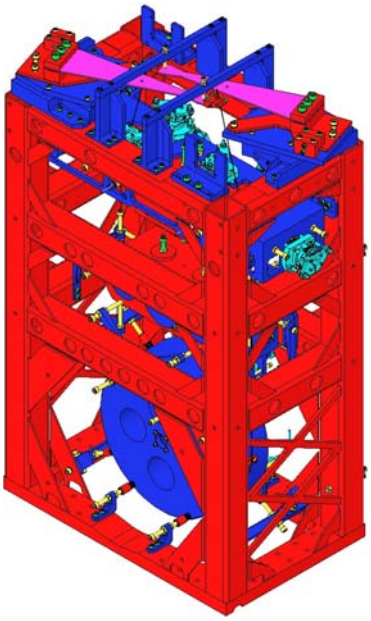

Fig 1: HLTS

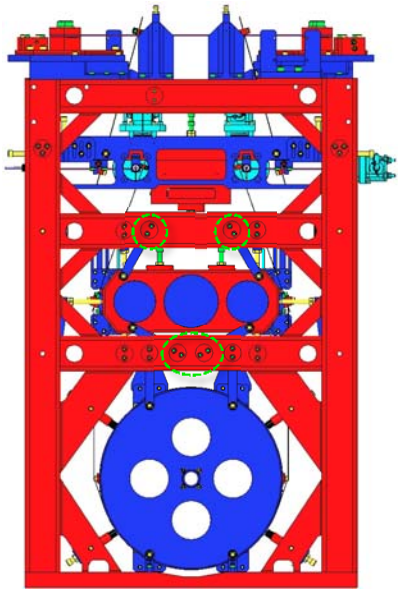

Fig 2: Front

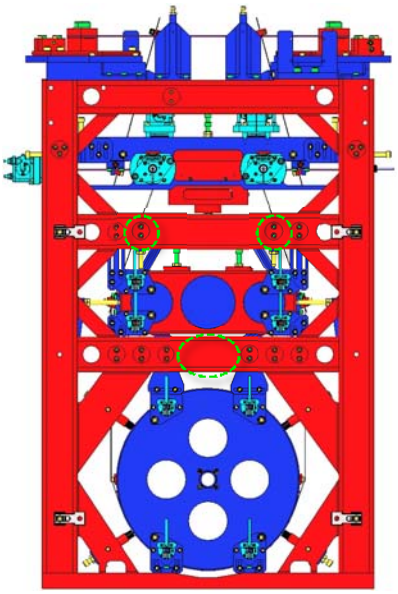

Fig 3: Rear

Note: Front vs. Rear of Weldment is identified by 3 hole patterns.

1 Safety

Please review E0900332 for concerns related to safe assembly and installation.

2 Objective and Scope

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

- General considerations for assembly
- Use of the assembly fixtures shown in D080718

3 Documents

D070308	HLTS Top Blade Guard Assembly
D070319	HLTS Bridge EQ Stops
D070326	HLTS Rotational Adjuster
D070334	HLTS Intermediate Mass Assembly
D070335	HLTS Upper Mass Assembly
D070337	HLTS Bottom Mass Assembly
D070340	HLTS Upper Wire Assembly
D070393	HLTS Intermediate Wire Assembly
D070436	HLTS Lower Loop Wire Assembly
D070442	HLTS Overall Assembly
D070447	HLTS Assembly Drawings
D080677	HLTS Coil Holder Assembly
D080718	HLTS Assembly Fixtures
D080726	HLTS EQ Stop, Long Mount
D080727	HLTS EQ Stop, Long Bracket
D0900626	HLTS Mounting Pad Assembly
D1001695	Magnet and Flag Assembly, BOSEM
D1002821	HLTS EQ Stop Assembly, Bottom Mass, Lower
D1102071	HLTS EQ Stop, Bridge, Upper
E080208	HLTS Assembly Instructions (this document)
E0900047	Contamination Control Plan
E1000043	HLTS Assembly and Installation Hazard Analysis
E1000045	HLTS Installation Procedure
E1100109	Suspensions Controls Arrangement
E960022	LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures
E990196	Magnet/Standoff Assembly Preparation
E1100472	HLTS Assembly and Installation Documentation
G1100147	HLTS Introduction
M0900034	RODA - Use of Magnets in Suspensions
T000053	Advanced LIGO Universal Suspension Subsystem Design Requirements
T010007	Cavity Optics Suspension Subsystem Design Requirements
T010103	aLIGO Suspension System Conceptual Design
T1000012	HLTS Final Design Document
T1000089	HLTS Test Plan
T1100066	General Torque Recommendations for Socket Head Cap Screws
T1100003	Building Suspensions Subassemblies in ICS

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.

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 Documents

T1100066 General Torque Recommendations for Socket Head Cap Screws

6.2 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 Class B clean tools in a Class 100 clean room.

6.3 Silver Plated Stainless Steel

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

6.4 Jam Nuts

All ¼-20 Jam (thin) Nuts have been replaced with ¼-20 AgPlated SSTL Hex Nuts (standard thickness).

6.5 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	

6.6 Torque Values

- Except where noted, Socket Head Cap Screws are to be tightened per the following table.
- “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).

	Torque (in-lb)		
Supplier	Generic (unmarked)	Holokrome UC	UC
Type	Unplated	Unplated AgPlated	Vented
Size			
2	3	4	3
4	5	6	7
8	20	30	25
¼”	75	100	86
5/16”	132	184	

7 Overview of Assembly Process

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

7.1 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.

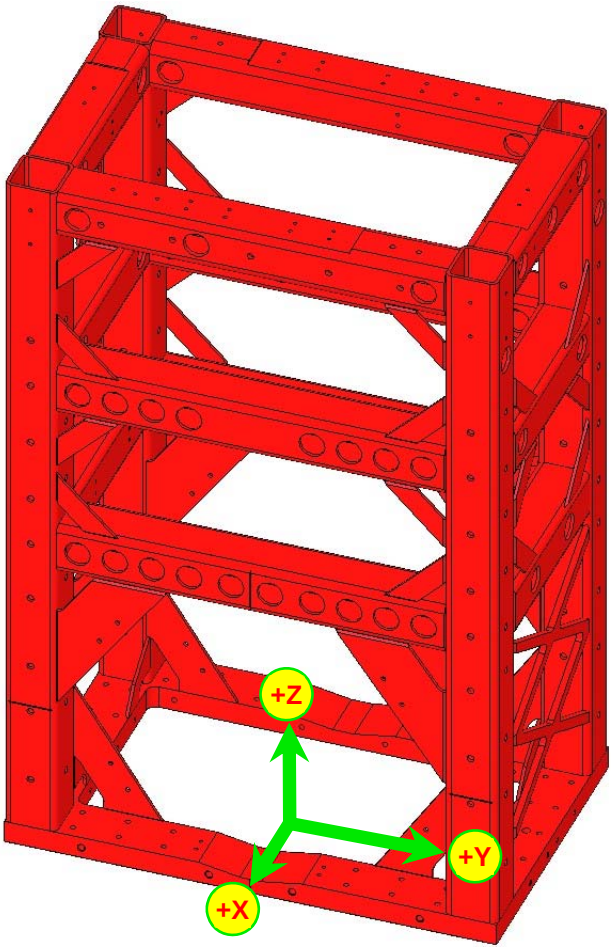

Fig 4: Frame of Reference

8 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 must 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, and until no residue 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 Assembling Upper Wires

9.1 Documents

D070340 HLTS Upper Wire Assembly

9.2 Materials

Qty	U	ID	Description
1	Ea	D0900594	HLTS Upper Wire Assembly Jig
4	Ea	D980184	LOS Clamps, Long
1	Ea	D020611	Upper Clamp, Upper Wire, Inside
1	Ea	D020652	C-Clamp, Upper Mass
1	Ea	D070341	Upper Clamp, Upper Wire, Outside
1	Ea	D020610	Upper Wire, Lower Clamp, Inside
4	Ea	NA	Socket Head Cap Screw 8-32 x 0.625” SSTL
4	Ea	NA	Socket Head Cap Screw 8-32 x 0.5” AgPlated
4	Ea	NA	Flat Washer #8 Vented SSTL
4	Ea	1185-2EN246	Helicoil 8-32 x .246”
1	Ea	NA	Hang Weight, 1 Kg, or D020660 Blade Pulldown Device
4	Ea	NA	Large Test Weights, 10, 5, 2, 1 Kg
1	Ea	NA	Small Test Weight Set, 1 to 500 g
1	Btl	NA	Methanol
1	Btl	NA	Acetone
1	Btl	NA	Isopropanol
			Steel Music Wire, 0.024” dia.
			Lint-Free Wipes
			Class B Wire Cutters

9.3 Procedure

2 Assemblies are required per HLTS.

Use safety glasses per E0900332.

1. Ensure the D0900594 Assembly Jig has been cleaned Class B per E960022.
2. Ensure Jig is fully assembled per the drawing.
3. Attach the D0900594 Jig to an Optical Table using the 4 D980184 LOS Clamps. The end of the Jig with the Clevis and Pin must hang over the edge of the Table enough to provide clearance for the hanging weight.

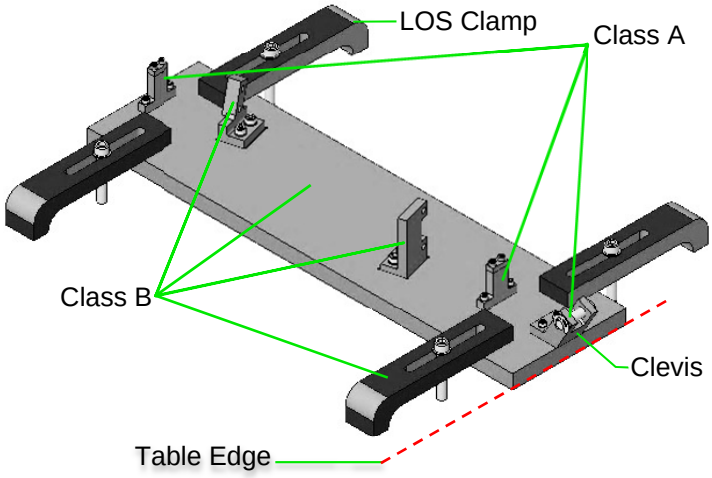

Fig 5: Jig

4. Assemble all the Clamps you'll need; do not tighten the clamps.

   Upper Wire Upper Clamp includes:
   - 1 D020611 Upper Wire Upper Clamp, Inside
   - 2 1185-2EN246 Helicoils 8-32 x .246"
   - 1 D070341 Upper Wire Upper Clamp, Outside
   - Socket Head Cap Screw
     2 8-32 x 0.5" AgPlated
   - 2 Flat Washer #8 Vented SSTL

   Upper Wire C-Clamp Assembly includes:
   - 1 D020652 Upper Mass C-Clamp
   - 1 D020610 Upper Wire Lower Clamp, Inside
   - 2 1185-2EN246 Helicoil 8-32 x .246"
   - 1 D020624 Upper Wire Lower Clamp, Outside
   - 2 Socket Head Cap Screws
     8-32 x 0.5625" SSTL
   - 2 Flat Washer #8 Vented SSTL

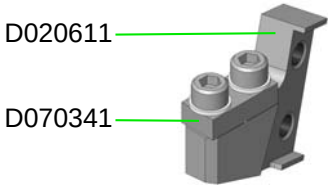

Fig 6: Upper Clamp

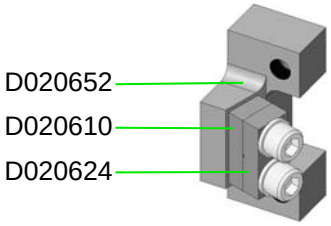

Fig 7: C-Clamp

5. Attach to the Jig:
   - 1 Upper Clamp Assembly
   - 2 Socket Head Cap Screws
     8-32 x 0.625" SSTL
   - 1 C-Clamp Assembly with
   - 2 Socket Head Cap Screws
     8-32 x 0.625" SSTL

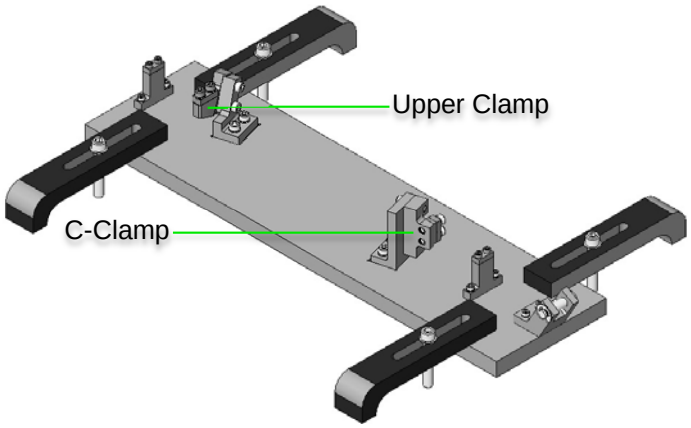

Fig 8: Clamps on Jig

6. Cut a 36" of 0.024" diameter Wire from the spool.
7. Clean the Wire per Section 12.4.
8. Feed the Wire through the Clevis and Clamps, as shown:
   - Over Clevis Pin
   - 1st Start Post;
   - L-Clamp;
   - C-Clamp;
   - 2nd Start Post
9. Tighten the 2nd Start Post Clamp, after feeding through about ½" of wire.

   Ensure Wire is secured within the Clamp groove.

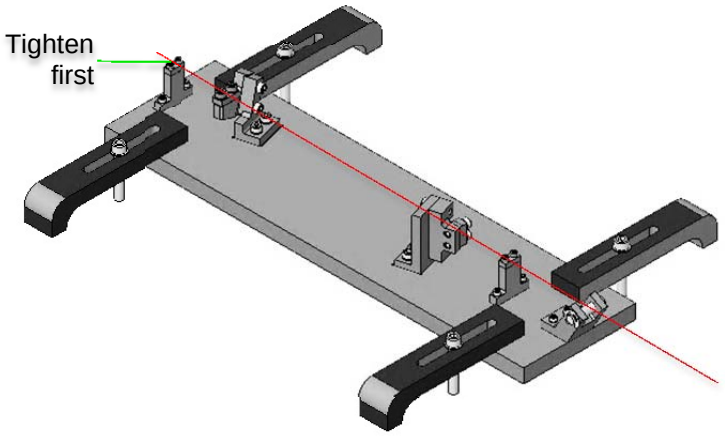

Fig 9: Wire Path

10. Tie a small loop in the end of the wire hanging off the Table and hang the 1 kg Hang Weight. Add large and small weights for a total of 18.252 kg. Then change gloves, since the weights are not clean.

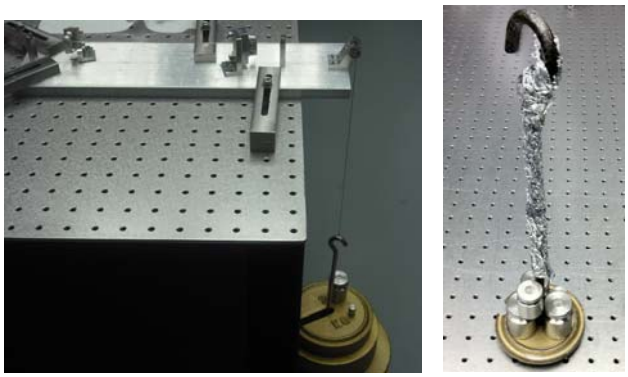

Fig 10: Hang Weight in use

11. Wait 5 minutes for the wire to come to equilibrium. Tighten the screws on each of the 3 remaining wire clamps in the order shown. Torque to 30 in-lb.

    During tightening:

    - Ensure Wire is secured within the grooves of each Clamp.
    - Ensure Clamp halves are aligned with each other by using a Precision Square.

12. Remove the Hang Weight and cut the Wire in the locations shown. Change gloves since the weights are not clean.
13. Loosen the Screws on the Wire Clamps on the jig and discard the leftover Wire.
14. Remove the Screws holding the Upper Wire Assembly to the Upper Wire Jig. Bend back the ends of the wire to eliminate sharp points.
15. Measure the Wire length between Clamps to confirm that it is 202.50mm.

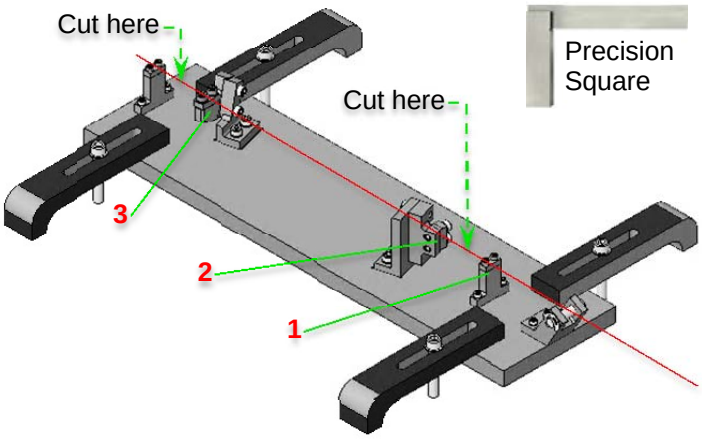

Fig 11: Cutting the Wires

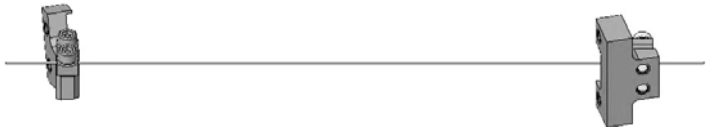

Fig 12: Upper Wire Assembly complete

10 Assembling Intermediate Wires

10.1 Documents

D070393 HLTS Intermediate Wire Assembly

10.2 Materials

Qty	U	ID	Description
1	Ea	D0900630	HLTS Intermediate Wire Jig
4	Ea	D980184	LOS Clamps, Long
1	Ea	D070585	Inside Upper Clamp
1	Ea	D070394	Outside Intermediate Wire Upper Clamp
1	Ea	D030149	Intermediate Wire Breakoff
1	Ea	D070405	Inside Intermediate Wire Lower Clamp
1	Ea	D070406	Outside Intermediate Wire Lower Clamp
2	Ea	NA	Socket Head Cap Screw 4-40 x 0.5” SSTL
3	Ea	NA	Socket Head Cap Screw 8-32 x 0.5” SSTL
2	Ea	NA	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 8-32 x 0.625” SSTL
2	Ea	NA	Flat Washer #8 Vented SSTL
2	Ea	1185-2EN164	Helicoil 8-32 x .164” Nitronic 60
2	Ea	1185-04EN224	Helicoil 4-40 x .224” Nitronic 60
1	Btl	NA	Methanol
1	Btl	NA	Acetone
1	Btl	NA	Isopropanol
1	Spl	NA	Steel Music Wire, 0.0134” dia.
1	Pkg	NA	Lint-Free Wipes
1	Ea	NA	Class B Wire Cutters
1	Ea	NA	Hang Weight, 1 Kg, or D020660 Blade Pulldown Device
4	Ea	NA	Large Test Weights, 10, 5, 2, 1 Kg
1	Ea	NA	Small Test Weight Set, 1 to 500 g

10.3 Procedure

4 Assemblies are required per HLTS.

Use safety glasses per E0900332.

1. Attach the D0900630 Jig to an Optical Table using the 4 D980184 LOS Clamps. The end of the Jig with the Clevis and Pin must hang over the edge of the Table enough to provide clearance for the hanging weight.

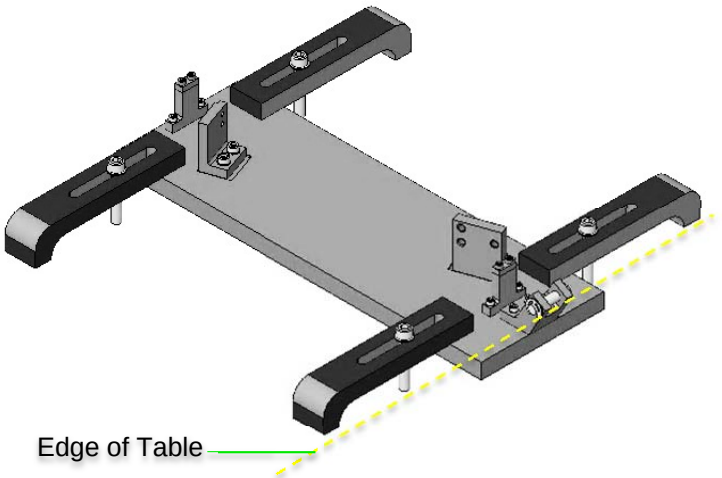

Fig 13: Jig

2. Assemble all the Clamps you'll need; do not tighten the clamps.

   Intermediate Wire Upper Clamp includes:
   - 1 D070585 Intermediate Wire Upper Clamp, Inside
   - 2 1185-04EN224 Helicoil 4-40 x .224"
   - 1 D070394 Intermediate Wire Upper Clamp, Outside
   - Socket Head Cap Screw
     2 4-40 x 0.375" AgPlated
   - 2 Flat Washer #4 SSTL

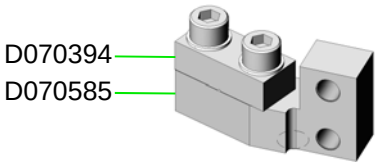

Fig 14: Upper Clamp

   Intermediate Wire Breakoff Assembly includes:
   - 1 D030149 Intermediate Wire Breakoff
   - 1 D070405 Intermediate Wire Lower Clamp, Inside
   - 2 1185-2EN164 Helicoil 8-32 x .164"
   - 1 D070406 Intermediate Wire Lower Clamp, Outside
   - 2 Socket Head Cap Screw
     8-32 x 0.625" SSTL
   - 2 Flat Washer #8 SSTL

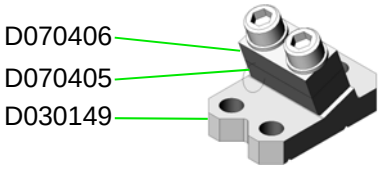

Fig 15: Breakoff

3. Attach to the Jig:
   - 1 Upper Clamp Assembly
   - 2 Socket Head Cap Screw
     4-40 x 0.5" SSTL
   - 1 Breakoff Assembly
   - 3 Socket Head Cap Screw
     8-32 x 0.5" SSTL

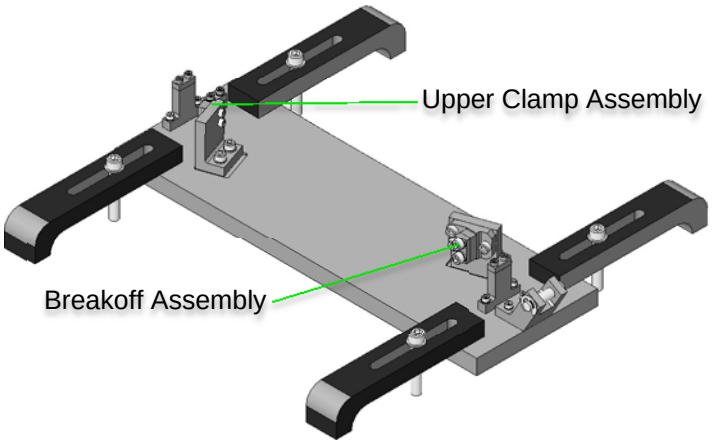

Fig 16: Clamps Attached to Jig

4. Cut 24" of 0.0134" diameter Steel Music Wire.
5. Clean the Wire per Section 12.4.
6. Feed the Wire through each set of 4 Clamps. Allow the extra Wire to hang over the edge of the Table.
7. Tighten the Screws on the Wire Start Clamp farthest from the Table edge.

   Ensure Wire is secured within the Clamp groove.

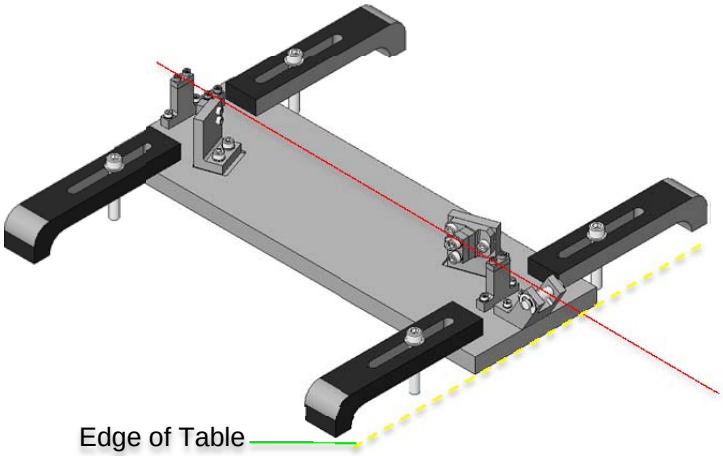

Fig 17: Wire Path

8. Tie a small loop in the end of the Wire hanging off the Table and hang the 1 kg Hang Weight or Pulldown Device from the loop. Add additional weights to the Hanger for a total of 6.092 kg. Then change gloves, since the weights are not clean.

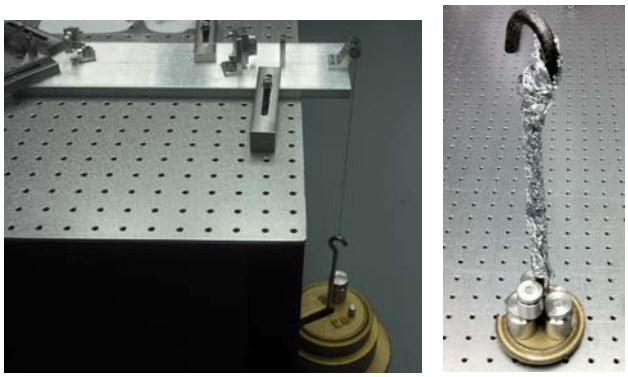

Fig 18: Hang Weight in use

9. Wait 5 minutes for the wire to come to equilibrium. Tighten the screws on each of the 3 remaining wire clamps in the order shown.
   - 4-40 Screws: Torque to 6 in-lb
   - 8-32 Screws: Torque to 30 in-lb

   During tightening:
   - Ensure Wire is secured within the grooves of each Clamp.
   - Ensure Clamp halves are aligned with each other by using a Precision Square.
10. Remove the Hang Weight and cut the Wire in the locations shown. Change gloves since the weights are not clean.
11. Loosen the Screws on the Wire Clamps on the jig and discard the leftover Wire.
12. Remove the screws holding the Intermediate Wire Assembly to the Intermediate Wire Jig. Bend back the ends of the wire to eliminate sharp points.
13. Measure the Wire length between Clamps to confirm that it is 203.60mm.

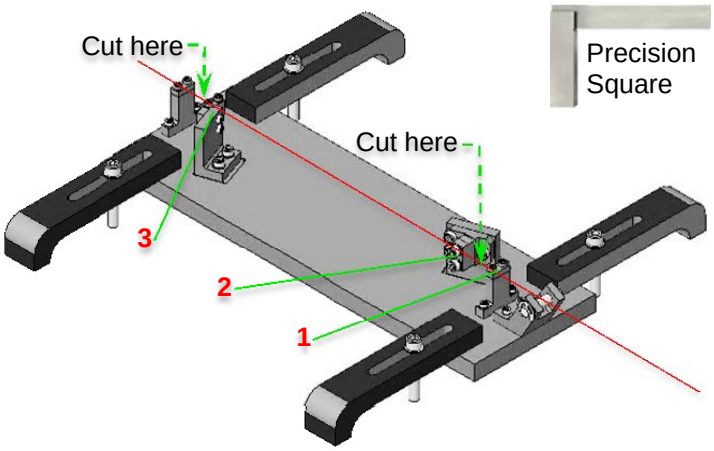

Fig 19: Cutting the Wires

Fig 20: Completed Intermediate Wire Assembly

11 Assembling Lower Loop Wire

11.1 Documents

D070436 HLTS Lower Loop Wire Assembly

11.2 Materials

Qty	U	ID	Description
1	Ea	D0901419	HLTS Lower Loop Wire Jig
4	Ea	D980184	LOS Clamps, Long
2	Ea	D030148	Lower Loop Wire Intermediate Mass Breakoffs
6	Ea	NA	Socket Head Cap Screw 8-32 x 0.5" SSTL
4	Ea	D070438	Lower Loop Wire Clamps
4	Ea	NA	Socket Head Cap Screw 8-32 x 0.5625" SSTL
4	Ea	NA	Flat Washer #8 Vented SSTL
4	Ea	1185-2EN164	Helicoil 8-32 x .164"
1	Btl	NA	Methanol
1	Btl	NA	Acetone
1	Btl	NA	Isopropanol
1	Spl	NA	Steel Music Wire, 0.0106" dia.
1	Pkg	NA	Lint-Free Wipes
1	Ea	NA	Wire Cutters, cleaned Class B
1	Ea	NA	Hang Weight, 1 Kg, or D020660 Blade Pulldown Device
4	Ea	NA	Large Test Weights, 10, 5, 2, 1 Kg
1	Ea	NA	Small Test Weight Set, 1 to 500 g

11.3 Procedure

One Assembly is required per HLTS.
Use safety glasses per E0900332.

1. Attach the D0901419 Lower Loop Wire Jig to an Optical Table using 4 D980184 Long LOS Clamps arranged so both ends of the Jig hang over the edges of the Table.

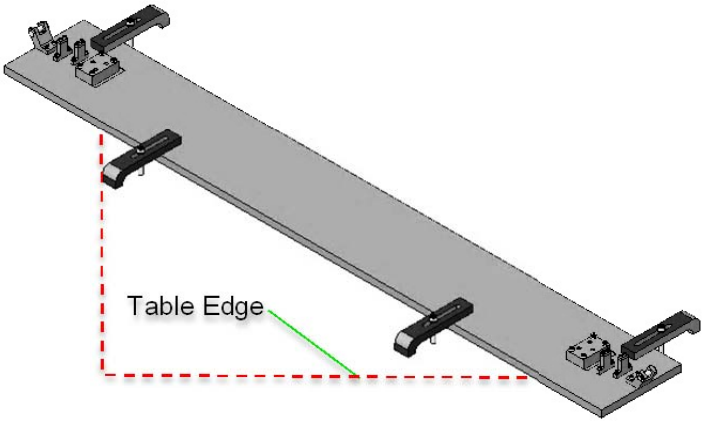

Fig 21: Jig

2. Assemble loosely the Lower Loop Breakoffs, each using:
   - 1 D030148 Breakoff
     Ensure the vent groove faces downward
   - 2 D070438 Lower Loop Wire Clamp
   - 2 Socket Head Cap Screw
     8-32 x .5625" SSTL
   - 2 Flat Washer #8 Vented SSTL

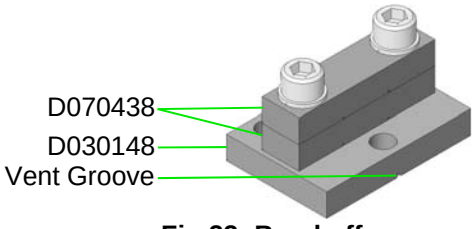

Fig 22: Breakoff

3. Attach the D030148 Lower Loop Wire Intermediate Mass Breakoffs, vent grooves facing down.
   - 6 Socket Head Cap Screw 8-32 x 0.5" SSTL

   Tighten the screws.

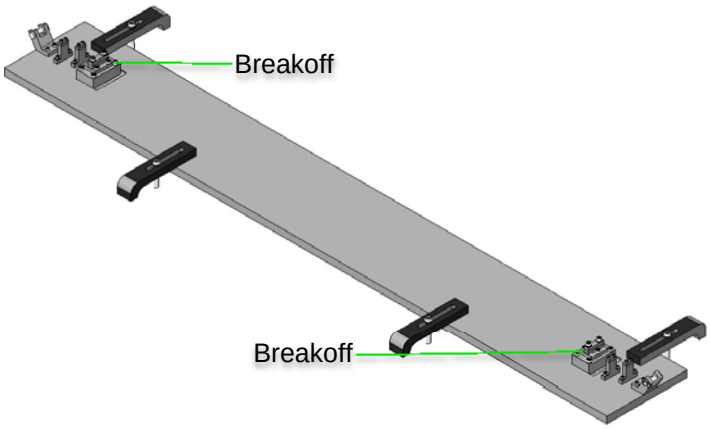

Fig 23: Attaching the Breakoffs

4. Cut one length of 0.0106" diameter Steel Music Wire.
5. Clean the Wire per Section 12.4.
6. Feed the Wire through a set of Wire Clamps in the order shown. Allow the long end of the wire to hang over the edge of the Table passing over the Wire Jig Pin Support.
7. Tighten Wire Start Clamp farthest from the corresponding Wire Jig Pin Support.

   Ensure the wire is secured within the groove of the clamp.
8. Repeat Steps 4-7 for the second wire, but feed the Wire through the Clamp in the opposite direction.

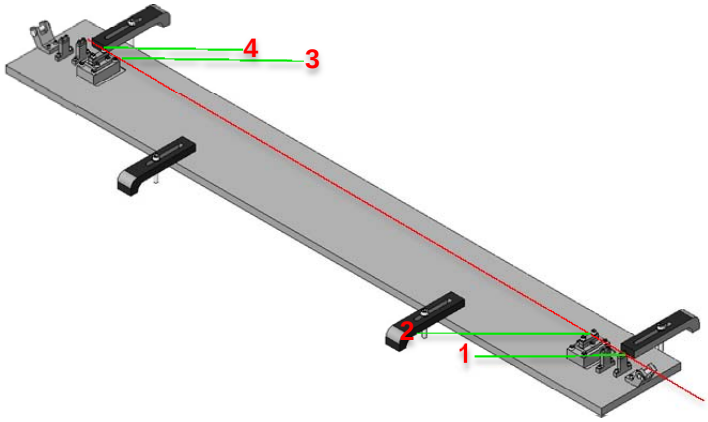

Fig 24: Loading the Wires

9. Tie a small loop in each Wire, at the end of the wire hanging off the Table. Hang a 1 kg Hang Weight from each loop. Add more weights to each hanger for a total of 6.071 kg per Wire. Then Change gloves since the weights are not clean.

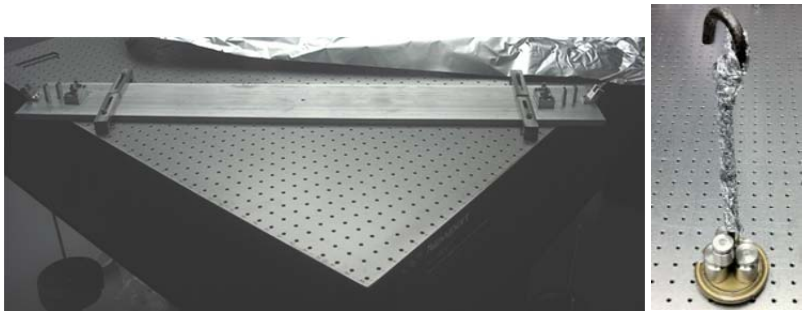

Fig 25: Hang Weight in position

10. Wait 5 minutes for the wires to come to equilibrium. Tighten the Screws on the Lower Loop Wire Clamps, then tighten the screws on the remaining Wire Start Clamps. Torque to 30 in-lb.

    During tightening:

    - Ensure Wire is secured within the grooves of each Clamp.
    - Ensure Clamp halves are aligned with each other by using a Precision Square.

11. Cut the wires between the Lower Loop Wire Clamps and the Wire Start Clamps.
12. Remove the weights on both ends. Change gloves since the weights are not clean.

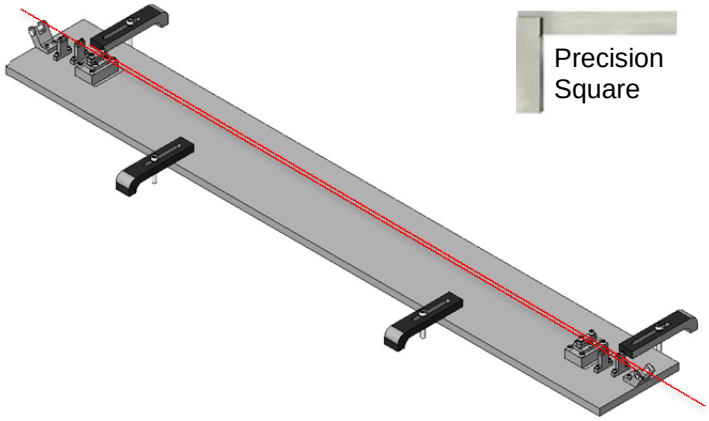

Fig 26: Tightening and Cutting the Wires

13. Loosen the screws on the Wire Start Clamps on the Jig and discard the leftover pieces of wire.
14. Remove the Screws holding the Lower Loop Wire Assembly to the Jig.
15. Bend back the ends of the wires to eliminate sharp points.

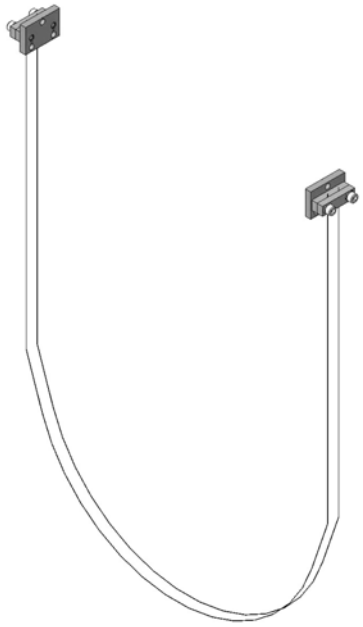

Fig 27: Lower Loop Wire complete Assembly

12 Assembling Upper Blade Guards

12.1 Documents

D070308 HLTS Top Blade Guard Assembly

12.2 Materials

Qty	U	ID	Description
4	Ea	D070309	Top Blade Guard Riser
2	Ea	D070310	Top Blade Guard Bar
8	Ea	NA	Socket Head Cap Screw ¼-20 x 1.0” SSTL
8	Ea	NA	Flat Washer, ¼” Vented SSTL
4	Ea	D0900999	Socket Head Cap Screw ¼-20 x 2.0” SSTL Round-Tip
4	Ea	NA	Hex Nut ¼-20 AgPlated

12.3 Procedure

1. Assemble 2 D070308 Top Blade Guard Assemblies, each with:
   - 2 D070309 Top Blade Guard Riser
   - 1 D070310 Top Blade Guard Bar
   - 4 Socket Head Cap Screws ¼-20 x 1.0” SSTL
   - 4 Flat Washers, ¼-20 Vented SSTL
   - 2 D0900999 Socket Head Cap Screw 2 ¼-20 x 2.0” SSTL Round-Tip
   - 2 Hex Nut ¼-20 AgPlated

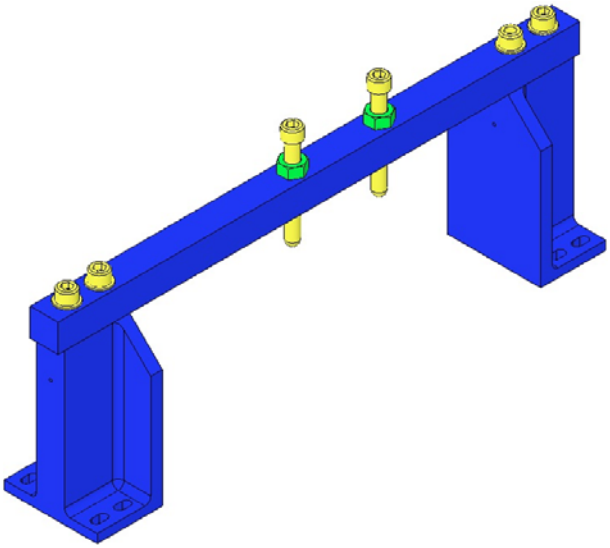

Fig 28: Top Blade Guard Assembly

13 Assembling the Rotational Adjusters

13.1 Documents

D070326 HLTS Rotational Adjuster
E1000169 Blade Characterization Spreadsheet
T0900559 Blade Pairings Spreadsheet

13.2 Materials

Qty	U	ID	Description
1	Ea	D080265	HLTS Upper Blade Bake Fixture
1	Ea	D070327	HLTS RA Base Plate
1	Ea	D070328	HLTS RA Rotating Plate
3	Ea	NA	Socket Head Cap Screw ¼-20 x 0.625" SSTL
3	Ea	NA	Flat Washer ¼"
1	Ea	D070329	HLTS RA Pull Plate
2	Ea	NA	Socket Head Cap Screw 8-32 x 1.0" AgPlated
1	Ea	D070330	HLTS RA Push Plate
2	Ea	NA	Socket Head Cap Screw 8-32 x 1.25" AgPlated
1	Ea	NA	Socket Head Cap Screw 8-32 x 1.5" Fully-Threaded SSTL
1	Ea	NA	Flat Washer #8 Vented SSTL
1	Ea	NA	Socket Head Cap Screw 8-32 x 1.5" Full-Thread Round-Tip SSTL
3	Ea	NA	Socket Head Cap Screw 5/16-18 x 1.75" AgPlated
3	Ea	NA	Flat Washer 5/16" Vented SSTL
1	Ea	D0900665	HLTS Upper Blade Library of Clamps
2	Ea	D020617	Upper Blade
2	Ea	Various	Upper Blade Clamp Inside
2	Ea	D070331	Upper Blade Clamp Shim, 1.0mm Consult with a Suspension Design Engineer to verify that 1.0 is appropriate; Shim height needed depends upon actual Weldment height.
1	Ea	D020660	Blade Pulldown Device
1	Ea	NA	Machinist's Square

13.3 Procedure

- Prepare a D020660 Blade Pulldown Device with:
- 1 D0901814 Upper Clamp, Inside
- 1 D070341 Upper Clamp, Outside
- Socket Head Cap Screw 8-32 x 0.5" AgPlated
- Flat Washer #8 Vented, SSTL
- 2' of 0.024" Wire.

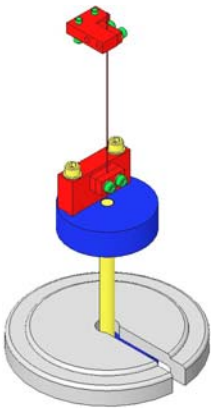

Fig 29: Blade Pulldown Device

1. Remove the Bridges and Side Supports from the D080268 Upper Blade Bake Fixture Base Plate.
2. Mount the Base Plate to an Optics Table, leaving one end of the Plate extending beyond the Table Edge to accommodate the Blade Pulldown Device.Assemble 2 D070328 Rotational Adjuster Rotating Plates to the Fixture Base Plate using:
   - 4 Socket Head Cap Screws ¼-20 x .625" SSTL
   - 4 Flat Washers ¼" Vented SSTL

   Tighten the Screws firmly.

   Square the edge of the Rotational Adjuster Rotating Plate against the Fixture Stop Block.
3. Assemble the D1003307 Hold Down Bar to the Fixture using:
   - 2 Socket Head Cap Screws ¼-20 x 1.00" SSTL
   - 2 Flat Washer ¼" Vented SSTL

   Tighten the Screws firmly.

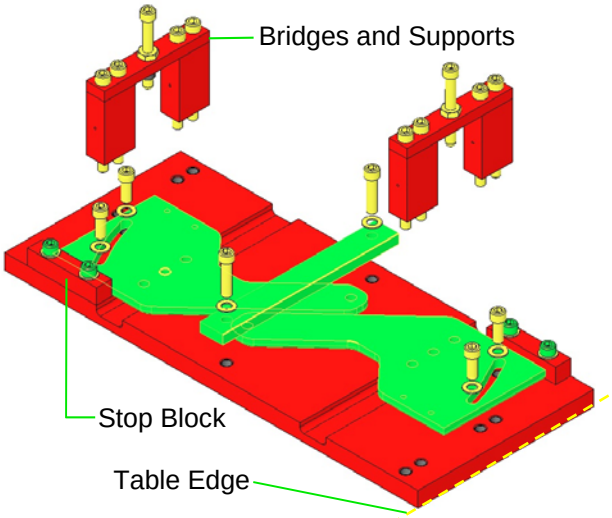

Fig 30: Rotating Plates & Hold Down Bar

4. Select a matching pair of Upper Blades and Clamps per the E1000169 Blade Characterization Spreadsheet:
   - Blade launch angle is set by Blade Clamps. These range from 0-3.5 deg. in .5 deg. increments.
   - Select Clamps from the D0900665 HLTS Upper Blade Library of Clamps
   - Select Clamps according to Blade Characterization data for stiffness and expected load.
   - Select Blades in pairs according to Blade Characterization data.
   - Align the Blade, Clamps and Shim using a Precision Square.
   - Record the Blade serial numbers and Blade clamp angles and orientations within ICS.

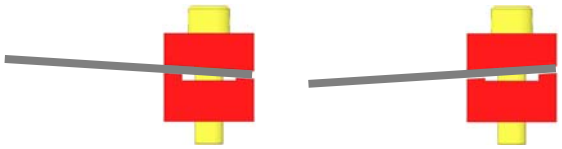

Fig 31: Clamps Control Launch Angle

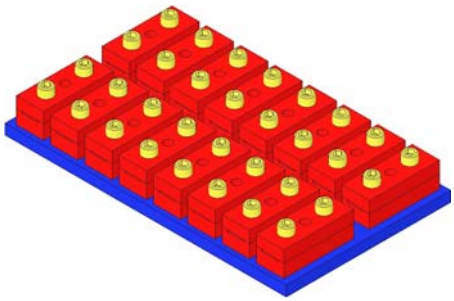

Fig 32: Upper Blade Library of Clamps

5. Assemble to the Rotational Adjuster Blade Rotating Plate furthest from the Table edge:
   - 3 Socket Head Cap Screws 5/16-18 x 1.75" AgPlated
   - 3 Flat Washers 5/16" Vented SSTL
   - D09006XX Upper Blade Clamp Outside
   - D020617 Upper Blade
   - D09006XX Upper Blade Clamp Inside
   - D070331 Upper Blade Clamp Shim 1.0mm

     Consult with a Suspension Design Engineer to verify that 1.0mm is appropriate; Shim height needed depends upon actual Weldment height.

     Using the Machinist's Square, Square the Blade, Clamps, and Shim to each other and to the Rotating Plate and hand-tighten the 3 Screws
6. Hang the 18.252 kg Pulldown Weight from the Blade Tip
7. Assemble to the Bake Fixture Base Plate:
   - 2 D1003306 Side Support
   - 1 D080267 Top Bridge
   - 4 Socket Head Cap Screws ¼-20 x 2.5" SSTL
     Tighten the Screws firmly
   - D0900999 Socket Head Cap Screw ¼-20 x 2.0" Round-Tip
   - Hex Nut ¼-20 AgPlated
8. Turn down the Round Tip Screw until the weighted Blade tip is level with the Blade root.

   Be careful not to damage the nickel plating on the blade

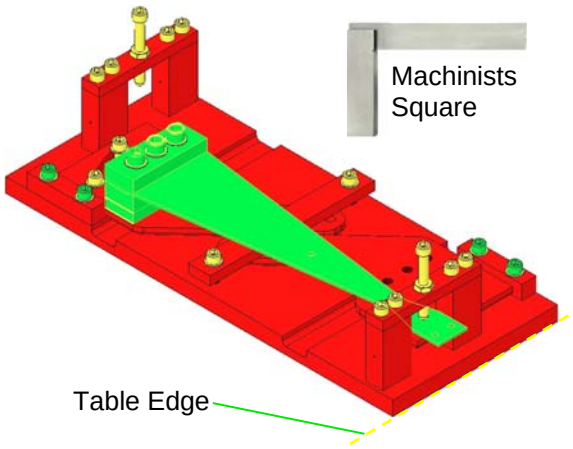

Fig 33: Blade & Clamps Assembled

9. Leaving the Wire Clamp attached to the Blade, remove the rest of the Blade Pulldown Device.
10. Tighten the 5/16" Screws to 184 in-lb.
11. Re-attach the Blade Pulldown Device to the Wire Clamp.
12. Turn back the Round Tip Screw and remove the Top Bridge and Side Supports.
13. Slowly lift and then remove the Blade Pulldown Device, allowing the Blade to curve fully upward.
14. Detach the Bake Fixture from the Optics Table, rotate it 180 deg., and remount it on the Optics Table, leaving one end of the Plate extending beyond the Table Edge to accommodate the Blade Pulldown Device.
15. Repeat steps 7-15 to assemble the second Upper Blade to the Bake Fixture.
16. Remove the Hold-down Bar.
17. Disassemble both Rotational Adjusters from the Upper Blade Bake Fixture.

18. Assemble the D070328 Rotating Plate to the D070327 HLTS Rotational Adjuster Base Plate using:
    - 3 Socket Head Cap Screw ¼ – 20 x 0.625" SSTL
    - 3 Flat Washer ¼" Hand-tighten only, for now.

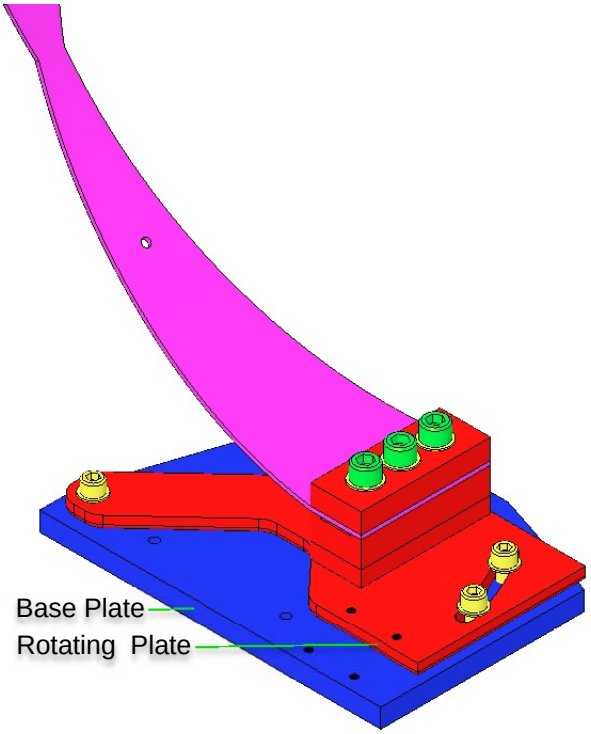

Fig 34: Attaching Base Plate

19. Assemble to the Base Plate:
    - 1 D070329 Pull Plate
    - 2 Socket Head Cap Screws 8-32 x 1.0" AgPlated
    - 1 D070330 Push Plate
    - 2 Socket Head Cap Screws 8-32 x 1.25" AgPlated
    - 1 Socket Head Cap Screw 8-32 x 1.5" Fully Threaded SSTL
    - 1 Flat Washer #8 Vented SSTL
    - 1 Socket Head Cap Screw 8-32 x 1.5" Fully Threaded, Round Tip SSTL

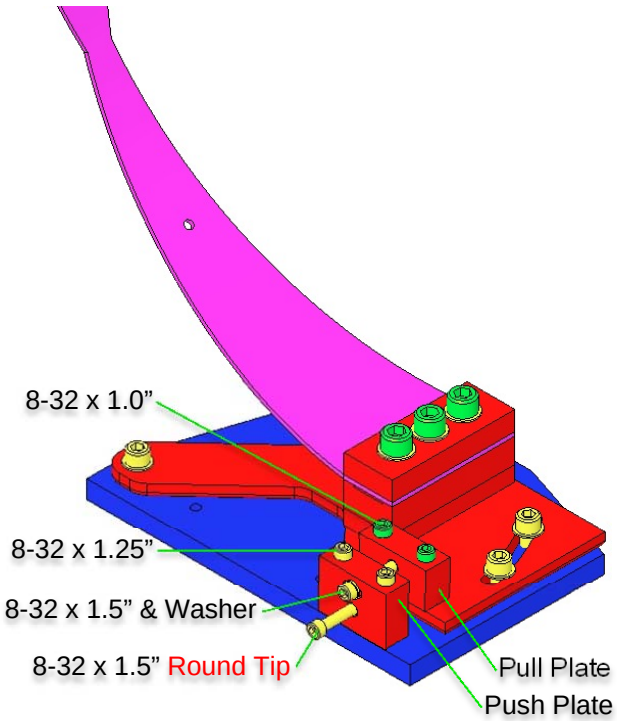

Fig 35: Assembling Push & Pull Plates

14 Assembling Magnets – Upper Mass

14.1 Documents

M0900034 RODA - Use of Magnets in Suspensions

D1001695 Magnet and Flag Assembly, BOSEM

14.2 Materials

Qty	U	ID	Description
9	Ea	D1100573	BOSEM Flat Magnet Flag
9	Ea	D1100574	BOSEM Flat Magnet Flag Disk
9	Ea	NA	Flat Head Socket Screw 4-40 x 0.1875” SSTL
9	Ea	DCNI 01888N	Sintered NdFeB Magnet, Ni Plated, 10mm x 5mm
9	Ea	D1001534	BOSEM Magnetic Plug
9	Ea	D1001697	HLTS BOSEM Magnet Retainer

14.3 Procedure – Assembly

1. Assemble 9 D1001695 BOSEM Magnet / Flag Assemblies, each with (shown left-to-right):
   - D1100573 BOSEM Flat Magnet Flag
   - D1100574 BOSEM Flat Magnet Flag Disk
   - Flat Head Socket Screw 4-40 x 0.1875” SSTL
   - Magnet D394394N35UHP Sintered NdFeB Ni-Plated 10 mm x 10 mm
   - D1001534 BOSEM Magnetic Plug
   - D1001697 HLTS BOSEM Magnet Retainer

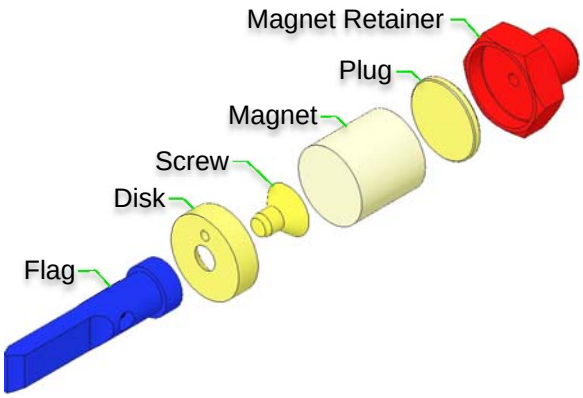

Fig 36: HLTS BOSEM Magnet/Flag Assembly

The Magnets attach the Flags to the Upper Mass. Since the Flags are aluminum and the Magnet Retainers are non-magnetic stainless steel, a magnetic 416 stainless steel Magnetic Plug is press-fit into each Flag and Magnet Retainer. The press-fitting operation must be done after all parts are cleaned and baked. The Press itself must be cleaned and/or wrapped in UHV foil.

14.4 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 37: Heating Fixture with Holders

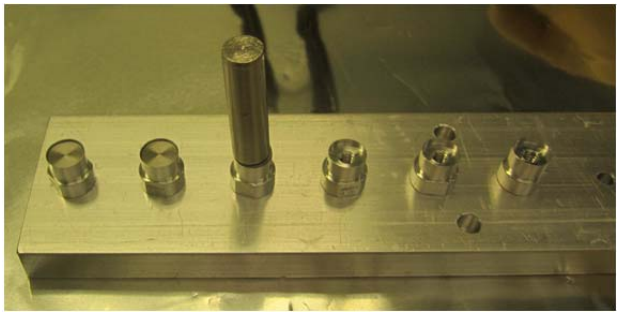

Fig 38: Insertion Tool in position

Note: Tapered end of Tool is up
Note: Seated Disks on left 2 Holders

15 Assembling Upper Mass and Coil Holder (M1)

15.1 Documents

D070335 Upper Mass Assembly
D080677 Coil Holder Assembly

15.2 Materials

Qty	U	ID	Description
1	Ea	D040259	Upper Mass Jig
1	Ea	D020605	**HLTS Upper Mass Main Section**
1	Ea	D020607	**Upper Mass T-Piece**
8	Ea	NA	Socket Head Cap Screw ¼-20 x 1.25” AgPlated SSTL
1	Ea	D1001669	Pitch Insert
1	Ea	NA	Socket Set Screw ½-20 x 3.5” AgPlated
2	Ea	NA	Socket Set Screw ¼-20 x 2.0” Fully-Threaded SSTL
2	Ea	D080221	HLTS Lower Blade Guards
4	Ea	D030025	Socket Head Cap Screws 8-32 x 1.0” SSTL Fully-Threaded Round-Tip
8	Ea	NA	Hex Nuts 8-32 AgPlated
4	Ea	NA	Socket Head Cap Screws 4-40 x 0.375” AgPlated SSTL
12	Ea	NA	Flat Washers #8 Vented SSTL
4	Ea	Various	HLTS Blade Clamp, Lower Blade, Inside
4	Ea	D020615	Lower Blade
4	Ea	Various	HLTS Blade Clamp, Lower Blade, Outside
10	Ea	NA	Flat Washer ¼” SSTL
4	Ea	D020653	Screwdrive Block
8	Ea	NA	Socket Head Cap Screw 8-32 x 1.0” AgPlated
4	Ea	NA	Socket Head Cap Screw ¼-20 x 1.125” AgPlated
1	Ea	D030139	Roll Offset, Upper Mass T-Piece
2	Ea	NA	Socket Set Screw ¼-20 x 0.5” AgPlated
4	Ea	NA	Socket Head Cap Screw ¼-20 x 2.0” SSTL
4	Ea	NA	Hex Nut ¼-20 AgPlated
9	Ea	D1001699	Magnet Holder, HLTS BOSEM
18	Ea	NA	Socket Head Cap Screw 4-40 x 0.625” AgPlated
9	Ea	D1001695	Magnet / Flag Assembly
2	Ea	D070340	**HLTS Upper Wire Assemblies**
4	Ea	D070393	**HLTS Intermediate Wire Assemblies**
1	Ea	NA	Machinist’s Square
			Components Added Only for Weighing
2	Ea	D020652	Upper Mass C-Clamp
2	Ea	D020610	Inside Upper Wire Lower Clamp
2	Ea	D020624	Outside Upper Wire Lower Clamp
4	Ea	NA	Socket Head Cap Screw 8-32 x 0.5” AgPlated
4	Ea	NA	Socket Head Cap Screw 8-32 x 1.125” SSTL
4	Ea	NA	Flat Washer #8 SSTL
1	Ea	D070449	**HLTS Coil Holder**
8	Ea	NA	Socket Head Cap Screw 4-40 x 0.25” AgPlated
4	Ea	NA	Flat Washer #4, Vented, SSTL

Qty	U	ID	Description
2	Ea	D020660	**Lower Blade Pulldown Device** • 6.092 kg Hang Weight • Lower Blade Wire Clamp from Intermediate Wire Assembly • 8 Socket Head Cap Screw 4-40 x 0.25" AgPlated • Music wire .008" dia. minimum, about 18" long, clamped at one end, and with a small loop tied in the other.)

15.3 Procedure

1. Assemble to the D020605 Upper Mass Main Section:
   - D020607 Upper Mass T-Piece
   - 4 Socket Head Cap Screws
     ¼-20 x 1.125" AgPlated
     Torque to 100 in-lb

2. Assemble to the D1001669 Pitch Insert:
   - 1 Socket Set Screw
     ½-20 x 3.5" AgPlated
3. Assemble to the T-Piece:
   - 1 D1001669 Pitch Insert
     Center the Insert within the T-Piece
   - 2 Socket Set Screws
     ¼-20 x 1.5" AgPlated

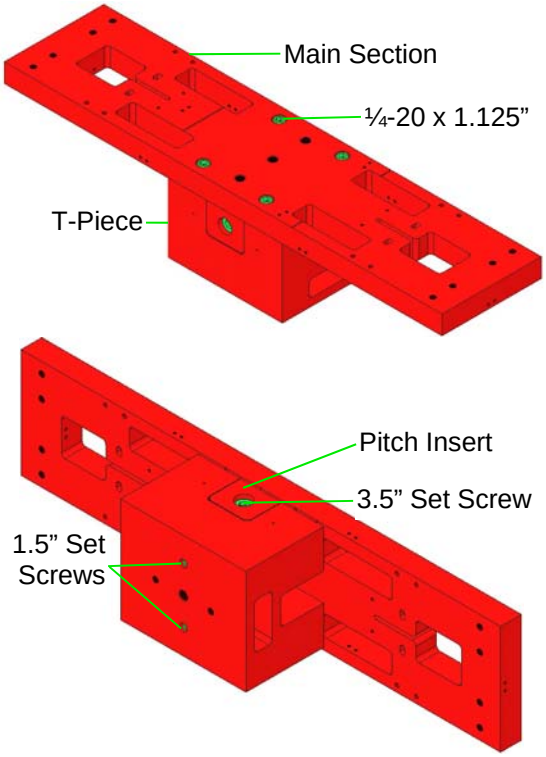

Fig 39: T-Piece Assembled to Main Section

4. Attach the D040259 Upper Mass Jig to an Optics Table with a ¼-20 Ag-Plated Bolt.
5. Thread the T-Piece 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.

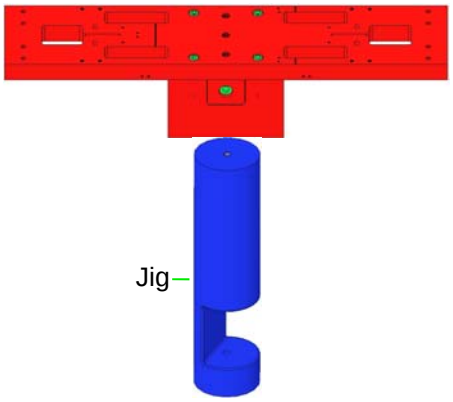

Fig 40: Upper Mass mounted on Jig

Use safety glasses per E0900332.

Note: Blades are shown here as flattened, but are actually curved until weighted.

6. Per data in T0900559 Blade Pairings, retrieve:
   - 4 matched D020615 Lower Blades.
   - 4 pair (Upper/Lower) of Lower Blade Clamps, each pair with a Clamp angle corresponding to the Matched Blades chosen above. The D0900681 Library of Clamps lists all Blade Clamp angles and part numbers.
   - Identify the placement of the blades 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

7. Attach the 2 Clamp/Wire Assemblies from the Lower Blade Pulldown Device to the tip of each Blade.
   - 2 D0901815 Upper Clamp, Int. Wire, Inside
   - 2 D0901813 Upper Clamp, Int. Wire, Outside
   - 4 Socket Head Cap Screw 4-40 x .375” AgPlated
   - 4 Flat Washer #4 Vented SSTL
   - 4 Socket Head Cap Screw 4-40 x .25” AgPlated

8. Assemble each Lower Blade as shown:
   - 2 Socket Head Cap Screws ¼-20 x 1.25” AgPlated SSTL
   - 2 Flat Washer ¼ Vented SSTL
   - 1 Lower Blade Clamp, Lower
   - 1 D020615 Lower Blade
   - 1 Lower Blade Clamp, Upper

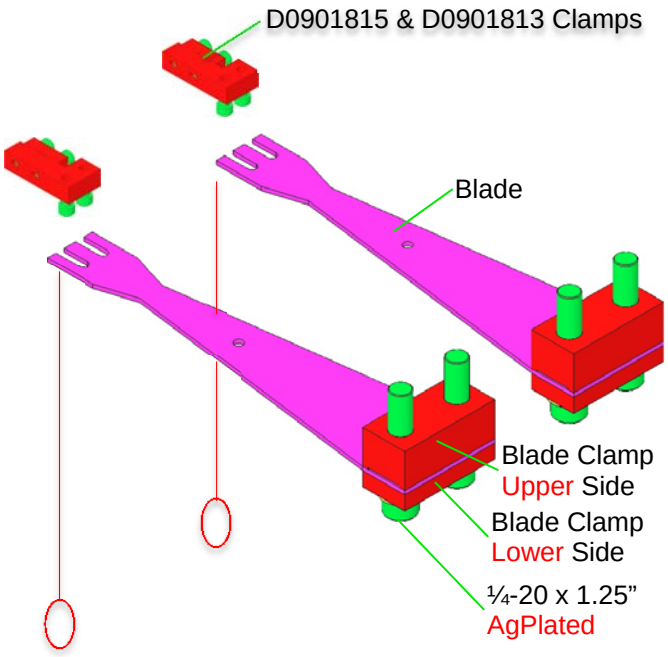

Fig 41: Weighting the Blades

9. Attach the 2 Blade assemblies to the Upper Mass Main Section and snug the bolts finger- tight. Ensure the Blades are aligned such that the Blade tips can move through the oval cutouts without touching the cutout walls.
10. Use the Machinist's Square to ensure the Blades and Blade Clamps are square with the Main Section.

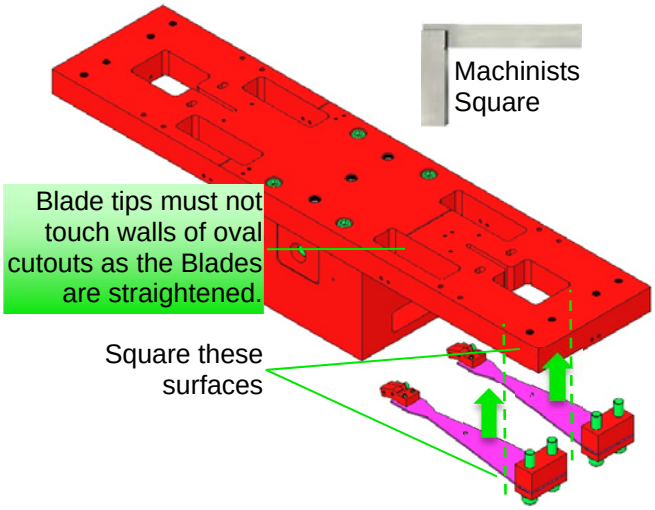

Fig 42: Attaching the Blades

11. Hang the 2 D020660 Pulldown Device Weights on the wire loops. The weight will pull the blade tip through the oval slot in the Upper Mass Main Section until the Blade is essentially flat.

    Torque the 4 Screws to 100 in-lb.

    Be sure to Torque the Screws only after the Blades have been pulled down.

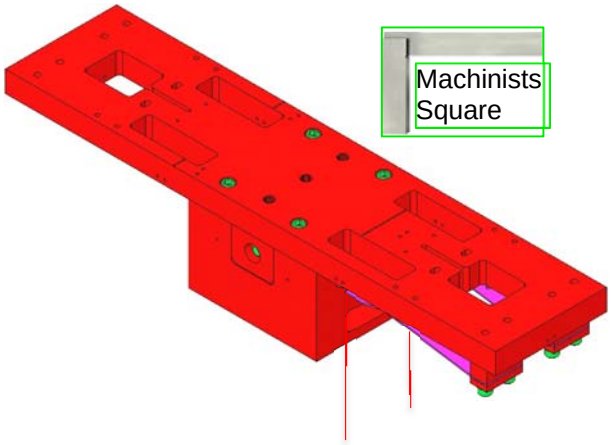

Fig 43: Adding Weight to the Blades

Fig 44: Verifying Blade Matching

12. Visually verify that the profiles of pairs of Blades match ± 0.5 mm.

    If the Blades are not of identical flatness within 1 mm, either the Blades or Blade Clamps must be replaced to achieve this flatness. Blade Clamps are available in angles from 0 – 3.5 deg.

    When using Blade Clamp pairs other than 0 deg., CAREFULLY INSPECT CLAMP ORIENTATION to ensure the pairs are aligned so that the Clamp sidewalls are parallel (and therefore, the bolt holes are concentric).

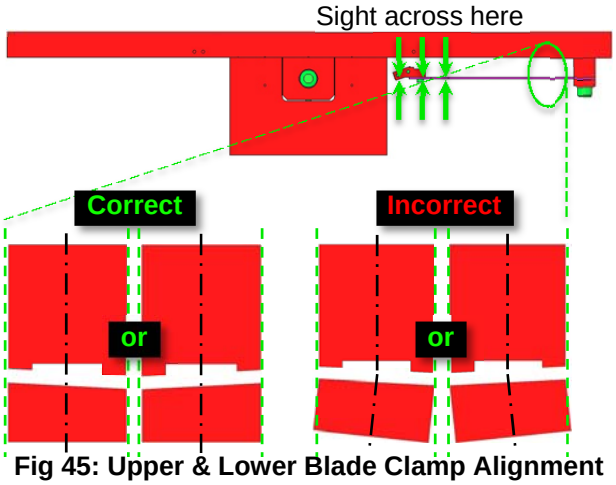

Fig 45: Upper & Lower Blade Clamp Alignment

13. Assemble to 2 D080221 Lower Blade Guards:
    - 4 D030025 Socket Head Cap Screws 8-32 x 1.0" Round Tip SSTL
    - 4 Hex Nuts 8-32 AgPlated
14. Attach the Blade Guards to the D020605 Main Section using:
    - 4 Socket Head Cap Screws 4-40 x 0.375" AgPlated
    - 4 Flat Washers #8 Vented SSTL

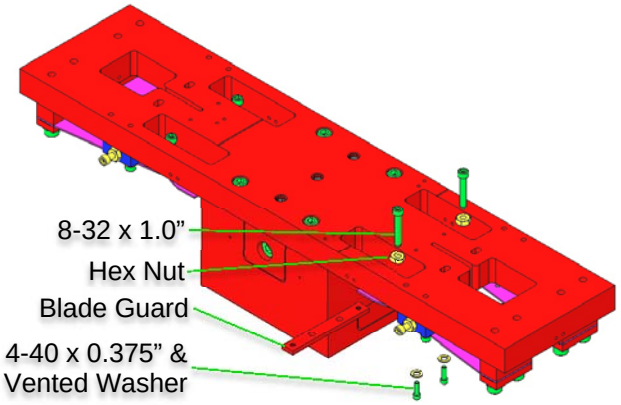

Fig 46: Main Section with Blade Guards

15. Assemble 4 sets of Screw Drives to the Upper Mass Main Section:
    - 1 D020653 Screwdrive Block
    - 2 Socket Head Cap Screw 8-32 x 1.00" AgPlated
    - 2 Flat Washer #8 SSTL
    - 1 Socket Head Cap Screw 8-32 x 1.50" SSTL Round Tipped
    - 1 Hex Nut 8-32 AgPlated Tighten Finger-Tight

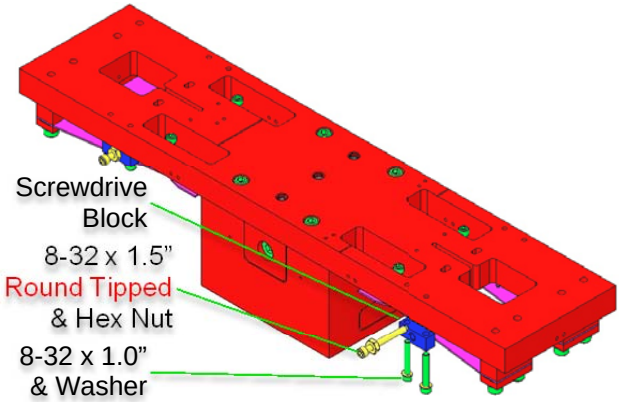

Fig 47: Screw Drives Installed

16. Assemble to the T-Piece:
    - D030139 Roll Offset Center the Offset within the T-Piece
    - 2 Socket Set Screw ¼-20 x 0.5"AgPlated
    - D1001669 Pitch Insert
    - 1 Socket Set Screw ½-20 x 3.0" AgPlated
    - 2 Socket Set Screw ¼-20 x 1.5" AgPlated
    - 2 Socket Head Cap Screw ¼-20 x 2.0" SSTL
    - 2 Hex Nut ¼-20 AgPlated

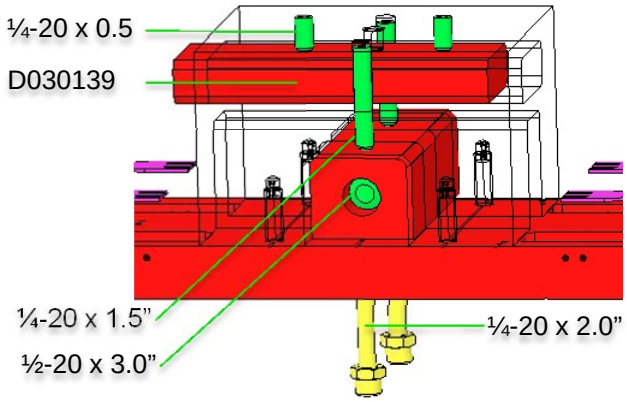

Fig 48: Roll Offset and Pitch Insert added

17. Assemble 9 assemblies to the Upper Mass Main Section, each with:
    - 1 D1001699 Magnet Holder
    - 2 Socket Head Cap Screws 4-40 x 0.625" AgPlated Torque to 6 in-lb
    - 1 D1001695 Magnet / Flag Assembly Leave off one of the end Magnet Flag assemblies until the Coil Holder has been assembled to the Upper Mass.

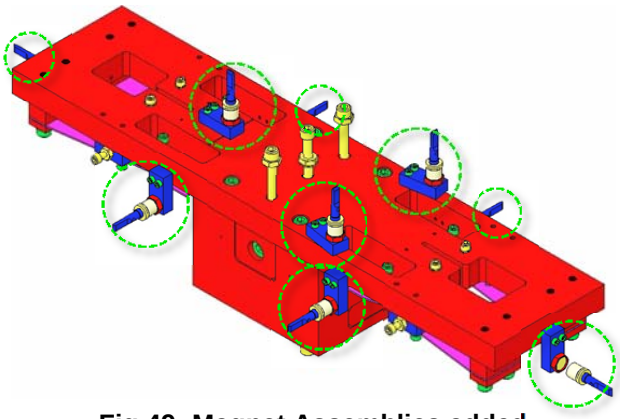

Fig 49: Magnet Assemblies added

18. Weigh the Upper Mass Assembly (including all 9 Magnet/Flag assemblies) along with these additional mass components:

    2 Upper Wire, Lower Clamp Assemblies
    - 2 D020652 Upper Mass C-Clamps
    - 2 D020610 Inside Upper Wire Lwr Clamp
    - 2 D020624 Outside Upper Wire Lwr Clamp
    - 4 Socket Head Cap Screw 8-32 x 0.5" AgPlated
    - 4 Flat Washer #8 Vented SSTL
    - 4 Socket Head Cap Screw 8-32 x 1.125" SSTL
    - 4 Flat Washer #8 SSTL

    4 Int. Wire, Upper Clamp Assemblies
    - 4 D070585 Upper Clamp, Inside
    - 4 D070394 Upper Clamp, Outside
    - 8 Socket Head Cap Screws 4-40 x .375" AgPlated
    - 8 Flat Washer #4 Vented
    - 8 Socket Head Cap Screws 4-40 x 0.25" AgPlated

    Hardware for Additional Mass Disks
    - 2 Socket Head Cap Screw ¼-20 x 2.0" SSTL
    - 2 ¼-20 Hex Nut AgPlated
    - 2 Flat Washer ¼" SSTL
    - Additional Mass Disks sufficient to bring the total mass to 12.087 kg. The additional mass should be divided equally between top disks and bottom disks.

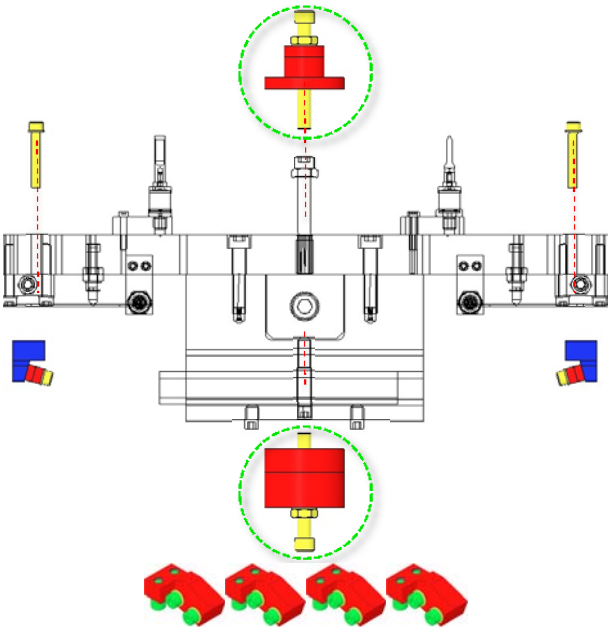

Fig 50: Weighing the Assembly

19. Record the actual mass, and the actual additional mass amount and locations, in ICS.

20. Attach 2 Upper Wire Assemblies. Grasp the Upper Clamp end of each D070340 Upper Wire Assembly and feed the Assemblies upwards through the outboard openings toward either end of the Upper Mass. Attach to the Upper Mass with:
    - 4 Socket Head Cap Screws 8-32 x 1.125" SSTL
    - 4 D1100785 Flat Washer #8 Nitronic 60

    If any Wire becomes bent during assembly, replace with another Wire Assembly.
21. Attach 4 D070393 Intermediate Wire Assemblies to the 4 Lower Blades, with:
    - 8 Socket Head Cap Screw 4-40 x 0.25" AgPlated Torque to 6 in-lb

    Fit the tab on the bottom of the Upper Clamp into a slot on the Lower Blade.

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

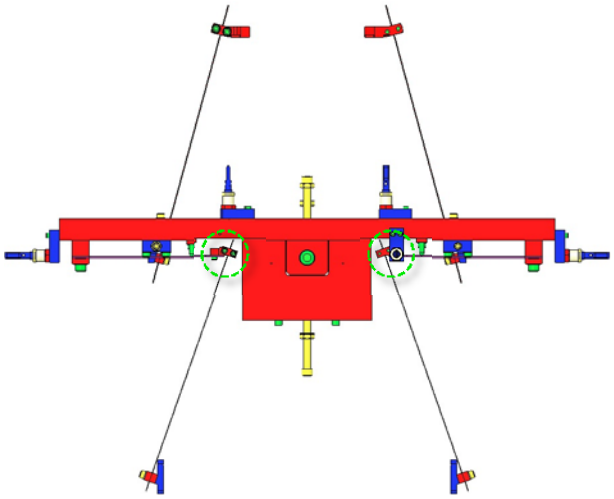

Fig 51: Intermediate Wire Assemblies added

22. Assemble 12 EQ Stops to the D070449 Coil Holder:
    - 12 Socket Head Cap Screws ¼-20 x 1.0" Fully-Threaded Round-Tip SSTL
    - Hex Nut ¼-20 AgPlated
23. Place the Coil Holder over the Upper Mass. Feed the Upper Wire Assemblies through the Coil Holder; feed the Intermediate Wires through the holes on the ends of the Coil Holder.
24. Assemble to the Upper Mass:
    - 2 Socket Head Cap Screws
    - ¼-20 x 2.0" Fully-Threaded SSTL
    - 4 Hex Nuts, ¼-20 AgPlated

    Tighten the Hex Nuts to secure the Upper Mass to the Coil Holder.

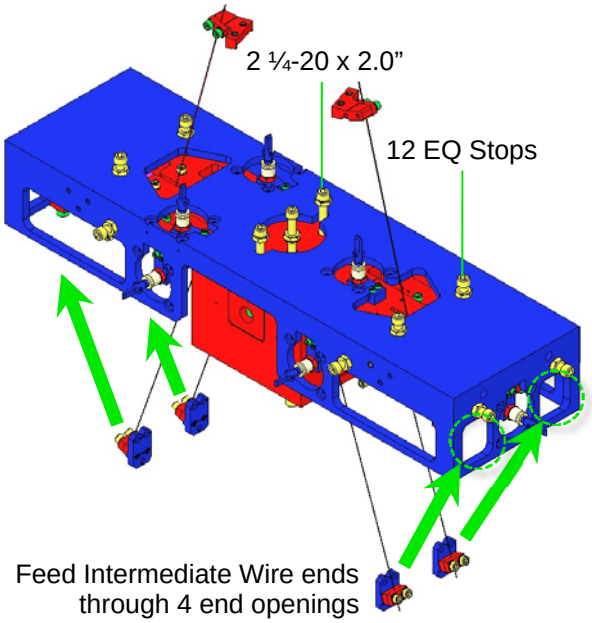

Fig 52: Coil Holder added

16 Assembling Intermediate Mass (M2)

16.1 Documents

D070334 HLTS Intermediate Mass Assembly

16.2 Materials

Qty	U	ID	Description
1	Ea	D070336	Main Section, Intermediate Mass
1	Ea	D080181	**Changer Assembly, Intermediate Mass**
1	Ea	D030155	Center Offset, Intermediate Mass
2	Ea	NA	Socket Head Cap Screw 8-32 x 0.75" SSTL
2	Ea	NA	Socket Head Cap Screw 8-32 x 0.75" AgPlated
X	Ea	D1001230	HLTS Additional Mass Disk 10g
X	Ea	D1001229	HLTS Additional Mass Disk 20g
X	Ea	D0901405	HLTS Additional Mass Disk 50g
X	Ea	D070333	HLTS Additional Mass Disk 100g
2	Ea	D030156	Side Offset, Intermediate Mass
4	Ea	NA	Socket Head Cap Screw ¼-20 x 1.5" Fully-Threaded SSTL
4	Ea	NA	Hex Nut ¼-20 AgPlated
4	Ea	NA	Flat Washer ¼ Vented SSTL
4	Ea	NA	Socket Head Set Screw ¼-20 x 0.50" AgPlated
2	Ea	NA	Socket Head Set Screw ¼-20 x 0.25" AgPlated
			Components for Weighing
4	Ea	D030149	Breakoff, Intermediate Wire
4	Ea	D070406	Lower Clamp, Intermediate Wire, Outside
4	Ea	D070405	Lower Clamp, Intermediate Wire, Inside
8	Ea	NA	Socket Head Cap Screw 8-32 x 0.625" SSTL
8	Ea	NA	Flat Washer #8 Vented SSTL
2	Ea	D030148	Lower Wire Breakoff
4	Ea	D070438	Upper Clamp, Lower Wire, Outside
4	Ea	NA	Socket Head Cap Screw 8-32 x 0.5625" SSTL
4	Ea	NA	Flat Washer #8 Vented SSTL

16.3 Procedure

1. Assemble the D080181 Changer Assembly:
   - D030155 Center Offset
   - 300g nominal Upper Collar D080223
   - 300g nominal Lower Collar D080232
     100g Collars shown
   - Socket Head Cap Screw
     8-32 x 0.75" SSTL or AgPlated
     Use SSTL with Aluminum Collars
     Torque SSTL Screws to 20 in-lb
     Use AgPlated with SSTL Collars
     Torque AgPlated Screws to 30 in-lb

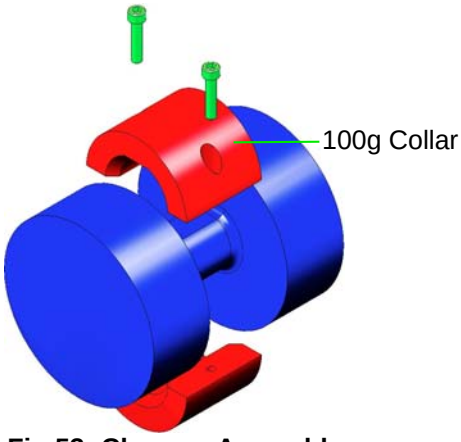

Fig 53: Changer Assembly

2. Assemble 2 Side Offset assemblies, each with:
   - 1 Side Offset D030156
   - 2 Mass Disk D070333 100g nominal
   - 2 Flat Washer ¼" Vented SSTL
   - 2 Hex Nut ¼-20 AgPlated
   - 2 Socket Head Cap Screw ¼-20 x 1.5" SSTL

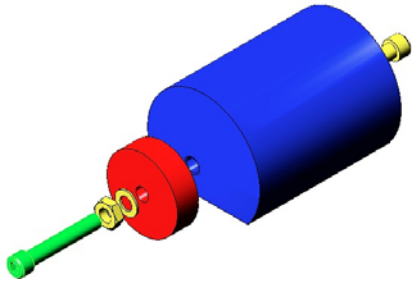

Fig 54: 1 of 2 Side Offset Assemblies

3. Slide the Changer Assembly and 2 Side Offsets into the D070336 Main Section and secure with:
   - 4 Socket Head Set Screw ¼-20 x 0.50" AgPlated
   - 2 Socket Head Set Screw ¼-20 x 0.25" AgPlated

   Rotate Side Offsets so Mass Disks are toward the center, and Scribe Lines are aligned.

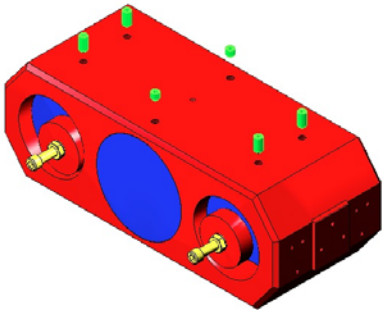

Fig 55: Changer and Offsets in Main Section

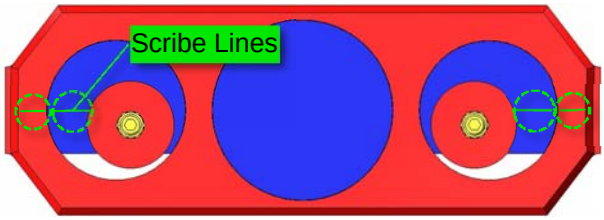

Fig 56: Completed Intermediate Mass Assembly

4. Weigh the completed Assembly along with:
   - 4 D030149 Breakoff, Intermediate Wire
   - 4 D070406 Lower Clamp, Intermediate Wire, Outside
   - 4 D070405 Lower Clamp, Intermediate Wire, Inside
   - 8 Socket Head Cap Screw 8-32 x 0.625" SSTL
   - 8 Flat Washer #8 Vented SSTL
   - 12 Socket Head Cap Screw 8-32 x .625" SSTL AgPlated
   - 2 D030148 Lower Wire Breakoff
   - 4 D070438 Upper Clamp, Lower Wire, Outside
   - 4 Socket Head Cap Screw 8-32 x 0.5625" SSTL
   - 4 Flat Washer #8 Vented SSTL
   - 6 Socket Head Cap Screw 8-32 x .625" SSTL AgPlated
   - 4 D0901927 Magnets
   - 4 D970075 Magnet Standoffs

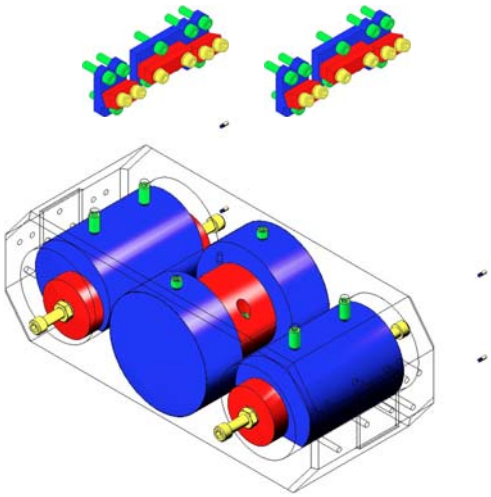

Fig 57: Items to Weigh

5. Swap Collars and Disks (red) to reach a total weight of 12.227 kg. Record the total weight, noting changes in Disks or Collars. Record the size and location of the added weights within ICS.

17 Assembling Bottom Mass and Optic (M3)

17.1 Documents

D070337 HLTS Bottom Mass Assembly

17.2 Materials

Qty	U	ID	Description
1	Ea	D070338	Metal Bottom Mass
1	Ea	D0902658	Optic Holder
1	Ea	D0902661	Sapphire Prism Bonding Jig
4	Ea	D980184	LOS Clamps, Long
2	Ea	D1100197	Spacer
2	Ea	033-0280	Optosigma Mirrors
8	Ea	NA	Socket Head Cap Screw 4-40 x 0.5” Vented SSTL
2	Ea	D080124	Prism Breakoff, Lower Wire, Lower Mass
4	Ea	NA	Socket Head Cap Screw 8-32 x 0.75” SSTL
12	Ea	NA	Flat Washer #8 Vented SSTL
8	Ea	NA	Flat Washer #4 Vented SSTL
2	Ea	D0901286	Secondary Metal Prism Breakoff
2		D070441	Sapphire Prism Breakoff

17.3 Procedure

1. Place the D070338 Metal Bottom Mass, with the inscribed arrow on top of the Mass, pointing away from the glued-on Dumbbell Magnets, into the D0902658 Optic Holder.

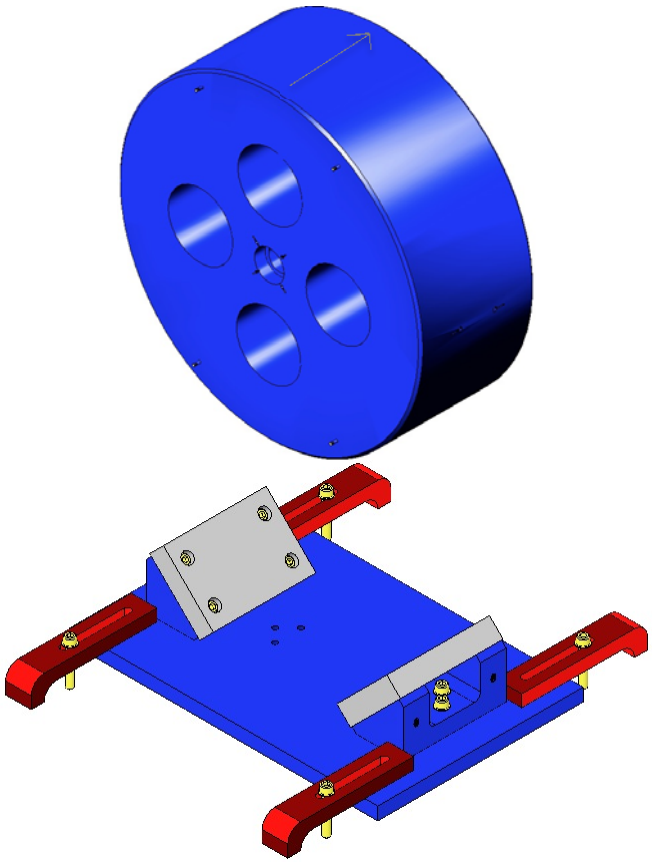

Fig 58: Optic Holder and Bottom Mass

2. Assemble to the Bottom Mass:
   - 2 D1100197 Spacers
   - 2 033-0280 Optosigma Mirrors
   - 8 Socket Head Cap Screws 4-40 x 0. 5" Vented SSTL
   - 8 Flat Washer # 4 Vented SSTL Torque to 7 in-lb

   - 2 D080124 Prism Breakoffs
   - 4 Socket Head Cap Screws 8-32 x 0.75 SSTL
   - 4 Flat Washers #8 Vented SSTL Torque to 25 in-lb

   The Spacer wings must be aligned with the Screw locations.

   Mirror Arrow must face outwards.

   Be especially careful not to damage the glued magnet/dumbbell assemblies.

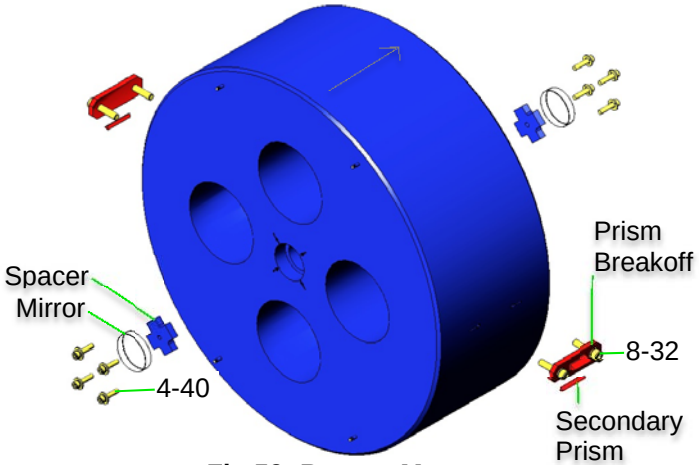

Fig 59: Bottom Mass

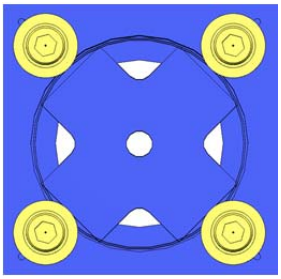

Fig 60: Orientation of Spacer

The fixture is used to attach the Sapphire Prism Breakoff (D070441) to the fused silica optics. The Sapphire Prism Placement Fixture is made up of the Optic Holder (D0902658) and the Sapphire Prism Bonding Jig (D0902661). The Sapphire Prism Bonding Jig itself is made up of the Sapphire Prism Bonding Fixture (D0902662) and the Sapphire Prism Holder Assembly (D0902663).

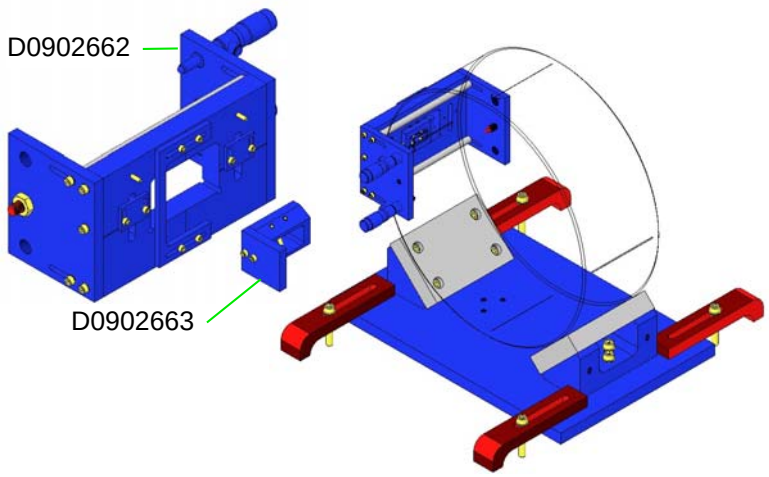

Fig 61: Sapphire Prism Bonding Jig

3. With the assembly process complete, weigh the Bottom Mass Assembly with the D0901286 Secondary Metal Prism Breakoffs; the combined weight should be 12.142 kg. Record this value in ICS. The Bottom Mass is not designed to be weight-adjusted; weight is added to or subtracted from the Intermediate Mass. So adjusting Bottom Mass weight is actually adjusting the combined weight of the Intermediate and Bottom Masses, a total of 12.227 + 12.142 kg = 24.369 kg.

18 Assembling EQ Stops For Intermediate and Bottom Masses

18.1 Documents

D070447	HLTS Overall Assembly
D080726	HLTS EQ Stop, Long Mount
D080727	HLTS EQ Stop, Long Bracket
D1002821	HLTS EQ Stop Assembly, Bottom Mass, Lower
D1102071	HLTS EQ Stop, Bridge, Upper
D070319	HLTS Bridge EQ Stops

18.2 Materials

Qty	U	ID	Description
10	Ea	D070460	Long EQ Stop Mount
8	Ea	D070322	Long EQ Stop Bracket
4	Ea	D1002823	EQ Stop Bracket Back, Bottom Mass, Lower
4	Ea	NA	Socket Head Cap Screws 8-32 x 1.0” SSTL
4	Ea	NA	Flat Washer #8 Vented SSTL
4	Ea	D070321	EQ Stop Bridge Crossbar
8	Ea	D1102072	Bridge EQ Stop Mount, Upper
28	Ea	D080725	EQ Stop for Metal or Glass
28	Ea	NA	Hex Nut ¼-20 AgPlated
8	Ea	NA	Socket Head Cap Screw ¼-20 x 0.75” SSTL
8	Ea	D1100785	Flat Washer, ¼”, Nitronic 60

18.3 Procedure

1. Assemble 10 D080726 Long Mount EQ Stops, each using:
   - 1 D070460 Long EQ Stop Mount
   - 1 D080725 EQ Stop for Metal or Glass
   - 1 Hex Nut ¼-20 AgPlated

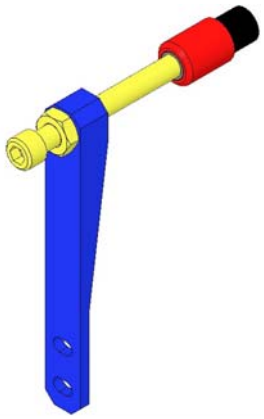

Fig 62: D080726 Long Mount EQ Stop

2. Assemble 8 D080727 Long Bracket EQ Stops, each using:
   - 1 D070322 Long EQ Stop Bracket
   - 1 D080725 EQ Stop for Metal or Glass
   - 1 Hex Nut ¼-20 AgPlated

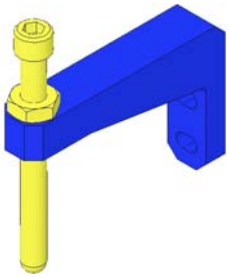

Fig 63: D080727 Long Bracket EQ Stop

3. Assemble 2 D1002822 EQ Stop Bracket Assemblies, 1 LH and 1 RH version, each using:
   - 1 D1002823 EQ Stop Bracket, Back
   - 1 D1002824 EQ Stop Bracket, Side
   - 2 Socket Head Cap Screw 8-32 x 1.00" SSTL
   - 2 Flat Washer #8 SSTL Vented

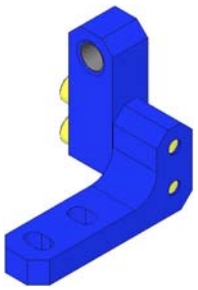

Fig 64: D1002822 Left

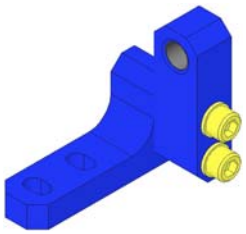

Fig 65: D1002822 Right

4. Assemble 2 D1002821 EQ Stop Assemblies, 1 LH and 1 RH version, each using:
   - 1 D1002822 EQ Stop Bracket (see above)
   - 1 D080725 EQ Stop for Metal or Glass
   - 1 Hex Nut ¼-20 AgPlated

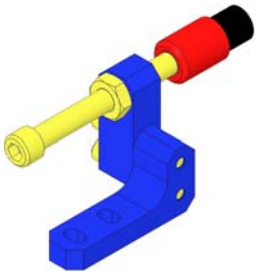

Fig 66: D1002821 Left

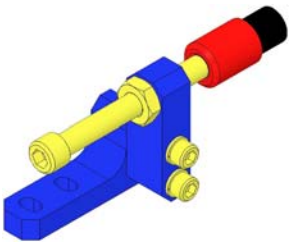

Fig 67: D1002821 Right

5. Assemble 4 D1102071 Bridge EQ Stops in 2 configurations.

   Initial Build:
   - Upper RH diagram: 2 above Metal;
   - Lower RH diagram: 2 beneath Metal.

   Optic Installation:
   - Reconfigure existing assembly (lower RH diagram) as upper RH diagram.

   Assemble all 4 with:
   - 1 D070321 Crossbar
   - 2 D1102072 Mount
   - 2 Socket Head Cap Screw ¼-20 x 0.75" SSTL
   - 2 D1100785 Flat Washer, ¼" Nitronic 60
   - 2 D080725 EQ Stop for Metal or Glass
     The tips (shown red & black) are not used for the Metal Mass
   - 2 Hex Nut ¼-20 AgPlated

     Hand-tighten all fasteners at this point

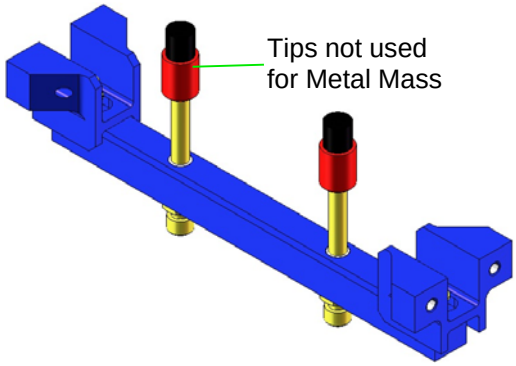

Fig 68: Above Metal / Optic & beneath Optic

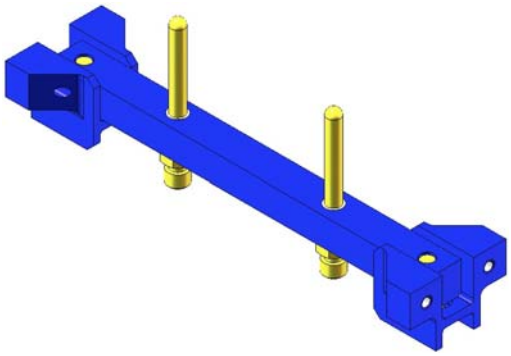

Fig 69: Use beneath the Metal Mass

19 Preparing The Weldment

1.1 Materials

Qty	U	ID	Description
8	Ea	1185-2EN492	Helicoil 8-32 x 3.0D
8	Ea	D980184	LOS Clamps
8	Ea	NA	Socket Head Cap Screw ¼-20 x 1.5" AgPlated

19.1 Procedure

1. Identify the Front vs Rear of the Weldment. The front has 4 pairs of adjacent, large-diameter through-holes.

2. Install at the base of the Weldment:
   - 8 1185-2EN492 Helicoils 8-32 x 3.0D

     Install these BEFORE securing the Weldment to the Optical Table!

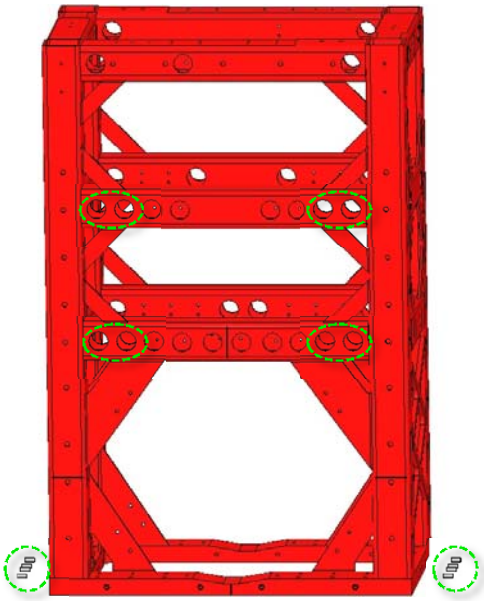

Fig 70: Helicoils in Weldment

3. Secure the D070442 Structural Weldment to the Optical Table with:
   - 8 D980184 LOS Clamps, 2 per corner
   - 8 Socket Head Cap Screws ¼-20 x 1.5" AgPlated

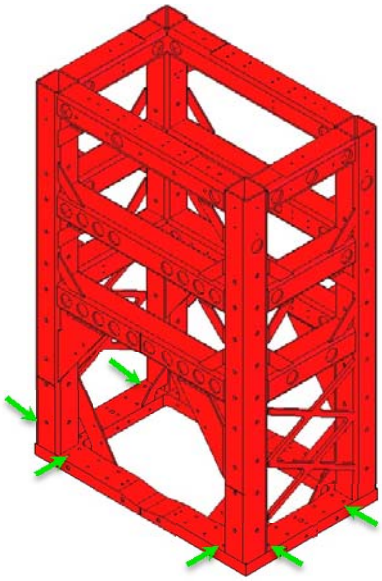

Fig 71: Securing the Weldment

20 Installing the Mounting Pads

20.1 Documents

D0900626 HLTS Mounting Pad Assembly

20.2 Materials

Qty	U	ID	Description
1	Ea	D070442	HLTS Structural Weldment
8	Ea	D980184	LOS Clamps
2	Ea	D070374	HLTS Mounting Pad
8	Ea	NA	Helicoil 8-32 x 0.246”
4	Ea	1185-2EN246	Helicoil 8-32 2B x 2.0D
2	Ea	D0900628	HLTS Mounting Pad Side Bracket
2	Ea	D0900627	HLTS Mounting Pad Front Bracket
4	Ea	NA	Socket Head Cap Screw 8-32 x 0.5” SSTL
14	Ea	NA	Socket Head Cap Screw 8-32 x 0.5” AgPlated
18	Ea	NA	Flat Washer #8 SSTL

20.3 Procedure

1. Assemble to each of the 2 D070374 Mounting Pads:

   Top of the Pad

   - 4 Helicoil 8-32 x 0.246 or longer

   Side of the Pad

   - 2 1185-2EN246 Helicoils 8-32 2B x 2.0D

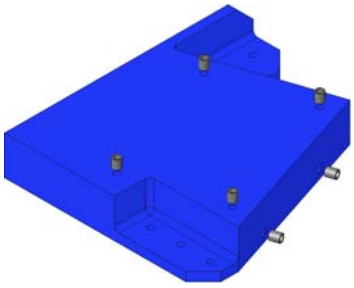

Fig 72: Helicoils in 1 of 2 Mounting Pads

2. Create 2 D0900626 Mounting Pad Assemblies:
   - 2 D070374 Mounting Pad Body
   - 2 D0900628 Mounting Pad Side Bracket
   - 4 Socket Head Cap Screw 8-32 x 0.5” SSTL
   - 4 Flat Washer #8 SSTL Torque to 20 in-lb

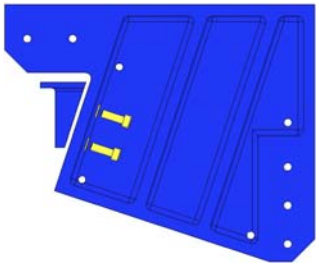

Fig 73: Mounting Pad Assembly

3. Assemble the Mounting Pad Assembly to the Structural Weldment using:
   - 2 D0900627 Front Bracket
   - 14 Socket Head Cap Screw 8-32 x 0.5” AgPlated
   - 14 Flat Washer #8 SSTL Torque to 30 in-lb

   The Serial Number for each Pad is stamped on a specific Weldment corner. Ensure each Pad is mounted on the correct Weldment location.

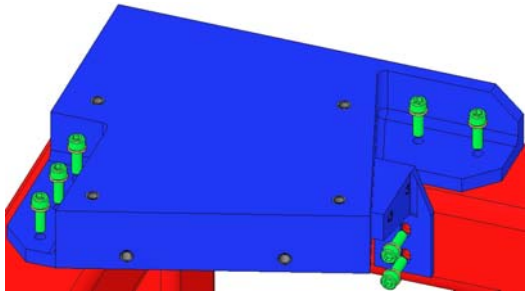

Fig 74: Mounting Pad on Weldment

21 Installing EQ Stop Mounts and Brackets

1.2 Documents

D070442 HLTS Overall Assembly

21.1 Materials

Qty	U	ID	Description
10	Ea	D080726	HLTS EQ Stop, Long Mount
8	Ea	D080727	HLTS EQ Stop, Long Bracket
4	Ea	D070319	HLTS EQ Stop, Bridge
4	Ea	D1002821	EQ Stop Assembly, Bottom Mass, Lower
4	Ea	D1102071	EQ Stop Assembly, Upper
52	Ea	NA	Socket Head Cap Screws 8-32 x 0.5” AgPlated
52	Ea	NA	Flat Washers #8 SSTL
4	Ea	NA	Socket Head Cap Screws 8-32 x 0.5” Vented AgPlated
4	Ea	NA	Flat Washers #8 Vented SSTL

21.2 Procedure

1. Attach 2 D1002821 Short Brkt EQ Stops to the inside front of the Weldment, using:
   - 4 Socket Head Cap Screw 8-32 x .5" Vented, AgPlated
   - 4 Flat Washer #8 SSTL Torque to 30 in-lb

2. Attach the following, using:
   - 52 Socket Head Cap Screws 8-32 x 0.5" AgPlated
   - 52 Flat Washers #8 SSTL Torque to 30 in-lb
   - 8 D080726 Long Mount EQ Stops to the inside front of the Weldment
   - 2 D080726 Long Mount EQ Stops to the inside rear of the Weldment
   - 4 D080727 Long Brkt EQ Stops to the inside front of the Weldment
   - 4 D080727 Long Brkt EQ Stops to the inside rear of the Weldment
   - 4 D1102071 Bridge EQ Stops to the Weldment.
3. At the Bridge EQ Stops, torque the 8 ¼-20 Screws (assembled earlier) that attach the Crossbars to the Bridge pieces, to 75 in-lb.

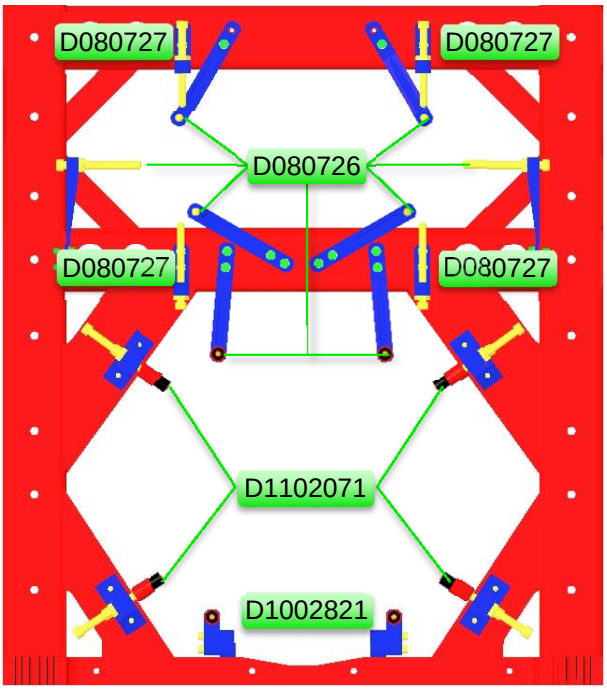

Fig 75: Facing Front from Inside of Weldment

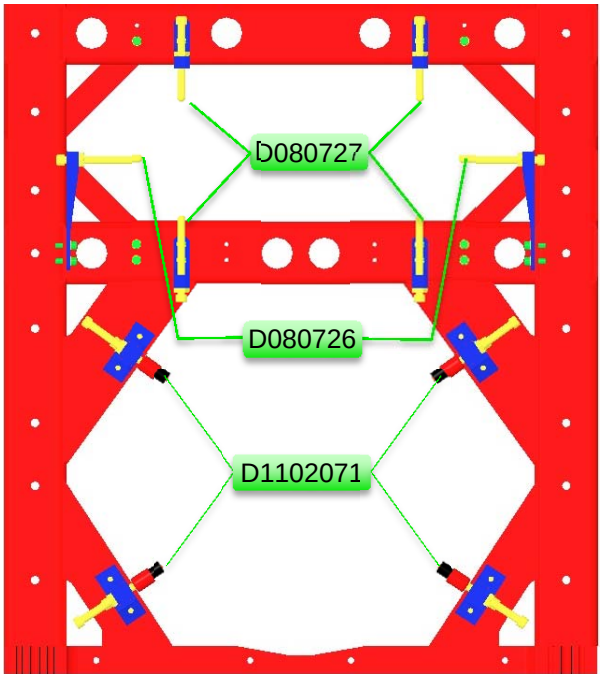

Fig 76: Facing Rear from Inside of Weldment

22 Installing Rotational Adjusters and Top Blade Guards

22.1 Documents

D070442 HLTS Overall Assembly

22.2 Materials

Qty	U	ID	Description
2	Ea	D020660	**Blade Pulldown Device**
2	Ea	D0901814	Upper Clamp, Inside, Class B Clean
2	Ea	D070341	Upper Clamp, Outside, Class B Clean
1	Roll	NA	Music Wire 0.024” dia.
1	Btl	NA	Methanol
1	Btl	NA	Acetone
1	Btl	NA	Isopropanol
1	Spl	NA	Steel Music Wire, 0.0106” dia.
1	Pkg	NA	Lint-Free Wipes
8	Ea	NA	Socket Head Cap Screw 8-32 x 0.50” AgPlated
4	Ea	NA	Flat Washer #8 Vented SSTL
2	Ea	D1102119	Blade Pulldown Support
1	Roll	NA	UHV Aluminum Foil
2	Ea	D070308	**HLTS Top Blade Guard Assembly**
16	Ea	NA	Socket Head Cap Screw 8-32 x 0.50” AgPlated
16	Ea	NA	Flat Washer #8 Vented SSTL
2	Ea	D070326	**HLTS Rotational Adjuster**
4	Ea	NA	Socket Head Cap Screw 8-32 x 0.75” SSTL HoloKrome
4	Ea	NA	Flat Washer #8 Vented SSTL

22.3 Procedure

1. Prepare 2 D020660 Blade Pulldown Devices, each with:
   - 1 D0901814 Upper Clamp, Inside
   - 1 D070341 Upper Clamp, Outside
   - 2 Socket Head Cap Screw 8-32 x 0.5” AgPlated
   - 2 Flat Washer #8 Vented, SSTL
   - 3’ of 0.024” Wire. Clean the Wire per Section 12.4.

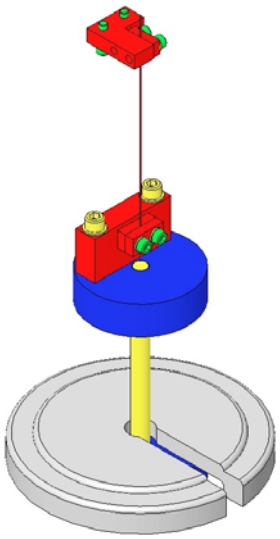

Fig 77: Blade Pulldown Device

2. Assemble the D070308 Top Blade Guard Assembly to the D070442 Structural Weldment using:
   - 16 Socket Head Cap Screws 8-32 x 0.5" AgPlated
   - 16 Flat Washers #8 Vented, SSTL
   Torque to 30 in-lb

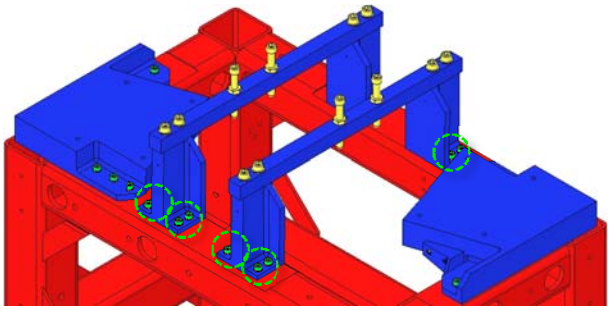

Fig 78: Top Blade Guards installed

3. Remove the D070310 Bars.

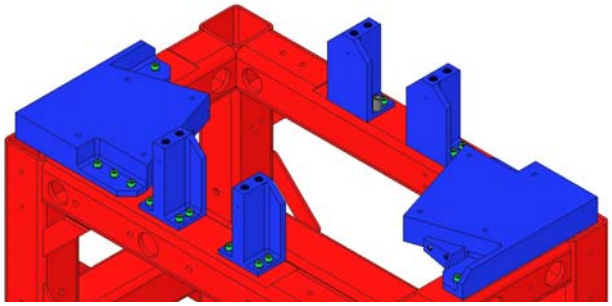

Fig 79: Bars removed

4. Install the 2 D070326 Rotational Adjusters to the Mounting Pads, using for each:
   - 4 Socket Head Cap Screws 8-32 x 0.75" SSTL
     Use HoloKrome Screws
   - 4 Flat Washer #8 Vented, SSTL
   Torque to 30 in-lb

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

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

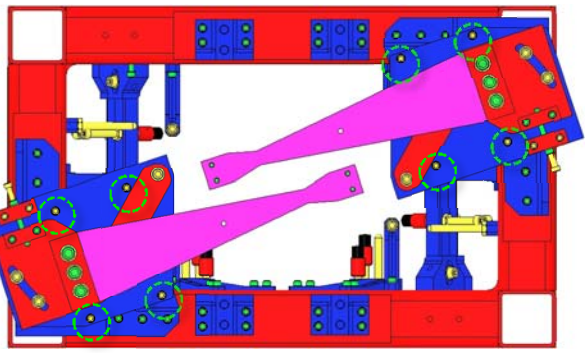

Fig 80: Rotational Adjusters Installed

Wear proper safety glasses per E1000043.

5. Attach the 2 D1102119 Blade Pulldown Supports to the Weldment location shown; that is, in the center of the end Weldment cross member, with the 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
     8-32 x 0.50" AgPlated
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 81: Blade Pulldown Support

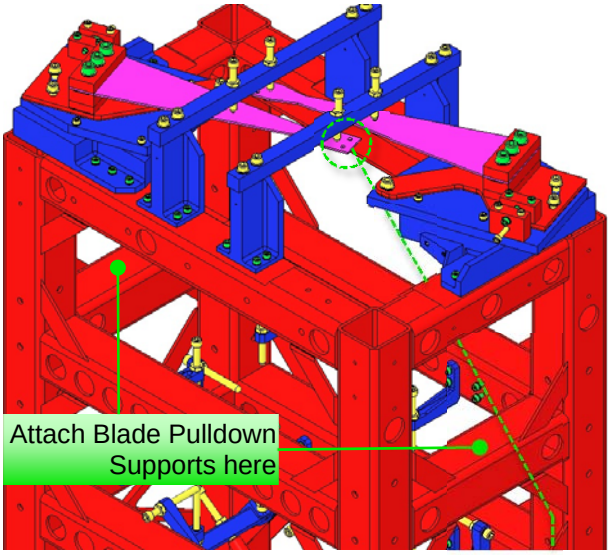

Fig 82: Location of Blade Pulldown Support

11. Re-Assemble the 2 D070310 Top Blade Guard Bars to the Risers, using for each:
    - 4 Socket Head Cap Screws
      ¼-20 x 1.0" SSTL
      Torque to 75 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.
12. Carefully remove the 2 Blade Pulldown Devices.
13. Remove the 2 Blade Pulldown Supports.

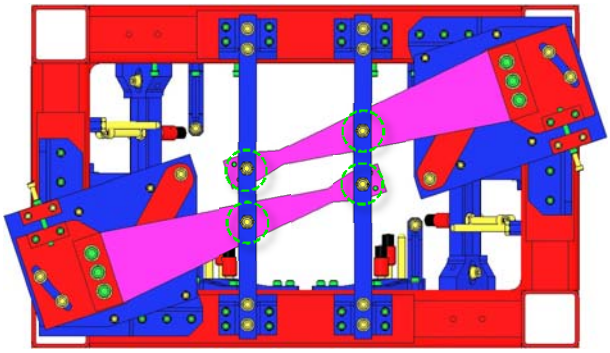

Fig 83: Top View: Screws centered over Blades

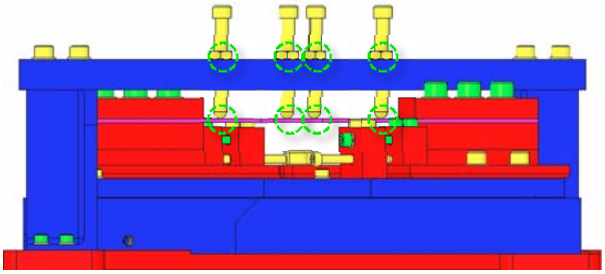

Fig 84: End View: Screws adjusted and secured

23 Installing Upper Mass and Coil Holder

23.1 Documents

D070442 HLTS Overall Assembly

D1101493 HSTS / HLTS / OMCS OSEM Orientations

23.2 Materials

Qty	U	ID	Description
1	Ea	D040259	**Upper Mass Jig**
1	Ea	NA	**HLTS Upper Mass and Coil Holder Assembly from section 17, above**
12	Ea	NA	Socket Head Cap Screws ¼-20 x 1.0" Round-Tip SSTL
14	Ea	NA	Hex Nut ¼-20 AgPlated
5	Ea	Several	**HLTS Additional Mass Disks** (10g, 20g 50g 100g)
2	Ea	NA	Socket Head Cap Screw ¼-20 x 2.0" SSTL
2	Ea	NA	Flat Washer ¼" Vented SSTL
NA	Ea	D1002133	**HLTS Coil Holder Bracket Assemblies**
4	Ea	D1002134	Bracket Lateral Section
4	Ea	D1002135	Bracket Longitudinal Section
8	Ea	NA	Socket Head Cap Screws 4-40 0.75" SSTL
8	Ea	NA	Flat Washer #4 Vented SSTL
12	Ea	NA	Socket Head Cap Screw 8-32 x 0.75" AgPlated
12	Ea	NA	Socket Head Cap Screw 8-32 x 0.625" SSTL
24	Ea	NA	Flat Washer #8 Vented SSTL

23.3 Procedure

The corner Brackets are shown here only for orientation and are not yet attached. Note the (2) Bracket Screws used for vertical adjustments.

1. Attach the D040259 Jig to an Optics Table.
2. Remove but keep all Add-On hardware from the bottom of the Upper Mass T-Piece.
3. Attach the previously-assembled Upper Mass and Coil Holder (with 6 Wire assemblies) to the Jig. (Jig not shown here, but in section on Assembling Upper Mass).
4. Using the pair of ¼-20 Screws at the top center, raise the Upper Mass completely into the Coil Holder, then tighten the Hex Nuts.
5. Remove the 4 side EQ Stop Screws and Hex Nuts.
6. Lock down the Upper Mass with the remaining 8 EQ Stop Screws and Hex Nuts.

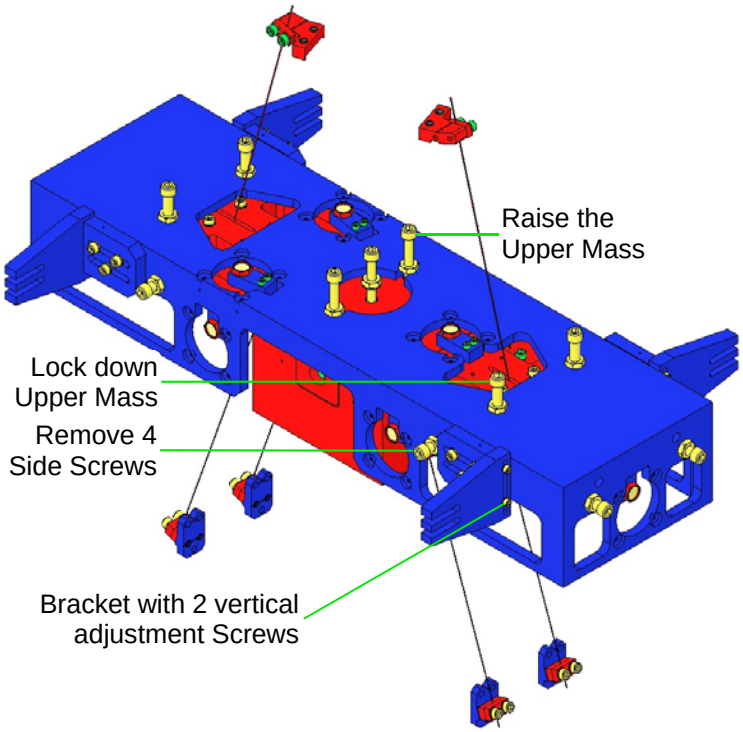

Fig 85: D1002133 Coil Holder Brackets (4)

7. Assemble 4 D1002133 HLTS Coil Holder Bracket Assemblies, each with:
   - 1 D1002134 Lateral Section
   - 1 D1002135 Longitudinal Section
   - 2 Socket Head Cap Screws 4-40 0.75" SSTL
   - 2 Flat Washer #4 Vented SSTL
   - Torque to 5 in-lb

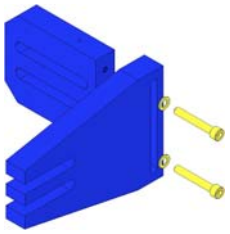

Fig 86: Bracket Assembly

8. Attach the 4 Brackets to the Weldment, using for each:
   - 3 Socket Head Cap Screws 8-32 x 0.75" AgPlated
   - 3 Flat Washer #8 Vented SSTL

   Torque Screws after Coil Holder is installed and aligned.

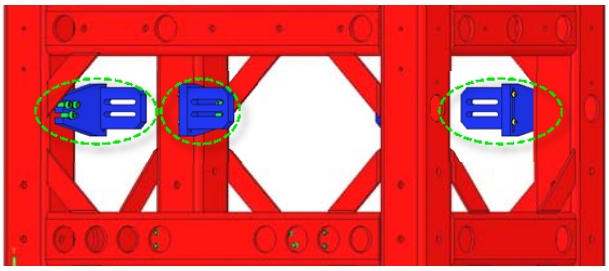

Fig 87: Coil Holder Brackets Installed

9. Insert the Upper Mass / Coil Holder Assembly through either narrow opening in the top section of the Weldment. The pair of BOSEMS on top of the Assembly must be at the –Y side of the Suspension per D1101493 OSEM Orientations.
10. Assemble the Coil Holder to the 4 Brackets using at each Bracket:
    - 3 Socket Head Cap Screws 8-32 x 0.625" SSTL
    - 3 Flat Washer #8 Vented SSTL Torque to 20 in-lb
11. Back out each of the 4 lower Clamps of the Intermediate Wire Assemblies, back through the 4 end openings in the Coil Holder.
12. Re-assemble 4 EQ Stop Screws to the long sides of the Coil Holder, each using:
    - 1 Socket Head Cap Screw ¼-20 x 1.0" Round Tip SSTL
    - 1 Hex Nut ¼-20 AgPlated

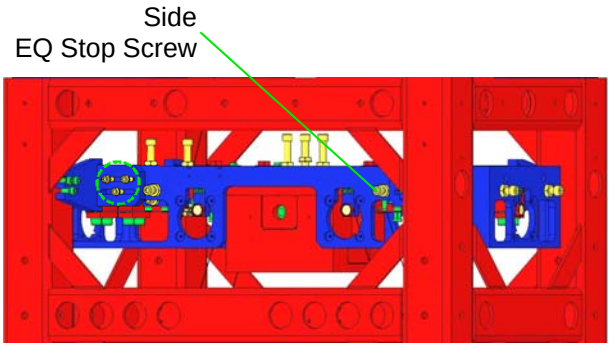

Fig 88: Upper Mass & Coil Holder Installed

13. Install the Additional Mass Disks on the top and bottom of the Upper Mass, as equally divided as possible; tighten the Hex Nuts to secure the Disks. Use:
    - 2 Socket Head Cap Screw ¼-20 x 2.0" SSTL
    - 2 ¼-20 Hex Nut AgPlated
    - 2 Flat Washer ¼" SSTL

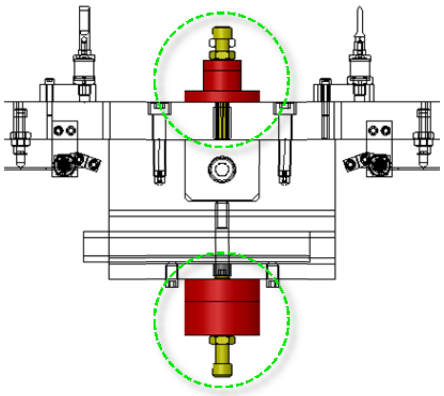

Fig 89: Additional Mass Disks Added

24 Installing the Intermediate Mass

24.1 Documents

D070442 HLTS Overall Assembly

24.2 Materials

Qty	U	ID	Description
1	ea	D070334	HLTS Intermediate Mass
1	Ea	D1102344	HLTS Intermediate Mass Lifting Plate Assembly

24.3 Procedure

1. Raise the 4 bottom EQ Stops as far as possible.
2. Back off the 12 top, front and side EQ Stops

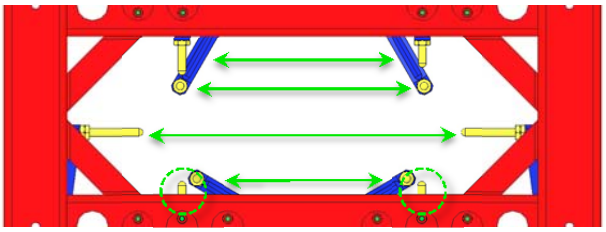

Fig 90: Rear View; EQ Stops prepared

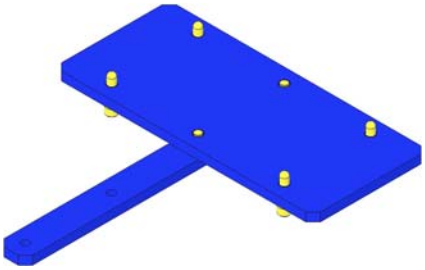

Fig 91: Lifting Plate

3. Using the D1102344 Lifting Plate Assembly, insert the D070334 Intermediate Mass assembly through the rear of the Weldment, ensuring the 4 Magnet assemblies are facing the rear. Center the assembly front-to-back and left-to-right on the bottom EQ Stops.

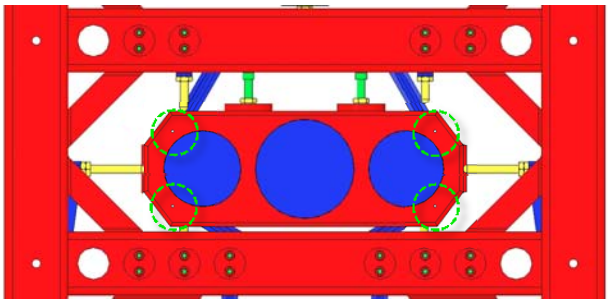

Fig 92: Rear View; Magnets facing rear

4. Lock down the Intermediate Mass assembly using the 8 top and side EQ Stops.

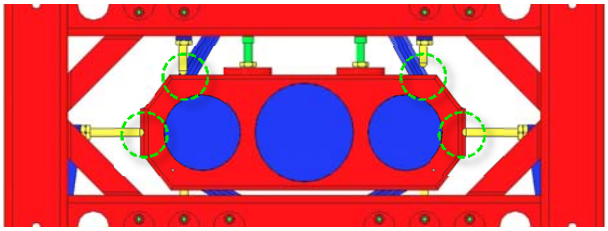

Fig 93: Rear View; Mass locked down

25 Installing Wire Assemblies

1.3 Documents

D070442 HLTS Overall Assembly

25.1 Materials

Qty	U	ID	Description
4	Ea	NA	Socket Head Cap Screws 8-32 x .50" AgPlated
18	Ea	NA	Socket Head Cap Screws 8-32 x .625" AgPlated

25.2 Procedure

Upper Wire Assemblies fully installed.

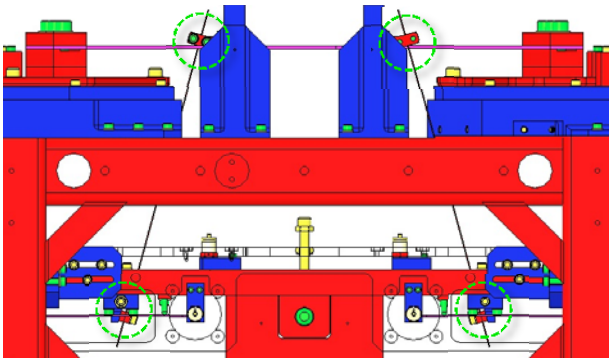

Fig 94: Upper Wire Assemblies installed

1. Raise the Upper Mass/Tablecloth Assembly on its brackets as high as possible and secure it in place.

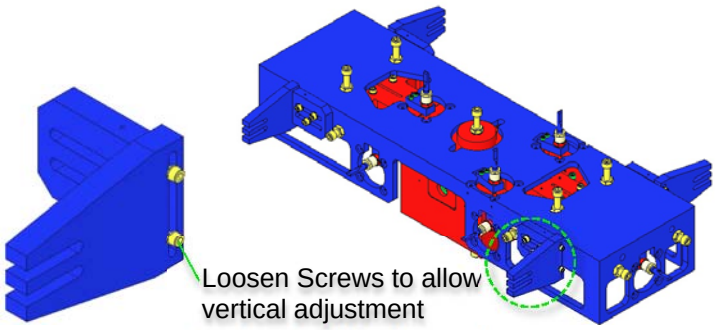

Fig 95: Raising Coil Holder on its Brackets

Be careful not to kink or twist the wires.

2. Attach the 2 Upper Wire Upper Clamps to the 2 Upper Blades using:
   - 4 Socket Head Cap Screws 8-32 x 0.50" AgPlated Torque to 30 in-lb

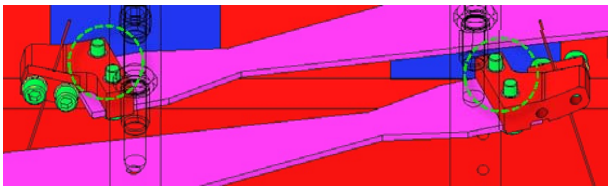

Fig 96: Upper Clamps attached to Upper Blades

3. Center the C-Clamps using the 4 Screwdrive System Screws, then tighten the Hex Nuts to lock the Screws.

   Torque the eight 8-32 x 1.125" C-Clamp Screws to 30 in-lb.

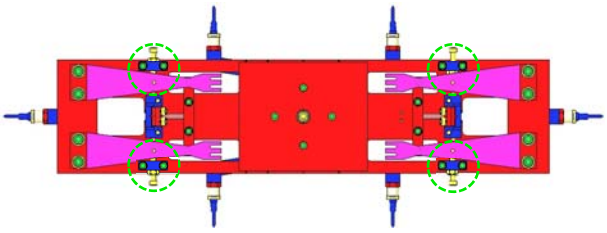

Fig 97: Centering C-Clamps with Screw Drives

4. Adjust the height of the Upper Mass/Tablecloth Assembly on its brackets to remove slack in the Upper Wires.

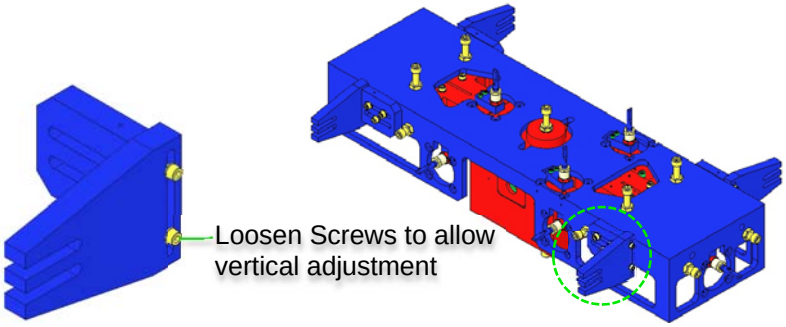

Fig 98: Lowering Coil Holder to eliminate slack in Wires

5. Attach the 4 Intermediate Wire Lower Clamps to each end of the Intermediate Mass Assembly using:
   - 12 Socket Head Cap Screws 8-32 x .625" AgPlated Torque to 30 in-lb

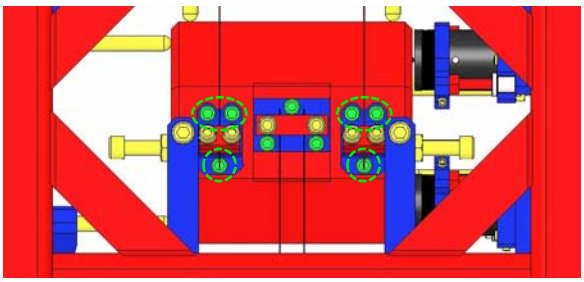

Fig 99: End of Intermediate Mass

6. Remove the 2 Screws and Hex Nuts at the top center of the Upper Mass Assembly that are holding the Upper Mass Assembly against the Coil Holder. The Upper Mass Assembly should still be locked relative to the Coil Holder using the top and side earthquake stops.

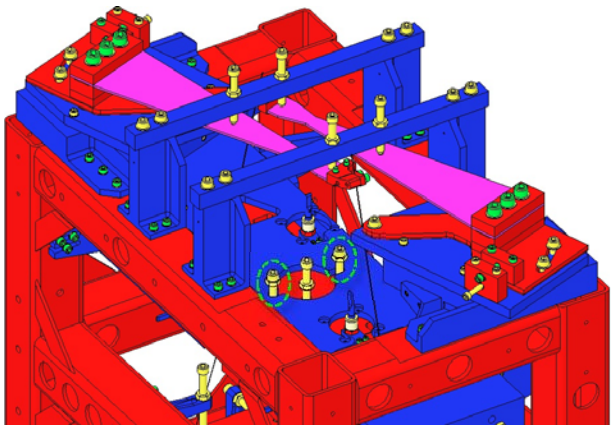

Fig 100: Screws to remove

7. Adjust any or all of the 16 top, bottom and side intermediate EQ Stops to remove slack in the Intermediate Wires.

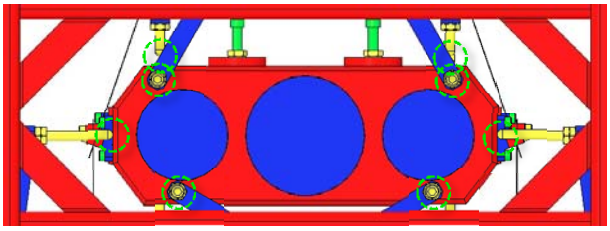

Fig 101: Front View, EQ Stops

8. Attach the Lower Loop Wire to the Intermediate Mass Assembly using:
   - 6 Socket Head Cap Screws
     8-32 x .625" AgPlated
     Torque to 30 in-lb

   Be careful not to kink, twist or tangle the wires. Use silver-plated SHCS.

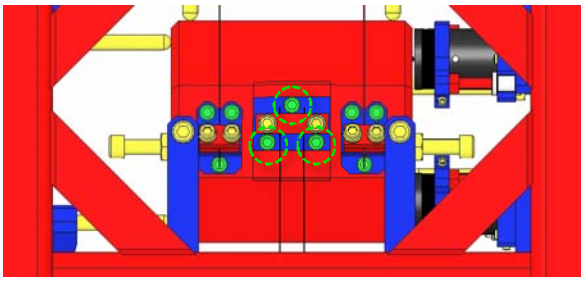

Fig 102: End View of Intermediate Mass

26 Assembling AOSEM Brackets

1 of each configuration is required. The difference between LH / RH is simply the orientation of the Mounting and / or Alignment Brackets.

D0902024
AOSEM Alignment Assembly
Upper Side of Intermediate Mass

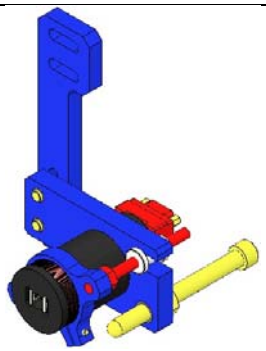

Fig 103: D0902024

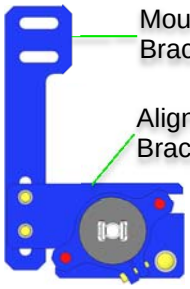

Fig 104: LH Config

Fig 105: RH Config

D0901551
AOSEM Alignment Assembly
Lower Side of Intermediate Mass

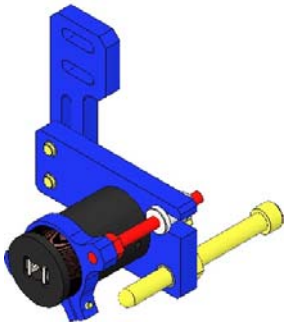

Fig 106: D0901551

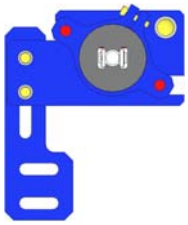

Fig 107: LH Config

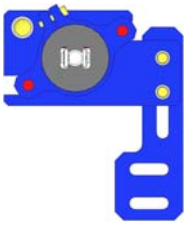

Fig 108: RH Config

D0901552
AOSEM Alignment Assembly
Upper Side of Bottom Mass

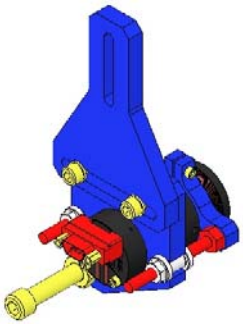

Fig 109: D0901552

Fig 110: LH Config

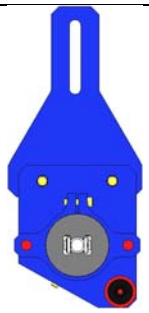

Fig 111: RH Config

D0901553
AOSEM Alignment Assembly
Lower Side of Bottom Mass

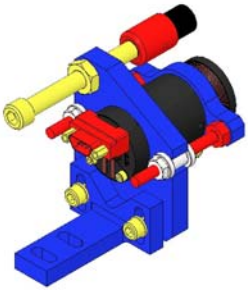

Fig 112: D0901553

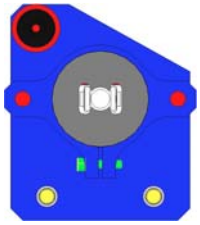

Fig 113: LH Config

Fig 114: RH Config

26.1 Documents

D070442 HLTS Overall Assembly

26.2 Materials

D0902024

Qty	U	ID	Description
1	Ea	D0902025	HLTS AOSEM Mounting Bracket, Upper Side of Intermediate Mass
1	Ea	D0901492	HLTS AOSEM Alignment Bracket, Intermediate Mass
1	Ea	D0901065	AOSEM Assembly
1	Ea	D1002858	AOSEM Adjustment Collar, Reverse Side
2	Ea	D1000659	Adjuster Shaft
2	Ea	D1002865	Adjustment Nut, Thick
2	Ea	NA	Socket Head Cap Screw, 8-32 x 0.625”, SSTL
2	Ea	1185-2EN246	Helicoil, 8-32 x 0.246”
2	Ea	NA	Flat Washer, Vented, #8
1	Ea	NA	Socket Head Cap Screw, 2-56 x 0.375” SSTL
1	Ea	D030021	Socket Head Cap Screw, ¼-20 x 2.5”, Round Tip SSTL
1	Ea	1185-4EN250	Helicoil, ¼-20 x 0.25”
1	Ea	NA	Hex Nut, ¼-20 AgPlated

D0901551

Qty	U	ID	Description
1	Ea	D0901493	Lower AOSEM Mounting Bracket, Intermediate Mass
1	Ea	D0901492	HLTS AOSEM Alignment Bracket, Intermediate Mass
1	Ea	D0901065	AOSEM Assembly
1	Ea	D1002858	AOSEM Adjustment Collar, Reverse Side
2	Ea	D1000659	Adjuster Shaft
2	Ea	D1002865	Adjustment Nut, Thick
2	Ea	NA	Socket Head Cap Screw, 8-32 x 0.625”, SSTL
2	Ea	1185-2EN246	Helicoil, 8-32 x 0.246”
2	Ea	NA	Flat Washer, Vented, #8
1	Ea	NA	Socket Head Cap Screw, 2-56 x 0.375” SSTL
1	Ea	D030021	Socket Head Cap Screw, ¼-20 x 2.5”, Round Tip SSTL
1	Ea	1185-4EN250	Helicoil, ¼-20 x 0.25”
1	Ea	NA	Hex Nut, ¼-20 AgPlated

D0901552

Qty	U	ID	Description
1	Ea	D0901550	AOSEM Mounting Bracket, Upper Position of Bottom Mass
1	Ea	D0901549	AOSEM Alignment Bracket, Bottom Mass
1	Ea	D0901065	AOSEM Assembly
1	Ea	D1002858	AOSEM Adjustment Collar, Reverse Side
2	Ea	D1000659	Adjuster Shaft
2	Ea	D1002865	Adjustment Nut, Thick
1	Ea	D080725	EQ Stop for Metal or Glass
2	Ea	NA	Socket Head Cap Screw, 8-32 x 0.625”, SSTL
2	Ea	1185-2EN246	Helicoil, 8-32 x 0.246”
2	Ea	NA	Flat Washer, Vented, #8
1	Ea	NA	Socket Head Cap Screw, 2-56 x 0.375” SSTL
1	Ea	1185-4EN250	Helicoil, ¼-20 x 0.25”
1	Ea	NA	Hex Nut, ¼-20 AgPlated

D0901553

Qty	U	ID	Description
1	Ea	D0900340	AOSEM Mounting Bracket, Lower Position of Bottom Mass
1	Ea	D0901549	AOSEM Alignment Bracket, Bottom Mass
1	Ea	D0901065	AOSEM Assembly
1	Ea	D1002858	AOSEM Adjustment Collar, Reverse Side
2	Ea	D1000659	Adjuster Shaft
2	Ea	D1002865	Adjustment Nut, Thick
1	Ea	D080725	EQ Stop for Metal or Glass
2	Ea	NA	Socket Head Cap Screw, 8-32 x 0.625”, SSTL
2	Ea	1185-2EN246	Helicoil, 8-32 x 0.246”
2	Ea	NA	Flat Washer, Vented, #8
1	Ea	NA	Socket Head Cap Screw, 2-56 x 0.375” SSTL
1	Ea	1185-4EN250	Helicoil, ¼-20 x 0.25”
1	Ea	NA	Hex Nut, ¼-20 AgPlated

26.3 Procedure

Assembly procedure is similar for all 4 units, but varies by the Mount Bracket and Alignment Bracket.

1. Assemble Adjustment Collar to AOSEM
2. Assemble SHCS 2-56 to Collar
3. Assemble Adjuster Shafts to Collar
4. Assemble AOSEM w/Adjuster Shafts to Alignment Bracket, paying close attention to part number and orientation of Bracket
5. Assemble Mount to Alignment Bracket
6. Assemble EQ Stop to Alignment Bracket with a Hex Nut

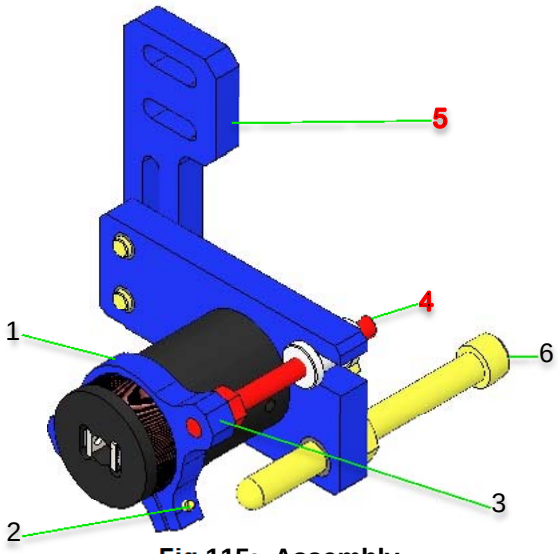

Fig 115: Assembly

27 Installing Bottom Mass

1.4 Documents

D070442 HLTS Overall Assembly

1.5 Materials

Qty	U	ID	Description
2	Ea	D0901286	HLTS Secondary Metal Prism Breakoff

27.1 Procedure

1. Adjust the Lower Bridge EQ Stops (4 Screws) as far in as possible.
2. Back off the Upper Bridge EQ Stops (4 Screws) and Front EQ Stops (4 Screws).

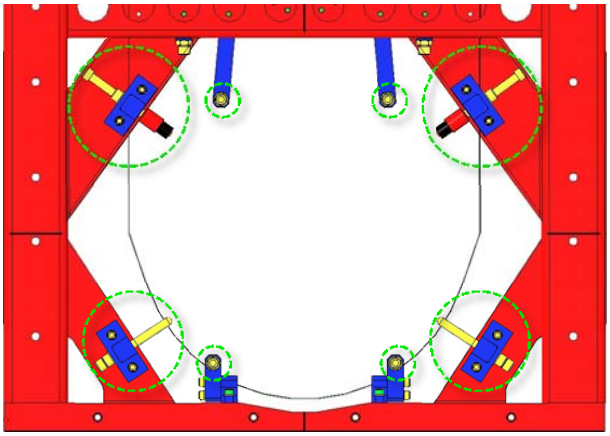

Fig 116: EQ Stops Adjusted

3. Install the Bottom Mass Assembly through the back of the HLTS Structure. Place the Bottom Mass Assembly above the Lower Wire Assembly, resting on the Lower Bridge EQ Stops, making sure that the 2 Wires are straight and fit in the 2 grooves of each Prism Breakoff.

   Be sure not to kink, twist or tangle the wires.
4. Install the 2 D0901286 Secondary Metal Prism Breakoffs. Insert the breakoffs between the Bottom Mass Assembly and the Lower Loop Wire at the points where the breakoffs just touch the wires.

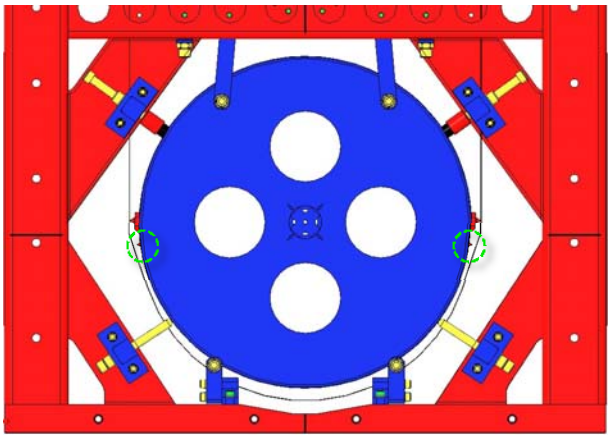

Fig 117: Lower Mass Placed on Bridge EQ Stops

28 Suspension and Alignment of Masses

Note: "Level" as referenced below, is defined as being within the visual indicators on the Bubble Levels used (Carpenter's Level for Optical Table, Single Bubble for Suspension Masses).

1.6 Materials

Qty	U	ID	Description
1	Ea	NA	Bubble Level
1	Ea	NA	Optical Level
1	Ea	NA	Lower Loop Wire Comb

28.1 Procedure

1. Unlock all Stops to allow the Suspension to hang freely:

   Bottom Mass
   - 4 Face EQ Stops
   - 8 Bridge EQ Stops

   Intermediate Mass
   - 16 EQ Stops

   Upper Mass
   - 4 Lower Blade Stops
   - 12 Coil Holder Stops

   Upper Blades
   - 4 Upper Blade Stops

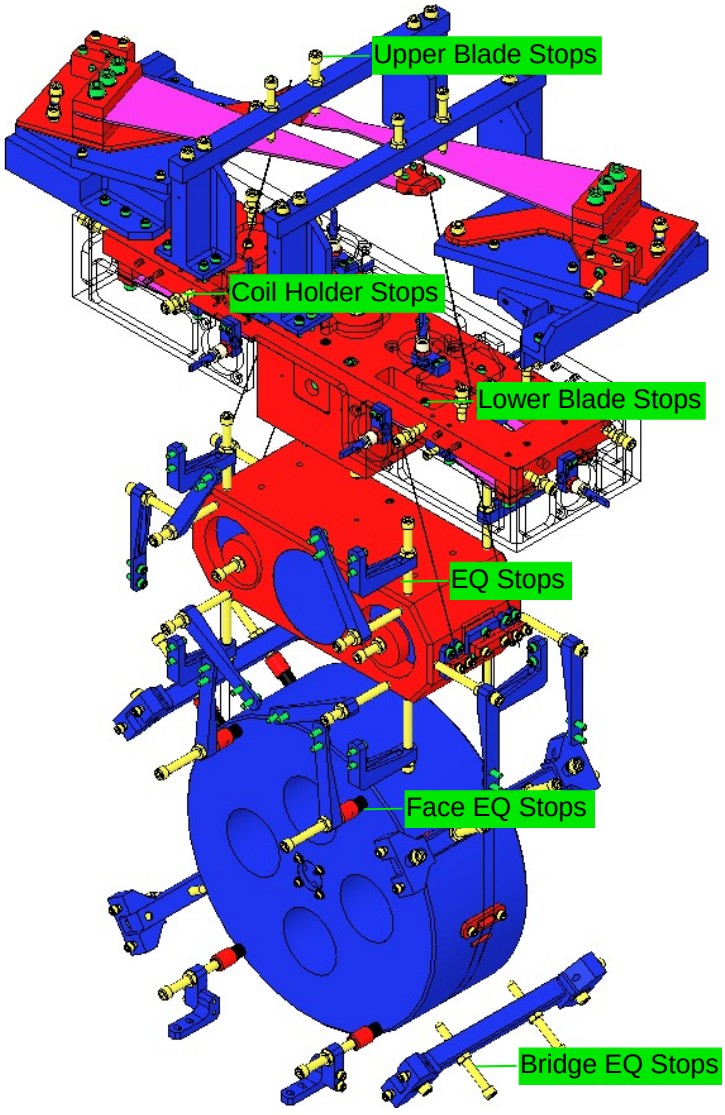

Fig 118: Unlock all Stops

Lock the Intermediate Mass

2. Lock the Intermediate Mass with the 16 EQ Stops such that the Mass is level. Use a Bubble Level, and then an Optical Level. The Mass height is unimportant at this point.

Adjust Bottom Mass Roll

3. Using the Lower Loop Wire Comb, ensure the Lower Wires are parallel and 10mm apart.
4. Measure and compare the heights of the bottom of the side bores, on the with side of the front of the Bottom Mass. Rotate the Mass until the heights are equal.

Adjust Bottom Mass Pitch

5. Measure and compare the heights of the bottom of the bores on the front and back of the Mass. If unequal, first repeat Step 3, above. Then verify that the Lower Wire Clamps are attached squarely to the Intermediate Mass. If the heights remain unequal, the lengths of the Lower Wires are unequal, and need to be replaced.

Unlock the Intermediate Mass

6. Once the Bottom Mass is level, unlock the Intermediate Mass.

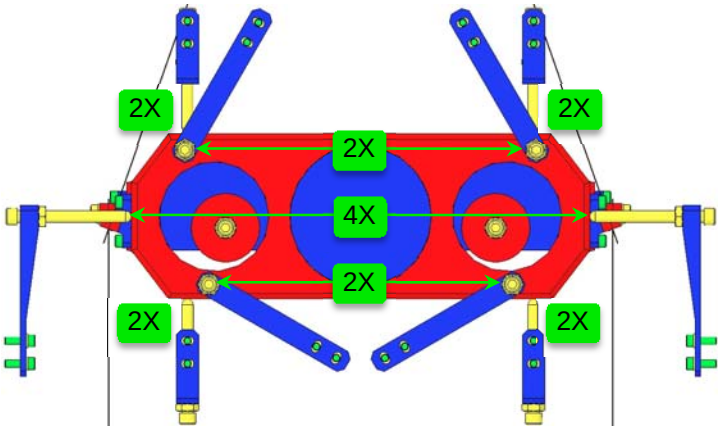

Fig 119: Intermediate Mass Leveling

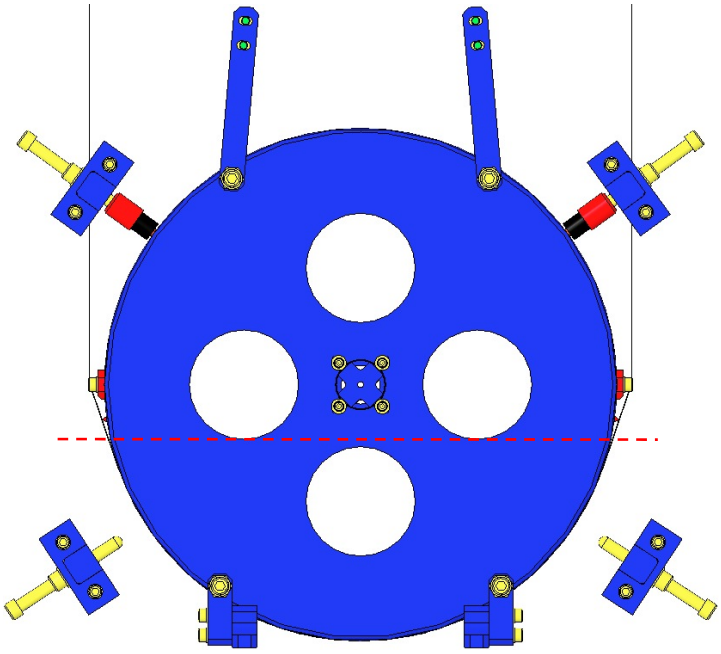

Fig 120: Adjust Roll and Pitch

Adjust Yaw

7. Using a Ruler while adjusting the Corner Brackets, center the Coil Holder within the Weldment, in the X direction (front-to-back).
8. Adjust the Rotational Adjusters as needed to center the Magnet Holders at either end of the Upper Mass within the Coil Holder Openings.

   To adjust the Rotational Adjusters, loosen the 3 screws attaching the RA to its base, then adjust the Push and Pull Screws, then tighten the 3 screws.

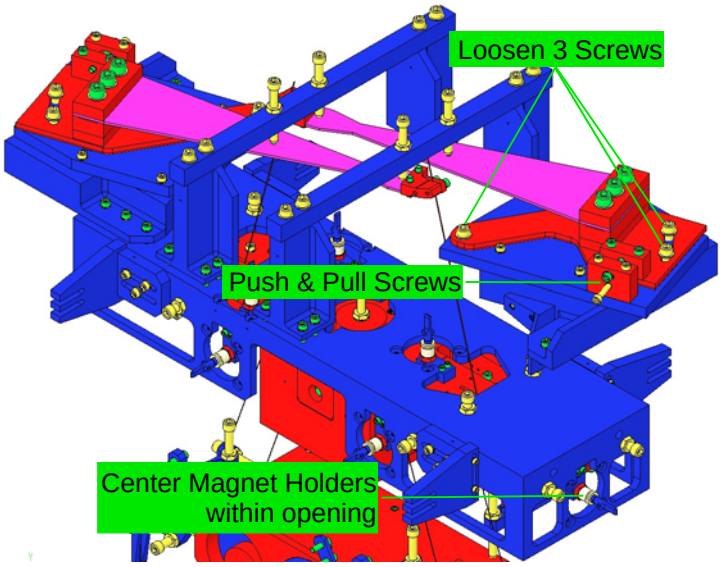

Fig 121: Adjusting Yaw

Adjust Upper Mass Pitch

9. Measure the heights of either the bottom of the T-Piece or the bottoms of the Screw Drive Blocks, front and back (+X & - X). To adjust Pitch, manipulate the Screw Drives to shift the location of the Upper Wire Lower Clamps.

   Diagram shows Upper Mass without Coil Holder nor Blades, for visibility.

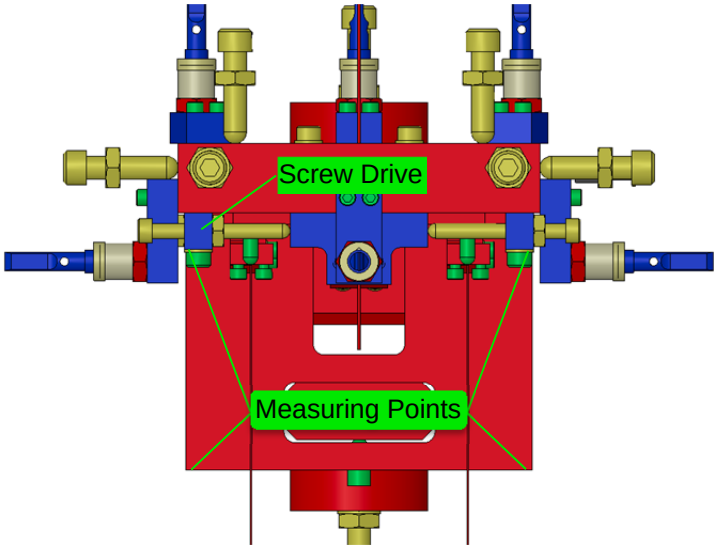

Fig 122: Upper Mass Pitch, End View

10. Measure heights in mm from the Optical Table surface of these points.

    *Not measurable with Optical Level

Upper Blade Wire Breakoffs (2)	NOT Blade tip	**806.120**
Coil Holder	Upper surface	**658.587**
Upper Mass – Screwdrive Blocks (4)	Bottom surface	**613.181**
Upper Mass – T-Piece	Bottom surface	**552.228**
Lower Blade Wire Breakoff (4)	NOT Blade tip	**608.838**
Intermediate Mass	Upper surface	**461.620**
Intermediate Mass	Lower surface	**371.620**
Bottom Mass Metal – Side Bores (2)	Bottom	**130.243**
Bottom Mass Metal or Optic	Centerline*	**158.500**
Bottom Mass Metal	Bottom	**25.984**

* Not measurable using an Optical Level

Perform the following on the 28 ¼-20 EQ Stop Screws shown at right:

11. Adjust each Screw so that it contacts the Mass, but applies no pressure.
12. Rotate each Screw ¾ turn counterclockwise to leave a 1 mm gap between the Screw Tip and the Mass.
13. Tighten the Hex Nuts at each of the Screws, to lock the Screws in position.

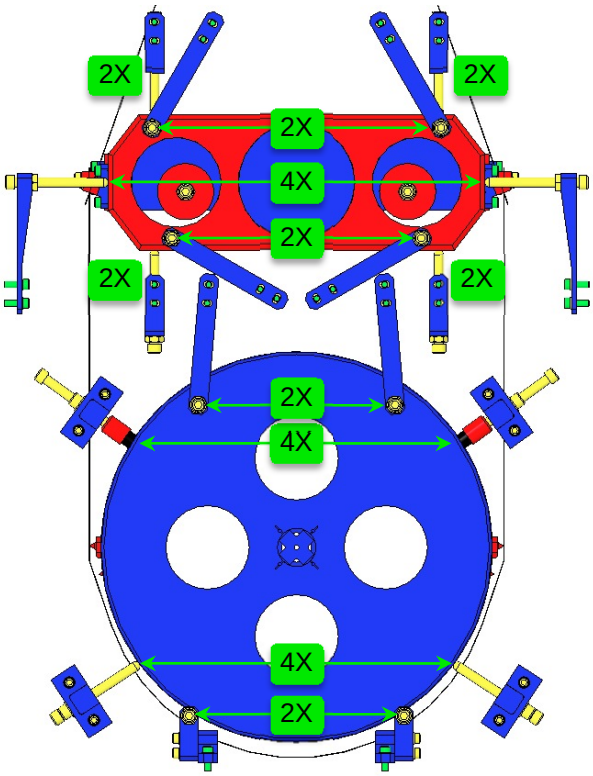

Fig 123: 1 mm gap at EQ Stops

14. Adjust the 4 Lower Blade Guard Screws so they contact the Lower Blades but apply no pressure.
15. Rotate the Screws 1 ¼ turns counterclockwise, to leave a 1 mm gap at the Lower Blades.
16. Repeat these 2 steps with the 2 Upper Blade Guard Screws, but with only a ¾ turn counterclockwise.

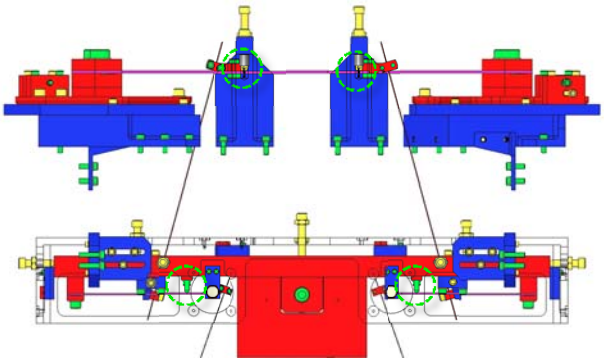

Fig 124: Blade Guard Screws

29 Assembling Magnets To Intermediate Mass

29.1 Documents

E990196 Magnet / Standoff Assembly Preparation

29.2 Materials

Qty	U	ID	Description
1	Ea	D0901461	**HLTS Magnet Placement Fixture, Intermediate Mass**
4	Ea	D980184	LOS Clamps
4	Ea	NA	Socket Head Cap Screw ¼-20 x 1.5” AgPlated
4	Ea	D020661	Magnet/Standoff Assemblies, 2 N and 2 S configurations
1	Ea	NA	Machinist Square, approx. 6” in length
1	Ea	TBD	Epoxy Gun Applicator, MasterBond
1	Ea	EP30-2	Epoxy, Double Barrel Cartridge with Mix Tube, MasterBond
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. Prepare 2 “N” and 2 “S” D020661 Magnet/Standoff assemblies per E990196 Preparation procedure.

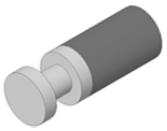

Fig 125: D020661 Magnet/Standoff Assembly

Place the Mass or Optic

2. Mount the Base Plate of the D0901461 Magnet Placement Fixture on an Optics Table using the 4 D980184 LOS Clamps.
3. Place the Intermediate Mass Assembly on the Base Plate with the back side facing up.

   The Intermediate Mass is symmetric; front/back is identified only after the Mass is balanced within the Weldment.
4. Place the Positioning Standoff over the Mass. Using a Machinist's Square, carefully align the engraved markings on the D0902452 Side Plates with those on the main Standoff Plate D0902445 (see red dashed lines at right). The Sides and Standoff Plate together form the D0902444 Positioning Standoff.

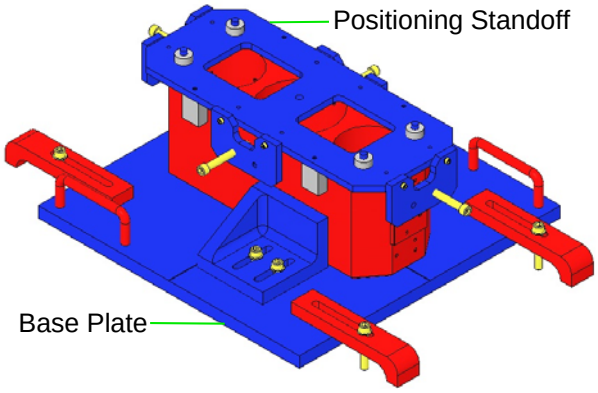

Fig 126: Magnet Placement Fixture

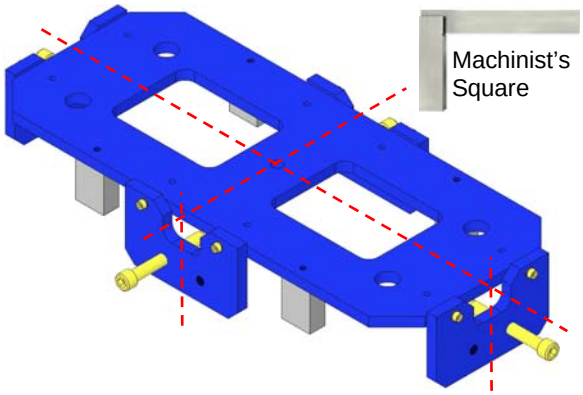

Fig 127: Aligning Side Plates with Main Plate

Load Plungers

5. Wipe the counterbore end of each plunger with Isopropanol and a Wipe.
6. 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.

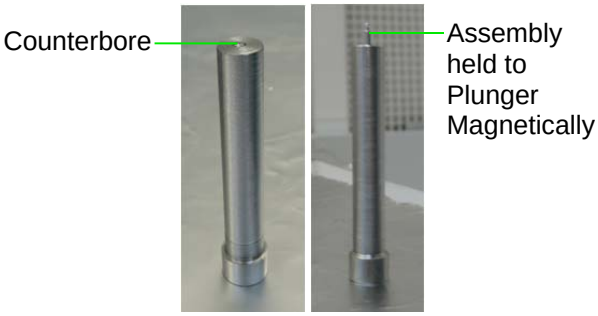

Fig 128: Plungers Empty and Loaded

7. Lay the loaded Plungers on the Optics Table around the Fixture per the Magnetic Polarity layout shown.

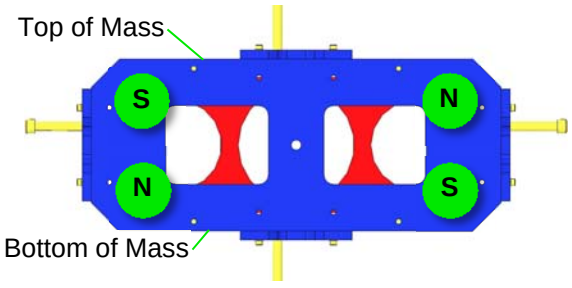

Fig 129: Magnet Polarity Layout

Bond Magnets to Mass

8. Load the EP30-2 Cartridge with Mix Tube attached, into the Gun Applicator.
9. Pull the trigger on the Gun Applicator 1 full stroke, to purge the Mix Tube of under-mixed adhesive.
10. Dispense a “quarter-sized” pool of Adhesive onto a small piece of clean UHV aluminum foil.
11. 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.
12. 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.
13. Load the Plunger, Magnet/Standoff down, into the appropriate Bushing in the MPF. Slide the Plunger down within the Bushing until the Standoff contacts the Mass. Press down on the Plunger lightly with one finger for about 2 seconds, then release.
14. Repeat steps 11-13 to load all 4 Plungers into the Placement Fixture.
15. Allow the Epoxy to cure within the Fixture at room temperature for 24 hours.

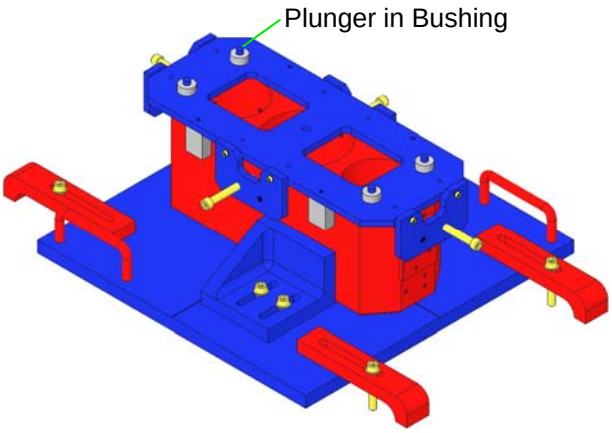

Fig 130: Loading Magnets into Fixture

16. Carefully remove the 4 Plungers from the Magnet Placement Fixture, and remove the Positioning Standoff from the Mass.
17. 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.

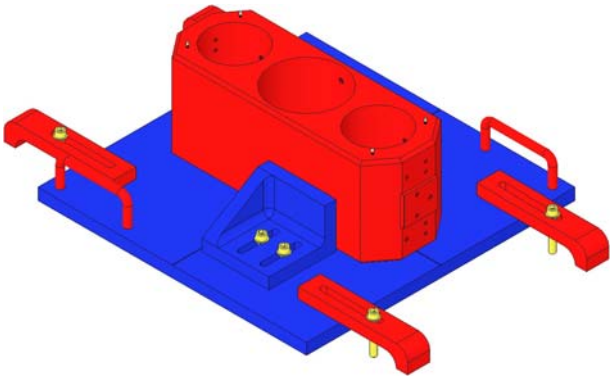

Fig 131: Heat Lamp Cure

30 Assembling Magnets To Bottom Mass

30.1 Documents

E990196 Magnet / Standoff Assembly Preparation

30.2 Materials

Qty	U	ID	Description
1	Ea	D0901460	**HLTS Magnet Placement Fixture, Bottom Mass**
4	Ea	D980184	LOS Clamps
4	Ea	NA	Socket Head Cap Screw ¼-20 x 1.5" AgPlated
1	Ea	D070338	HLTS Bottom Mass
1	Ea	Various	HLTS Optic
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	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

30.3 Procedure

- 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 Placement Fixture.

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

Fig 132: D0902432 Magnet/Standoff Assembly

Place the Mass or Optic

2. Mount the Base Plate of the D0901460 HLTS Magnet Placement Fixture on an Optics Table using the 4 D980184 LOS Clamps.
3. Place the Test Mass or Optic on the Base Plate.

   The Mass/Optic Arrow must be facing downwards.

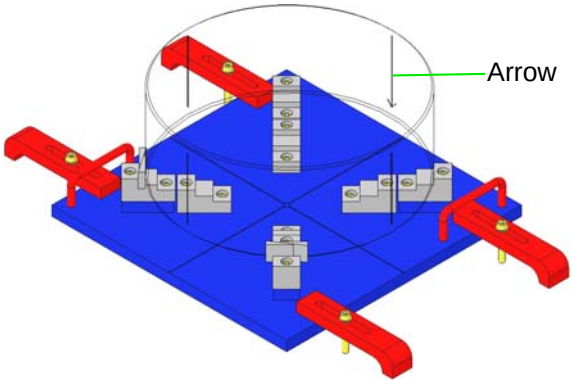

Fig 133: Base Plate Mounted on Optics Table

4. Place the Magnet Positioning Fixture (MPF) on top of the Mass / Optic.
   For the Optic, ensure the PFA440HP-tipped Stops are installed on the Stop Screws

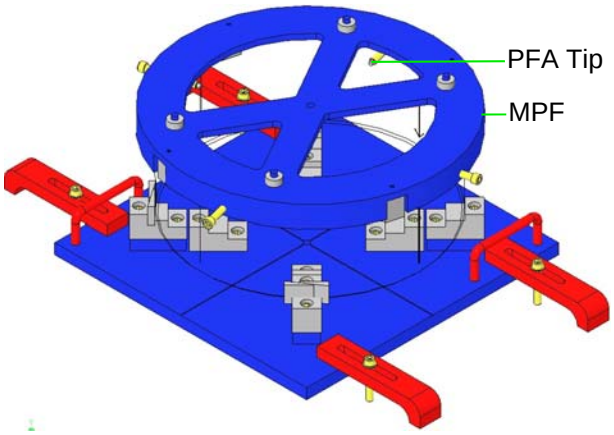

Fig 134: MPF in place

Align the MPF and Mass / Optic scribe lines:

For clarity, the Base Plate is not shown.

The MPF Scribe Lines are not visible in the drawings; they fall within 4 flat areas on the MPF perimeter, about 15° clockwise from each Screw.

5. Center the MPF on the Mass / Optic by obtaining equidistant readings between opposing pairs of MPF Scribe Lines and the Mass Optic perimeter, using a Depth Gage. The MPF Screw tips must barely contact and not "clamp" the Mass/Optic.
6. For a Metal Mass, rotate the Mass while using a Machinist Square to align the Mass and Fixture scribe lines. Align at 2 Lines 90° apart.
   For an Optic, sight across (through) the glass through 2 opposing scribe lines, then rotate the Optic while using a Machinist Square to align the MPF and Optic scribe lines.

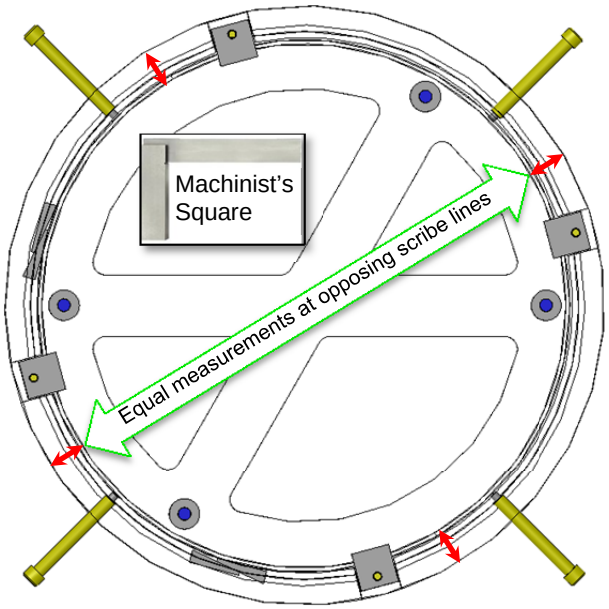

Fig 135: Centering the MPF on the Mass / Optic

Load Plungers

7. 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.

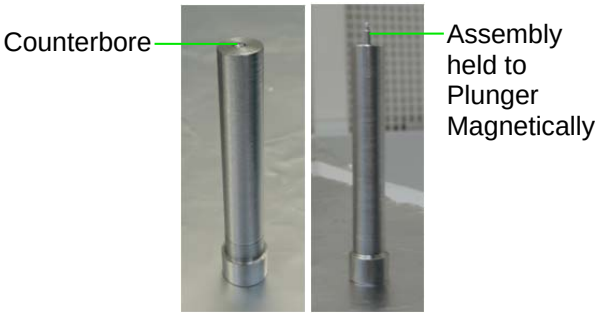

Fig 136: Plungers Empty and Loaded

9. Lay the loaded Plungers on the Optics Table around the Fixture per the Magnetic Polarity layout shown.

   Note that the "X" pattern is rectangular and not square; this pattern defines the Magnet layout.

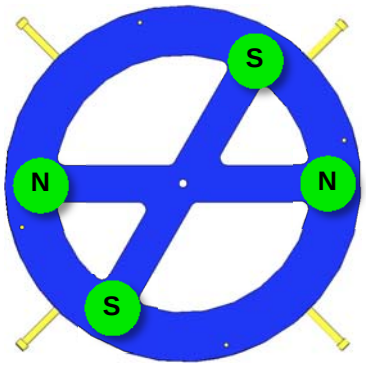

Fig 137: Magnet Polarity Layout

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. Hold a Plunger loaded with a Magnet/Standoff assembly 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.

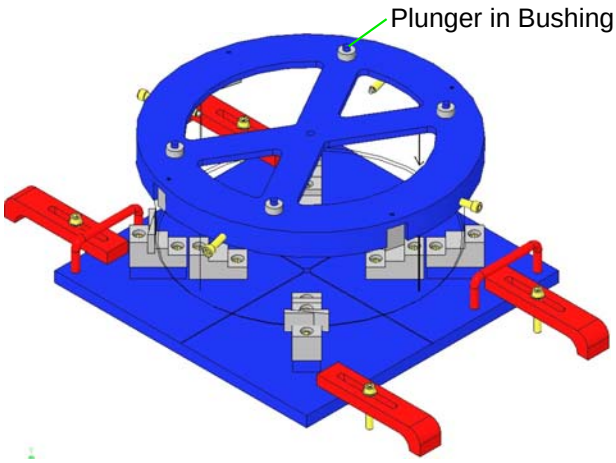

Fig 138: Loading Magnets into Fixture

15. Load the Plunger, Magnet/Standoff down, into the appropriate Bushing in the MPF. 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 the MPF, and remove the MPF 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.

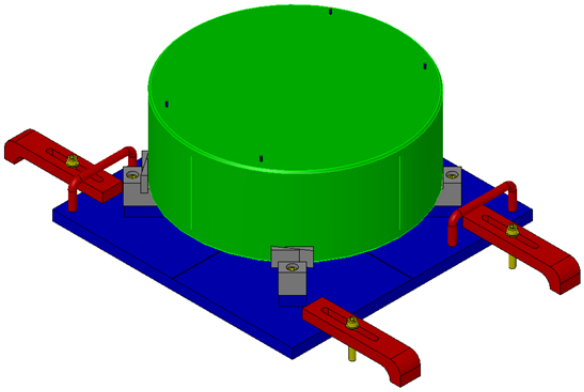

Fig 139: Heat Lamp Cure

31 Installing the BOSEMs

1.7 Documents

D070442 HLTS Overall Assembly

1.8 Materials

Qty	U	ID	Description
6	Ea	D060218	**BOSEM Assembly**
24	Ea	NA	Socket Head Cap Screw 4-40 x 7/8” SSTL
24	Ea	NA	Flat Washer #4 SSTL

1.9 Procedure

1. Install the 6 BOSEMs in the arrangement shown, using:
   - 24 Socket Head Cap Screws 4-40 x 7/8” SSTL
   - 24 Flat Washers #4 SSTL
     Torque to 5 in-lb

   It may be necessary to install the end BOSEM opposite from the end shown, due to space requirements inside the HAM chamber. Use a non-magnetic hex key to avoid attracting the hex key to the Magnet and Flag Assembly.

   Be careful not to bend the Magnet Flags.

   Record the serial number and position of each BOSEM in ICS.

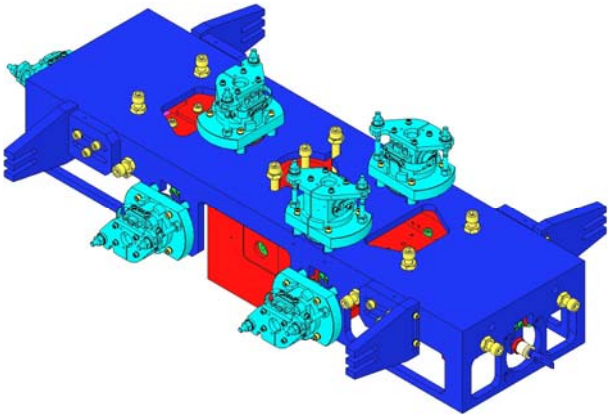

Fig 140: BOSEMs Installed

2. After all 6 BOSEMs are attached, install the in-vacuum cabling and related cable connectors and clamps. Use silver-plated SHCS in threaded holes in the HLTS Structure.

32 Installing AOSEM Brackets

32.1 Procedure

1. Adjust the push and pull screws on each AOSEM bracket so that the front face of each AOSEM is as far back as possible. Back off the earthquake stop on each AOSEM bracket.
2. Attach the AOSEM brackets (as shown in Figure 37) to the HLTS Structure in this order: Bottom Mass Lower AOSEM Alignment Assembly (D0901551), Bottom Mass Upper AOSEM Alignment Assembly (D0901552), Intermediate Mass Lower AOSEM Alignment Assembly (D0901551), Intermediate Mass Upper AOSEM Alignment Assembly (D0902024). Record the serial number and position of each AOSEM on the HLTS Process Traveler.

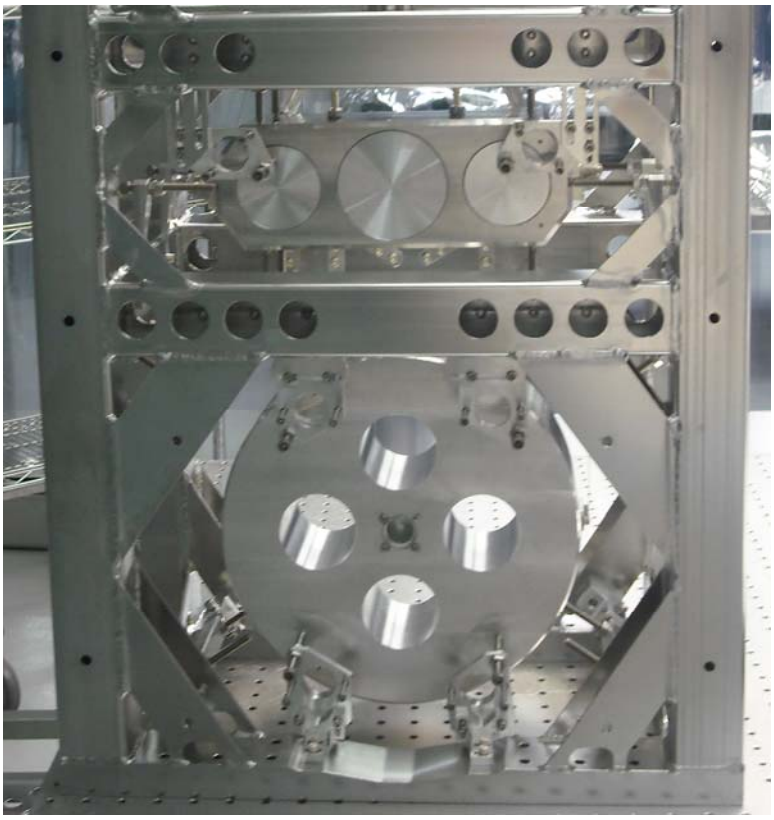

Fig 141: AOSEM Bracket Arrangement

3. Align each AOSEM vertically and laterally using the slots on the AOSEM brackets. Look through the barrel of the AOSEM and align the magnet/dumbbell assembly with the center axis of the AOSEM.
4. Adjust the earthquake stop on each bracket to a distance of approximately 1 mm from the corresponding mass. Tighten the hex nuts on either side of the bracket to lock the earthquake stop in place.
5. After all AOSEM brackets are installed, connect the in-vacuum cabling and related cable connectors and clamps.

33 Aligning OSEMs

33.1 Procedure

1. Connect the in-vacuum cabling for the AOSEMs and BOSEMs to the Triples Test Stand. Confirm that each cable is connected correctly.
2. Using the MEDM screens on the Triples Test Stand, read the open light voltage for each BOSEM. Adjust the BOSEM using the SHCS connecting it to the tablecloth for rough positioning. Use the PEEK hex nuts for fine adjustment. Position the BOSEM so that the Triples Test Stand indicates 50% of the open light value.
3. Using the MEDM screens on the Triples Test Stand, read the open light voltage for each AOSEM, starting with those for the Intermediate Mass. Use the push and pull screws on each bracket to adjust the position of each AOSEM. Position each AOSEM so that the Triples Test Stand indicates 50% of the open light value.