

APPROVALS	DATE	REV	DCN NO.	BY	CHECK	DCC	DATE
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	6/09	V2					
CHECKED:							
APPROVED:							
DCC RELEASE							

### 1 Scope

This specification covers the assembly of the Advanced LIGO OSEMs, D0901065, which will be used in many Advanced LIGO suspensions.

All steps performed in this document shall be done in the appropriate environment according to the cleanliness required at that assembly step.

### 2 References

- (1) E030350-A, *D. Coyne, C. Torrie* - "Drawing Requirements".
- (2) T040111-00, *M. Gerfen, L. Jones, C. Torrie* - "Galling Tendencies and Particles Produced by Ultra Clean Screw Threads".
- (3) E960022-B-E, *LIGO Systems Engineering* - "LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures".
- (4) T050111-01-K, *S. M. Aston, D. M. Hoyland* - "Noise Prototype OSEM Preliminary Design Document & Test Report".
- (5) E030084-02-D, *J. Romie* - "Hybrid OSEM Assembly Specification"
- (6) T070107-00-K, *D. Lodhia, S. M. Aston* - "Noise Prototype OSEM Test Specification"
- (7) T0900286-v1, *R. Abbott, M. Barton, B. Bland, B. Moore, J. Romie* - "Advanced LIGO OSEM Final Design Document"
- (8) T060233-02, *S. M. Aston & D. Lodhia* - "BOSEM Assembly Specification"
- (9) T040127-00, *R. Taylor* - "Cleaning Procedure for Magnet Wire with ML/HML Insulation" - NOTE - this reference pertains only to SEI magnet wire - not SUS OSEM wire.
- (10) E0900169-v1, *R. Abbott, B. Bland, B. Moore, C. Osthelder, J. Romie* - "Sensor/Actuator Testing Specification"
- (11) T1000240-v1 *R. Abbott, B. Bland* - "AOSEM Set Screw Torque Specification"

### 3 Drawing List

- D0901065, OSEM Assembly
- D0901048, OSEM Head
- D0901066, OSEM Flexi-circuit assembly
- D0901049, PEEK Stiffener
- D0901252, Flexi-circuit
- D070156, Quad Suspension Pig-tail Harness Overview and Labeling Scheme
- D000209, Photodiode Optical Filter



## Advanced LIGO OSEM Assembly Specification

### 4 Head Fabrication

#### 4.1 Head Part Number

D0901048, OSEM Head

The head drawing details the dimensional requirements for the heads.

#### 4.2 Fabrication Specifications

For all fabricated parts, the detailed drawings provide the specification required for part manufacture. Drawings generated have been detailed and dimensioned in accordance with reference [1]. These drawings also include instructions to vendors regarding use of machining fluids and locations for part labeling. The head is made from ESD 480 PEEK.

#### 4.3 General Inspection

When parts are provided by the vendor, they are inspected for dimensional acceptance. Confirm that threaded holes and other features comply with callouts shown on the drawing. Ensure that all burrs/frays and sharp edges (especially around the coil winding groove and wire-threading hole) have been completely removed. Reject any parts that do not meet the drawings.

#### 4.4 Part Number Marking Inspection

Inspect the part marking. Be sure that the identification is legible and that the parts are clean. Record serial numbers upon receipt for inventory control in the ICS or traveler for the batch.

### 5 Assembly of Magnet Coil

#### 5.1 Head Cleaning and Vacuum Baking

It is necessary to clean the PEEK heads prior to winding the coil wire. Clean the heads per the cleaning procedures in E960022, reference [3]. Contamination control protocols will need to be followed when handling the head for coil winding.

#### 5.2 Coil Cleaning and Winding

It is necessary to carry out a pre-cleaning process on the coil winding wire, as supplied by the manufacturer. The aim of the procedure is to remove any trace contaminants (e.g., paraffin, mineral oil, etc.) prior to winding the coils. Clean the magnet wire vendor recommended instructions:

- 1) Clean takeup spool with isopropyl alcohol.
- 2) Dereel wire from shipping spool to clean takeup spool. While dereeling, pass wire through isopropyl soaked clean wipe and air dry wire, onto takeup spool.



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Using the Kapton wire called out on the drawing, thread the end of the wire down through the hole near the coil groove and out the back of the head. Wind the wire clockwise on the head 400 turns, looking from the front of the head. The back of the OSEM is the end with the threaded holes. Take care to align the wire in the coil groove so that the wire is flush or inside of the OD of the head. Thread the end of the coil down through the same hole to the inside of the head and bring the wire out the back. Leave approx. 6" at the beginning of the coil and 6" at the end of the coil, measured from the back of the head, to allow for dressing of the wires. For identification purposes, tie a knot at the end of the "finish" coil wire (not the "start" wire.) Secure the wires to the head by wrapping the head in UHV foil or equivalent so that the coils will not unwind during inspection and shipment.

### 6 LED, PD, and Connector assembly to Flexiboard

D0901066, Flexiboard Assembly

The LED, PD, and Connector will be mounted to the Flexiboard by the Flexiboard manufacturer.

Note: All of the following steps should be performed under contamination control. While the parts are not yet Class A, there is potential for assembly steps to trap contamination, so gloves should be worn and activities should take place in a clean environment.

### 7 AOSEM Assembly

#### 7.1 Device test

Mount the assembled Flexiboard onto the go-no-go test jig and perform initial verification that light is emitted and received by the LED/PD pair.

#### 7.2 Mount & bond filter

Lay the flexi-circuit onto a clean, flat table. Turn it over, such that the connector is touching the table. Look for the "PD" on the board. Carefully clean the photodiode filters. Mount a filter, D000209, on the flexi-circuit, centered over the photodiode through-hole. Use a very small amount of UV curing epoxy (EMIUV Optocast 3553-LV-UTF-HM) to hold the filter to the board. Follow instructions TBD to cure epoxy with UV heat gun.

#### 7.3 Mount Flexi-circuit, align, and test components

The arms of the flexi circuit have to be gently bent toward each other, taking care not to crease the Kapton, and then moved along the slots in the OSEM body, from back to front. The back of the OSEM is the end with the threaded holes. The arm ends of the flexi-circuit should be flush to the front face of the OSEM head. Use the set screws to control this position, making sure as not to bow the flexi-circuits. Visually check that the components are aligned to each laterally, then adjust their position relative to each other such that the appropriate PD current is achieved.



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To lock the set screws down, apply 0.5 inch-pounds of torque above the torque needed to turn the screw (reference [11] T1000240). Note that the flexiboard could suffer damage if the set screws are over torqued! Pull the coil wires through the central hole of the flexiboard.

Using the vented stainless SHCS, mount the flexi circuit to the OSEM head, taking care not to compress the magnet coil wires. Torque the SHCS to 4-6 in-oz.

Measure the noise of the AOSEM and record in the traveler for the batch of heads.

### 7.4 Coil Winding Soldering and Cleaning

With the two coil wires sticking out the back, bend them down to the surface mount pads in order to cut them to length. Measure the resistance of the coil.

Strip the ends of the coil wire using the magnet wire stripper made by The Eraser Company, model no. DCF1/ Item # AR4501, or equivalent. Strip approximately .250" of the Kapton so that no copper wire is exposed after soldering. The start end of the coil wire is soldered to the pad labeled "ST". The end of the coil wire is soldered to the pad labeled "FN". Tin and solder the wires to the flexi-circuit. Use a minimal amount of solder on these joints. Inspect each solder joint under a stereo microscope to ensure no undesirable joints (e.g. dry or cold joints) are present. Conduct any solder joint re-working (and cleaning) as necessary.

Check the winding polarity with a compass by passing current through the coil.

Using the testing jig, power up the LED and photodiode through the 9-pin connector and make sure that the components function properly, while proving continuity of the traces and connections.

Soak the heads in isopropyl alcohol for 10 minutes. Carefully brush the boards clean. This step should remove most of the flux. Use another beaker of clean isopropyl alcohol for a final cleaning. Carefully push the wires to the sides of the inside of the bore to provide clearance for the magnet.

### 7.5 Final Clean and Vacuum Bake

As described in reference [3], ultrasonic clean the complete OSEM in methanol for 10 minutes.

Then, soak in isopropyl alcohol for 10 minutes, agitating regularly. Finally, bake in-vacuum at 120 deg C for 48 hours.

**Note:** Assembly screws will need to be loosened or removed for the vacuum bake step – care should be taken during handling such that the flexiboard and soldering joints do not get damaged.

### 7.6 Post Bake Testing

Perform complete performance tests, per reference [10]. Perform a final alignment of the LED and photodiode and lock down the set screws, as per the torque spec T1000240, reference [11]. A minimum amount of torque should be applied to these set screws to avoid distortion of the flexi-circuits, while maintaining position of components relative to each other in the OSEM head.

Document this data using the OSEM head serial number, on the "Test Data Form", in the traveler.