such that it is centered around its magnet. Assemble each to the Coil Holder with:
   - 4 Socket Head Cap Screw 4-40 x 1.0” AgPlated
   - 4 Flat Washers #4 SSTL Torque to 6 in-lb

   Each HSTS assembly must contain 1 fully-characterized BOSEM, mounted at the T2 position (the –Y location).

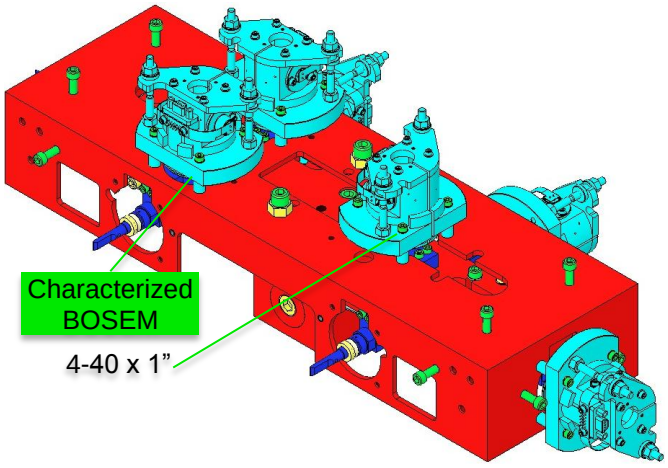


Fig 150: B OSEMS mounted on Coil Holder

3. Using the electronics test stand, read the open light voltage for each B OSEM, and position the BOSEM longitudinally to 50% open light voltage.

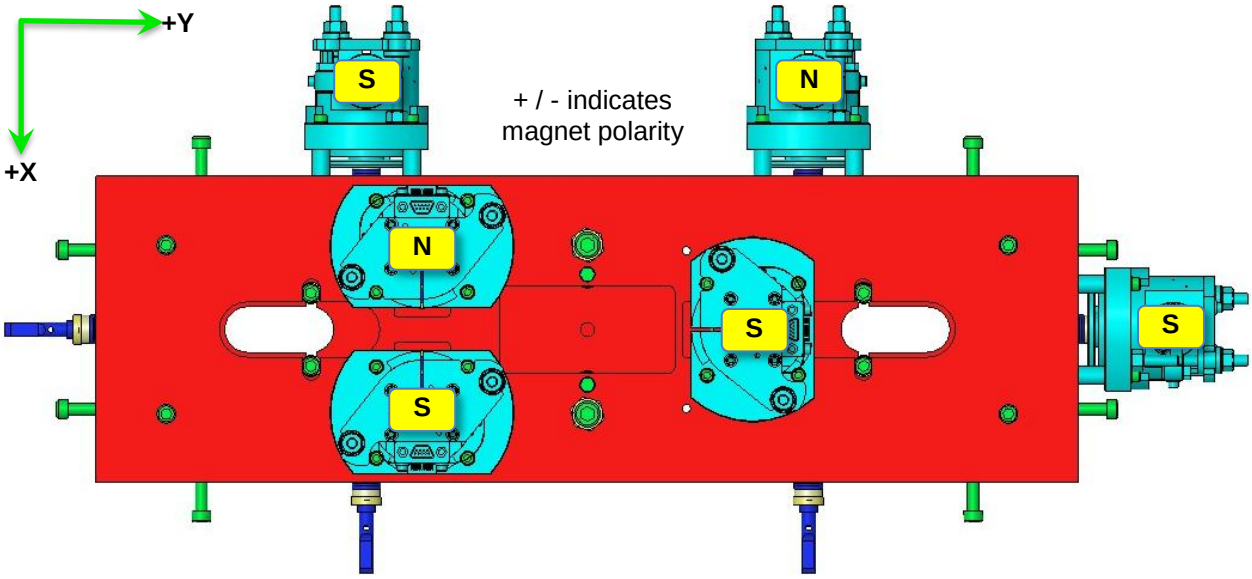


Fig 151: Top View of Upper Mass and BOSEMS

4. Place 4 AOSEMs in the Brackets behind the Intermediate Mass. Place another 4 A OSEMs in the Brackets behind the Lower Mass or Optic. Position each A OSEM such that it is centered around its magnet.

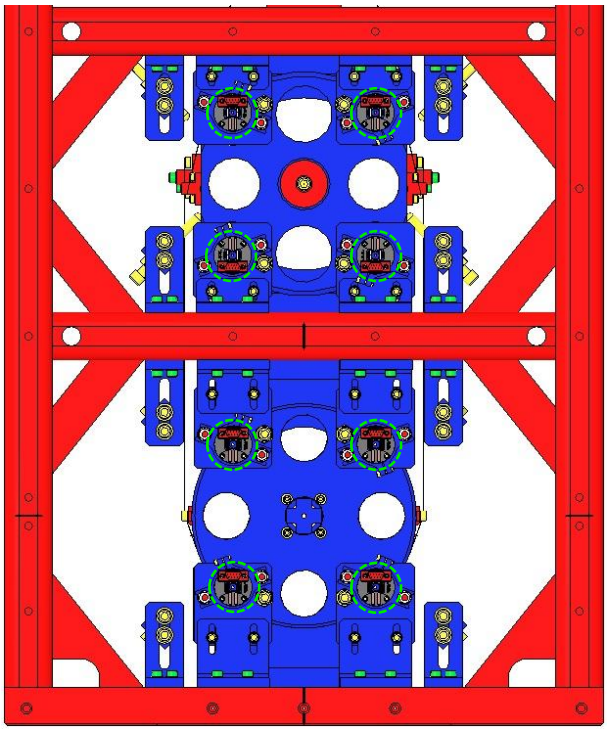


Fig 152: A OSEMs installed in Brackets

33 Balancing of the Suspended Masses

The alignment tolerance for the Metal Build is much greater than that for the Optic Build. This procedure references the Optic requirements.

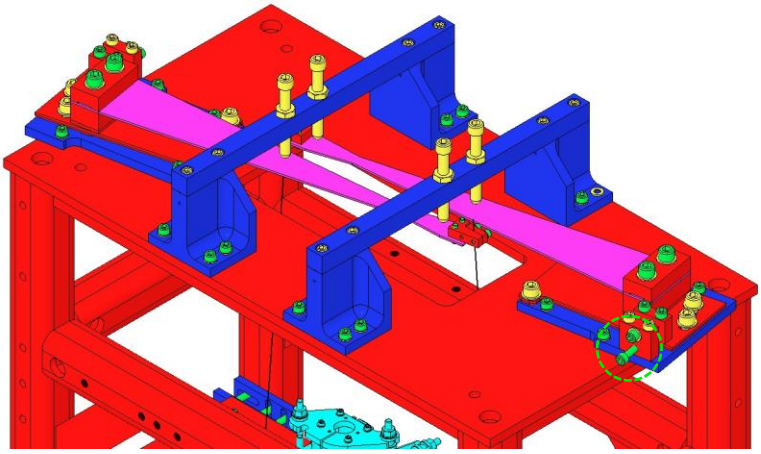


Fig 153: Yaw Adjustment with Push/Pull Screws

33.1 Documents

T1200209 Balancing of HSTS Suspensions

E0900342 ALIGO IO HSTS and HLTS Optic Orientations

T010076-v1 Optical Layout for Advanced LIGO, beam height requirement, Table 2, page 26 of v1

M1100192 RODA: Accuracy of Height of Mirrors in HSTS and HLTS. Accuracy of the height of the mirrors for HSTS & HLTS is +/- 1mm. This RODA supersedes just the vertical positioning static alignment requirements in the Cavity Optics Suspensions, Table 1, page 9

T010007 Core Optics Suspension Subsystem Design Requirements, Table 1, page 9

33.2 Materials

Qty	Unit	Part Number	Description
TBD	TBD	TBD	TBD

33.3 Desired Results of Balancing

The goal of balancing is to produce a suspension with the following key attributes:

1. All suspension stages are balanced and free of pitch and roll
2. Blade tips are set to the correct d-value of 2mm. In practice, setting the d-values to between 2 and 3mm has yielded very good results in testing.
3. Blade tips are within .5mm of each other
4. The height of the lower optic is within +/-1mm of its correct height of 215mm.

Additionally, for the sake of uniformity between suspensions, it is desirable to keep the mass of the system as close to nominal as possible. This is not, however, a strict requirement.

33.4 Adjustments Available for Balancing

There are several different ways in which the various masses are able to be adjusted:

- Rotational Adjusters (Upper Blades)
    - Push-Pull Plates

These screw-driven plates adjust the yaw of the upper mass by adjusting where the tip of the blade falls.

    - Upper Blade Clamps

This adjusts the height of the upper blade tips. Each 0.5 degree increment amounts to nominally 2mm of tip height adjustment.

- Upper Mass
    - Screwdrives

These adjust the attachment position of the upper wires to the upper mass. Sliding the clamp left and right will alter the pitch of the mass (and will also very slightly alter the yaw).

    - Sliding Mass

This sliding mass will adjust the roll of the upper mass.

    - Adjustment Screw

A large silver plated screw in the upper mass is the fine adjustment for pitch.

    - Addable Masses

Adjusts the height of the upper mass while leaving the relative heights below it unchanged. Useful for final optic height adjustments.

    - Lower Blade Clamps

Adjusts the height of each blade tip. One blade clamp swap of 0.5 degrees is nominally 1mm of independent height adjustment. It is important to note that this is not the case when it is installed in the structure because the load is shared between all the springs. This is discussed in more detail below.

- Intermediate Mass
    - Addable Masses

The addition and removal of addable masses does two things. Firstly, it can lower and raise the intermediate mass (thereby adjusting the blade tip height relative to the upper mass) and it can adjust pitch of the intermediate mass if addable masses are removed from either the front or the back. It has been determined that each side of the intermediate mass works relatively independent from the other. So, in order to correct pitch, mass need only be removed or added to one side at a rate of roughly 1 gram for .1mm adjustment.

- Lower Mass
    - Lower Wire

The lower mass can be adjusted in the lower wire (i.e. where the prism contacts the wire) to compensate for roll. There is no way to compensate for pitch differences between the lower and intermediate masses.

33.5 Theory of Balancing

The theory behind the balancing of this suspension is in some ways unintuitive. Because of the way each stage plays off the ones below and above it, it is important to understand how one adjustment can affect the other parts of the system.

33.6 Upper Blades

When it is necessary to make a clamp swap to the upper blades, the added height of one of the blade tips will affect the height of everything below it. A clamp swap of 0.5 degrees will change the blade height by 2mm. Because there are two blades and only one of them is being switched, the net effect on the center of mass of the lower levels is that they will rise by 1mm. This effect adds linearly. Therefore, the total change of the height of the lower levels is given by the total clamp angle difference multiplied by 2mm. For example, if both clamps are switched upward by 0.5 degrees, the net change would be (0.5+0.5)*2mm = 2mm rise in the center of mass of the intermediate mass.

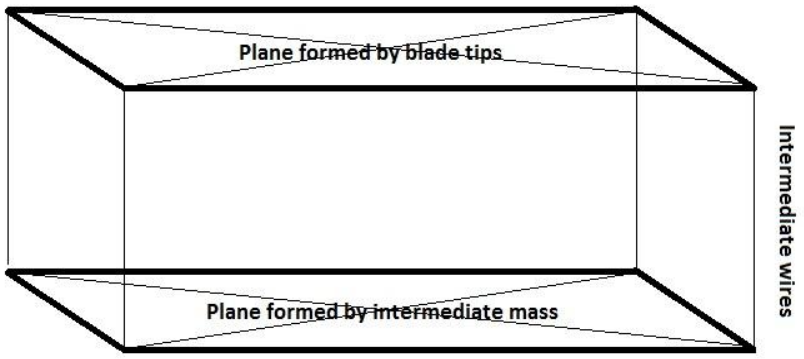
33.7 Upper Mass

The upper mass seems to have strange effects on things such as d-values when it is not level. It is very important to make sure the upper mass is as level as possible before taking any measurements. In practice, .25mm corner-to-corner height difference has been shown to be sufficient. Failure to do so will result in sometimes large errors for critical parts of the balancing process.

33.8 Lower Blades

The blade tips are rigidly attached to the intermediate mass by the intermediate wires. Before beginning the balancing method, it should be ensured that the clamps are pushed to their highest position on the intermediate mass. This will cause the clamps to be square with respect to the intermediate mass. There are other ways of doing this, but this has been found to be an effective method. Failure to mount the clamps properly will result in meaningless data.

Once this is done, the blade tips should all be equal distance from the intermediate mass. This is guaranteed by the assumption that the intermediate wires are all the same length. Using this assumption, we can see that if the clamp holes in the intermediate mass are drilled straight, then the blade tips must also be parallel.

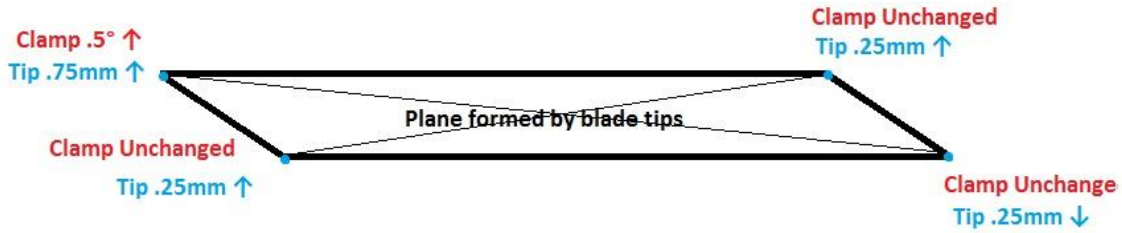


As the figure above shows, the blade tips must have two criteria: Firstly, they must form a plane. Because we know that the intermediate mass has its holes drilled properly and the wires are the same length, the 4 blade tips must also be planar. It is not possible for 3 blade tips to be equal with one blade tip either too high or too low. If this condition occurs, there is an error with the wire length and it must be

replaced. Secondly, in addition to the blade tips being in plane with each other, the plane it forms must be parallel to the plane formed by the intermediate mass. Therefore, the pitch and roll of the blade tip "plane" must be the same as the pitch and roll of the intermediate mass.

This has serious implications for balancing. It is very important to understand that correction of one blade tip while leaving the others alone is not possible. When adjusting only one of the blade clamps on the lower blades, you will ultimately have an effect on the other 3 lower blades. The best idea is to attempt to correct pitch and roll independently, as these are very easy to control by switching two clamps at a time.

A one-clamp swap will, in theory, have the following effect on the blade tips: The adjusted blade will move by 1.5mm/degree, the two adjacent blade tips will move by 0.5mm/degree, and the opposite blade tip will move by -.5mm/degree as illustrated below.



These effects can be superpositioned. Therefore, switching two clamps on one side will cancel out the effects on the opposite side. This is why it is very important to switch two clamps at a time.

The overall effect of a clamp swap on the stages below it is roughly 0.5mm/degree of net clamp swap. Therefore, if two clamps are switched by 0.5 degrees upward, the net clamp change is 1 degree and will move the center of mass of the intermediate and lower masses upward by .5mm. Similarly (and intuitively) if 4 clamps are each switched by 0.5 degrees upward, the net effect will be a change of 1mm upward in the lower and intermediate masses.

33.9 Intermediate Mass

The intermediate mass is adjustable with the one set of weights on either side of the mass. Addition and removal of these masses will affect the pitch of the blade tips, intermediate mass, and lower mass because all three are rigidly attached with wires. The rate of pitch adjustment is roughly .1mm/gram per side. This means that if 10 grams are removed from the +X side, the +X blade tips will move by 1mm, the +X side of the intermediate mass will move by 1mm, and the +X side of the lower mass will move by 1mm. The -X side, however, will remain relatively unchanged, thus isolating pitch adjustment. Note that the upper mass will need to be re-balanced after any mass is changed on the intermediate mass.

The rate of the center of mass rising is roughly equal to .05mm/gram of weight added or removed. So, if 10 grams are removed, it is expected that the center of mass of the intermediate mass will rise by .5mm.

33.10 Lower Mass

The lower mass is of course rigidly attached to the intermediate mass and cannot be adjusted in pitch. It is, however, infinitely adjustable in roll. It is a good idea to correct a bit of roll from the lower mass before attempting to take measurements. Within +/- 1mm between the tops of the horizontal holes has been found to be adequate. Subsequent roll reduction of the lower mass showed little to no effect on the upper stages. Final balancing will require that all of the roll be removed [INSERT REQUIREMENT] before testing.

33.11 Steps in the Balancing Process

Once the suspension has been assembled and is hanging freely, the following steps should be performed to balance the suspension.

33.12 Ensure All Hardware is Present

The first step is to ensure all hardware is present on the upper mass. Double check with ICS that the correct addable masses are present on the top and bottom of the mass. Also check that the magnet and flag assemblies have been installed and that the upper wires are roughly centered (these will be adjusted in a later step). Unlock all stages, starting with the bottom.

33.13 Adjust Upper Mass Yaw

The yaw needs to be adjusted next. In theory it should have no effect on the pitch and roll of the upper mass, but keeping the mass correctly centered in the tablecloth has additional benefits such as keeping the mass away from rubbing on the earthquake stops and tablecloth. This adjustment can be made by loosening the 3 x 1/4-20 bolts on the upper blade rotational adjusters and using the push pull plates to move the blade tips. The position of the upper mass can be determined by looking through the +Y and -Y OSEM holes. At this stage, a visual alignment is sufficient.

33.14 Balance the Upper Mass

Before anything else, the upper mass must be as level as possible. In practice, it has been found that the upper mass needs to be level to within .25mm corner-to-corner. Failure to do so will result in incorrect d1-values.

The first step to balancing the mass is to place a bubble level on top of the upper mass (on the actual upper mass itself, not atop the addable masses). Then adjust the screw drives to correct for pitch. Once pitch is correct, use the slider to adjust the roll of the mass. If it is found that the slider is all the way or nearly all the way out, an upper clamp must be switched.

If it is necessary to switch an upper clamp, the height of the lower mass should first be measured (the nominal height of the top of the optic is 215mm). Any clamp swap at the upper level will have a 1mm effect on the lower mass. So, if the lower mass is too high, switch to a lower upper clamp and vice versa. Once the swap has been performed, begin the balancing process again.

33.15 Take Measurements of the Whole System

The next step is to measure the heights of all critical points in the system. The purpose of this is to determine the following:

1. Upper blade tip heights
2. Upper mass pitch and roll
3. Lower blade tip heights (and therefore d1-values, pitch, and roll)
4. Intermediate mass pitch and roll
5. Lower mass pitch and roll

In order to achieve this, the following points must be measured:

1. Upper blade wire breakoffs – Measure where the wire enters the upper clamp of the upper wire assembly.
2. Upper mass through the OSEM holes – Measure the top side of the upper mass through the (+X+Y), (+X-Y), (-X+Y), and (-X-Y) OSEM holes. These 4 measurements give pitch and roll.

3. Lower blade wire breakoffs – Measure the upper clamp of the intermediate wire assembly where the wire enters the clamp. This is used to calculate d-values
4. Top of the intermediate mass holes – Measure the tops of the (+X+Y), (+X-Y), (-X+Y), and (-X-Y) holes in the intermediate mass. These will give the pitch and roll of the intermediate mass.
5. Top of the lower mass – This will give you the height of the lower mass (which should be 215mm)
6. Top of the lower mass holes – Measure the tops of the (+X+Y) and (+X-Y) (or (-X+Y) and (-X-Y)) holes to determine the roll of the lower mass.

Enter all of the values into a spreadsheet as they are measured from the top of the table. This will make the next steps easier.

33.16 Determine What Changes Must Be Made

This is probably the most difficult part of the process because each stage depends on each other. Recall our objectives in this procedure: We want to have a suspension with the lower mass at 215mm (+/-1mm), d1-values between 2 and 3, and as little pitch and roll of each stage as possible.

33.17 Determine the Wire Lengths

First, before any adjustment can be made, it must be determined whether or not the blade tips are coplanar with the intermediate mass. That is to say, the pitch and roll of the blade tips must be identical (or nearly identical) to that of the intermediate mass. This should be readily observable by looking at the spreadsheet you created in 5.4. If there appears to be a wire that is too short or too long with respect to the other three, it must be switched. If there seems to be no correlation between the blade tip plane and the intermediate mass plane, they should all be re-pulled and replaced.

A simple way to check that the blade tips are planer is to use the following equation:

$$\text{Height}(+X+Y) + \text{Height}(-X-Y) = \text{Height}(+X-Y) + \text{Height}(-X+Y)$$

Next, look at the pitch difference between the lower and intermediate mass. They should be very close, if not identical. If there is a difference between the two, check with the wire comb that the wire is properly in the prism grooves and is the correct width all the way around the metal mass. After this, re-balance and re-shoot the system. If the problem persists, try flipping the wire around so that the clamp that was on the +Y side is now situated on the -Y side. Readjust the wire, re-balance the upper mass, and re-shoot. If it is still incorrect, you will need to replace the lower wire. A correct lower wire will show no pitch difference between the two masses. Because the lower wires are so precious (due to a shortage of wire), it may be necessary to live with wires that are incorrect. Since the wire is to be replaced when the actual optic is inserted, we can get away with less than .5 mm or so of pitch difference, but know that this means a more time-consuming adjustment period after the optic goes in (the adjustment will need to be made with intermediate addable masses) and less accurate testing. Additionally, if there is a pitch difference, you should be trying to correct the pitch in the lower mass, not the intermediate mass and upper blades. The pitch of the lower mass is far more critical than the the d1-value difference in the lower blades, so if there is a problem with the wire, make sure you are not trying to correct both, as it is a Sisyphean task.

After any wires are replaced, the suspension must be re-balanced and re-shot. Return to the top of Section 5. Proceed to 5.7 ONLY when the wires are as correct as possible.

33.18 Adjusting the Lower Blades

Once the wire lengths are correct, the most isolated item to adjust is first the lower blade clamps. The d1-values only depend upon the clamp angle and the mass of the intermediate mass. For consistency between suspensions, it is preferable to adjust the clamps before adjusting mass (which will slightly alter the frequency of the blades).

Look at the spreadsheet and determine the pitch and roll of the blade tips. If there is more than 1mm of pitch in the blade tips or more than 0.75mm of roll, a blade clamp swap will be necessary. It is almost always preferable to adjust either pitch or roll (but not both) with a clamp single swap. This is because the manufacturing inconsistencies in the clamps can actually cause an effect in both roll and pitch, even when only trying to correct one. You may find, for example, that switching clamps to only fix pitch will also fix your roll issue (conversely, it can exacerbate your problem).

The amount of pitch and roll adjustment is theoretically 1mm per 0.5 degrees of adjustment. If there needs to be 1.5mm of adjustment, for example, it is preferable to only move your clamps by the smaller increment (that is to say, round down). It has been found in practice that the blade tips move sometimes more than the clamp swap would predict them to.

Let's look at an example (Center of Mass = 20mm below top of upper mass):

	+X+Y	+X-Y	-X+Y	-X-Y
Top of Upper Mass	549.25	549.25	549.25	549.25
Blade Tips	527	527	525.5	525.5
d1-Values	2.25	2.25	3.75	3.75
Current Clamp Angle	.5	1	0.5	1
Recommended New Clamp Angle	.5	1	1	1.5
Expected New d1-Values	2.25	2.25	2.75	2.75

In this simple example, we only dealt with a correction in pitch. Obviously, these fictitious numbers will not be so nice in a real-world setting. This is just to illustrate the method in which clamp swaps should be performed: They should be 2 or 4 clamps at a time, by the same amount, between adjacent blades.

After each clamp swap, it will be necessary to re-balance and re-shoot the entire system. If you are careful and thorough in your approach, you will eventually dial in the pitch and roll of the system. It is vital, therefore, that clamp angles and serial numbers be recorded with each swap, in case you need to return to a previous configuration. It is also a very good idea to keep the wires on the same blade tips. This will eliminate any error associated with different wire lengths (though in theory we correct this in the previous step).

33.19 Adjusting the Intermediate Mass

By this point, roll and pitch of the blade tips should be roughly correct and the d1-values should be between 2 and 3. Unfortunately, there is no roll correction available for the intermediate mass, so we are limited to adjusting pitch with weights. Take another look at your d1-values. Weight should be added to the side for blade tips that need to be brought down and weight should be removed from sides that are too low at a rate of around 10grams/mm. If everything was done properly in the previous step, very little weight will need to be removed from the mass. After adjustments of the weights, you will need to re-level the upper mass and re-shoot the blade tips. Do this until all pitch has been eliminated from all 3 levels of the suspension (or, if you know that your lower wire is wrong, do this until the lower mass shows no pitch).

33.20 Adjusting the Height of the Lower Mass

The lower mass height adjustment should be the absolute last thing you do because it can be adjusted in two ways without affecting other critical parts of the system. The upper blade clamps can be swapped and mass can be added/removed from the upper mass. If the lower mass needs to move by more than 2mm, it is preferable to attempt to switch clamps on the upper mass. This can be a trying experience, so getting it correct will take patience. Hopefully, because we have up until this point not adjusted weights too much, the lower mass will be in roughly the correct place. If it is more than 2mm high or low, the upper clamps should be switched up or down by .5 degrees (the rate of movement is, in theory, 2mm per half degree). In practice, the blade clamps used at LLO are wildly inconsistent. We have found 0.5 degree clamps that are actually more than 1.0 degrees. Care should be taken to inspect the clamps for obvious defects such as this (holding the two profiles up to one another has proven useful more than once). If you see inconsistent movement when switching clamps, it is likely that either the one that was replaced was bad or the one that replaced it is bad. Trial and error here is the only advice I can give. Fortunately, upper clamp swaps do not require the removal of the upper mass and can be done reasonably quickly. It is especially important that serial numbers of clamps be recorded for this process as well, so that incorrect clamps can be identified and removed from circulation.

After the upper mass is level and the optic is within 2mm of where it should be, weights should be added and removed from the upper mass. The easiest way I have found to do this is to remove the weights from the top of the upper mass and have a partner set the optical level to 215mm (the nominal height of the top of the lower mass). Place the crosshairs over the lower mass and re-add the weights to the upper mass until the top of the lower mass just touches the crosshairs. After a final weight has been determined, the weight should nearly evenly split between the top and bottom of the mass. This keeps the center of mass roughly the same which keeps your d1-values from changing too much.

33.21 Final Steps

At this stage, you should have a well-balanced suspension. Now, everything must be balanced, shot, and recorded. Finally, when all looks good, the suspension can be pulled apart and placed into a creep bake. The spreadsheet containing your shootings, angles, and weights should be placed into an aLOG.

34 Replacing the Lower Mass with the Optic

34.1 Documents

34.2 Materials

Qty	Unit	Part Number	Description
TBD	TBD	TBD	TBD

34.3 Procedure

The D0901791 Metal Test Mass assembly has bolted-on D0901790 Primary Prisms similar to the bonded-on D0810033 Primary Prisms for the Optic.

The D0901278 Secondary Prisms are the same for each.

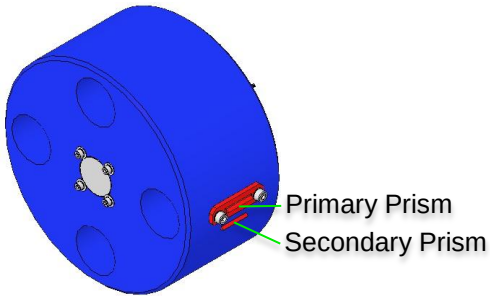


Fig 154: Metal Test Mass

1. Weigh the Test Mass and Optic, including:
   - 4 Magnet Assemblies
   - 2 Primary Prisms
   - 2 Secondary Prisms
   - 2 Mirrors
   - 8 Screws
   - 8 Washers

   The weights must be within a few hundred grams of each other. Compensation can be made at the Upper or Intermediate Masses.

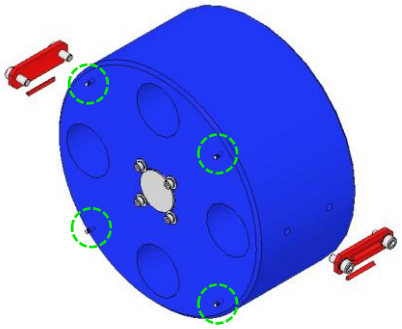


Fig 155: Test Mass Assembly

2. Document the data in ICS.
3. Bond the sapphire prisms to the optic using epoxy TBD and the bonding fixture, D0902543.
4. Bond magnet/standoff assemblies to the optic, per the procedure detailed in Section 6.3.
5. Move the bottom EQ stops up onto the metal test mass. Remove the front stops and brackets. Move the stops up even further to provide slack in the wire. Remove and set aside the secondary prisms. Carefully remove the metal test mass, while leaving intact the wires.
6. Replace all of the test mass EQ stops with silica tipped ones: Earthquake Stop For Glass (Glass Tip), Simplified, 2 Inch, D0900932.
7. Carefully, move the optic in place of the metal test mass, onto the bottom EQ stops. Make sure the wires are securely positioned in the v-grooves of the sapphire prisms. Replace the front stops and brackets. Back down on the bottom EQ stops, until the optic is just suspended. Re-insert the secondary prisms, until there is no slack in the wire between the primary prism and the place where the wire meets the optic.
8. Realign the BOSEMs & AOSEMs. Check for damping with the electronics test stand.

9. Torque all bracket screws to 20 in-lb. Check torque on all blade clamp screws at 30 in-lb.

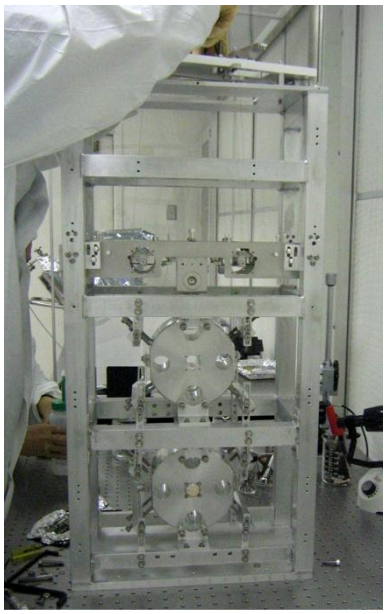


Fig 156: Prototype Small Triple Suspension

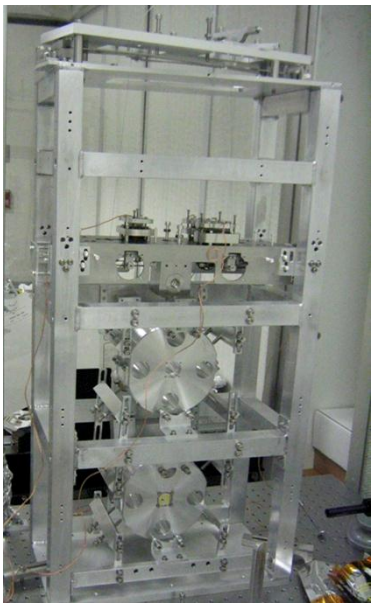


Fig 157: Prototype Small Triple Suspension with Control System