LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T070298-00-D *ADVANCED LIGO* 5th December 2007

ALIGO NP-type: - Preparations of Ear Bonding at LASTI on 10th December – 14th December 2007

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Rev 00	*15th November 2007*	*First draft of report for comment (M. Van Veggel, R. Jones, H. Armandula)*
Rev 01	*5th December 2007*	*Right before travel draft (M. van Veggel, R. Jones, H. Armandula)*

Introduction

In the week of Monday 10th December until Friday 15th December a second exercise will be done at LASTI for bonding silica ears to the second penultimate mass and glueing prisms to the first and second penultimate mass and the reaction mass as part of the ALIGO ETM/ITM noise prototype activity.

A preceding bonding exercise from 27th August to 31st August 2007 during which ears were bonded to the first penultimate mass and the test mass. A report of this document has reference LIGO-T070223-00-D.

This document is a preparation document for the second exercise. It lists: goals, needed documents, check list of needed materials, list of tasks to be completed before the exercise starts.

1 Reference documents

Design documentation 'glass' essentials	
D050421-05-K	NP- type ETM Penultimate Mass
D040431-C-D	Quad ETM Silica Test Mass
D050420-06-D	NP-type ETM Reaction Test Mass
D060055-02-K	NP-type Refined Ear (Type A)
D060056-02-K	NP-type Refined Ear (Type B)
Design documentation of the alignment jigs	
D070391-05-D	NP-type ear bonding jig GA
Measurement reports on 'glass' essentials	
GNL-4025-R1	Penultimate mass 1 measurements
GNL-4027-R2	Penultimate mass 2 measurements
GNL-4020-R1	Reaction mass measurements
C070035-00	Test mass measurements
E070163-00-K	Test report on A ears for Advanced LIGO monolithic suspension[1] (update required)
E070164-00-K	Test report on B ears for Advanced LIGO monolithic suspension[2] (update required)
Back ground documents	
E050228-00-D	(Specification) Silicate Bonding Procedure
T070138-00-K	Ribbon/Fibre Length Budget
T070156-01-K	Advanced Testing of the Noise Prototype Ear Bonding Jig
T070223-00-K	ALIGO NP-type: - Report on Ear Bonding at LASTI 27th August – 31st August
E970154-00-D	Large optics suspension balancing: component specification
E070070-00-D	LASTI Test Mass, Handling and Shipping Procedures
NOLIGO-1	Calibration document of scale VW-330-C

[1] Note there has been a renumbering of the ears characterized in E070163 – "A" replaced with "BB".

[2] Note there has been a renumbering of the ears characterized in E070164 – "B" replaced with "AA".

2 Goals

Goals of the visit are to:

1) Weigh masses
2) Bond ears to the 2nd penultimate mass
3) Measure electrical conductivity of the gold electrostatic drive of the ERM

3 Prospected time schedule

Table 3.1 Time schedule

	Monday 10-12-2007		Tuesday 11-12-2007		Wednesday 12-12-2007		Thursday 13-12-2007		Friday 14-12-2007	
Preparations										
Weigh test mass										
Measure position of the ears on test mass										
Weigh 2nd PM										
Bond ears to side 1 2nd PM										
Bond ears to side 2 2nd PM										
Weigh 1st PM										
Measure position of the ears on 1st PM										
Weigh + measure electrical conductivity of gold coating ERM										
Pack masses and clean										

4 Short discussion of tasks 10 December 2007 – 14 December 2007

4.1 Preparations

Fill in safety forms with David Schoemaker and Rich Mittleman. Main safety risk is the lifting of the masses. There are no chemical safety risks as the bonding solution is not hazardous. Check if all required items are accounted for

Set-up the cleanroom

4.2 Weighing masses

Each mass will be weighed. The mass of the TM, 1st PM, 2nd PM and RM will have to be measured with an accuracy of +/- 30 g (see e-mail exchange between Ian Wilmut, Ken Strain, Mark Barton, Russell Jones, Helena Armandula and Marielle van Veggel on 8th November 2007).

Steps:

- Set-up weighing scale VW-330-C
- Calibrate it using two 20 kg (+/- 0.002 kg) masses (according to NOLIGO-1)
- Lift mass from container onto weighing scale
- Weigh mass 1st time
- Lift mass and back onto weighing scale
- Weigh mass 2nd time
- Lift mass and back onto weighing scale
- Weigh mass 3rd time
- Lift mass and put it onto the bonding table

4.2.1 Calibration

- **Setting the resolution (count-by) and calibration weight**
  - ◊ Turn the VW330 OFF.
    - (1) *Note the power switch is located on the bottom of the scale in the front on the right side.*
  - ◊ Press and hold the 'ZERO/MENU' key while turning the VW330 ON
  - ◊ The display will prompt:
    - < d = 0.000x
    - Cal = XX
    - Where 0.000x is the resolution and XX is the calibration weight.
  - ◊ The 'bullet' < on the display will be pointing to kg or lb indicating the selected unit of measure .
  - ◊ Use the units switch to select the desired calibration unit as indicated by the bullet '<' lb or kg.
    - (1) *Note the units switch is located on the bottom of the scale in the front on the left side.*
  - ◊ Press the 'TARE/CHG' key to toggle through the available resolutions (d = 0.000x) until the desired resolution is displayed.
  - ◊ Press the 'ENT' key to clear the calibration weight to 00.
  - ◊ Use the numeric keys to enter the desired calibration weight.
  - ◊ When the resolution and calibration weight are set power down the VW330.
- **Calibration**

◊ Turn the VW330 OFF.
(1) *Note the power switch is located on the bottom of the scale in the front on the right side.*
◊ Press and hold the 'ENT' key while turning the VW330 ON. There may be a slight delay when powering up in the calibration mode.
◊ The display will prompt:
COUNT
CT330C
XXXXX where XXXXX is the internal raw weight value.
◊ With no weight on the scale wait for the internal weight value to stabilize. A small amount of motion is acceptable.
◊ Press the 'ZERO/MENU' key. The display will flash 'SAVE'
◊ Apply the previously selected calibration weight (see above).
◊ Wait for the internal weight value to stabilize. A small amount of motion is acceptable.
◊ Press the 'ZERO/MENU' key. The display will flash 'SAVE'
◊ Power down the VW330

◊ Turn the VW330 on in the normal weighing mode and check calibration.

4.3 Ear bonding to 2nd penultimate mass

4.3.1 Ear allocation

Table 4.1 Ears to go on to the 2nd penultimate mass

	Side 1	**Side 2**
Left ear	Ear AA010[3]	Ear AA014[3]
Right ear	Ear BB005[4]	Ear BB012[4]

Spare ears: Ear AA001[3], Ear AA003[3], Ear BB016[4], EarBB001[4]

[3] D060055-02-K "NP-type Refined Ear (Type A)", E070163-00-K "Test report on A ears for Advanced LIGO monolithic suspension"

[4] D060056-02-K "NP-type Refined Ear (Type B)", E070164-00-K "Test report on B ears for Advanced LIGO monolithic suspension"

4.3.2 Template settings

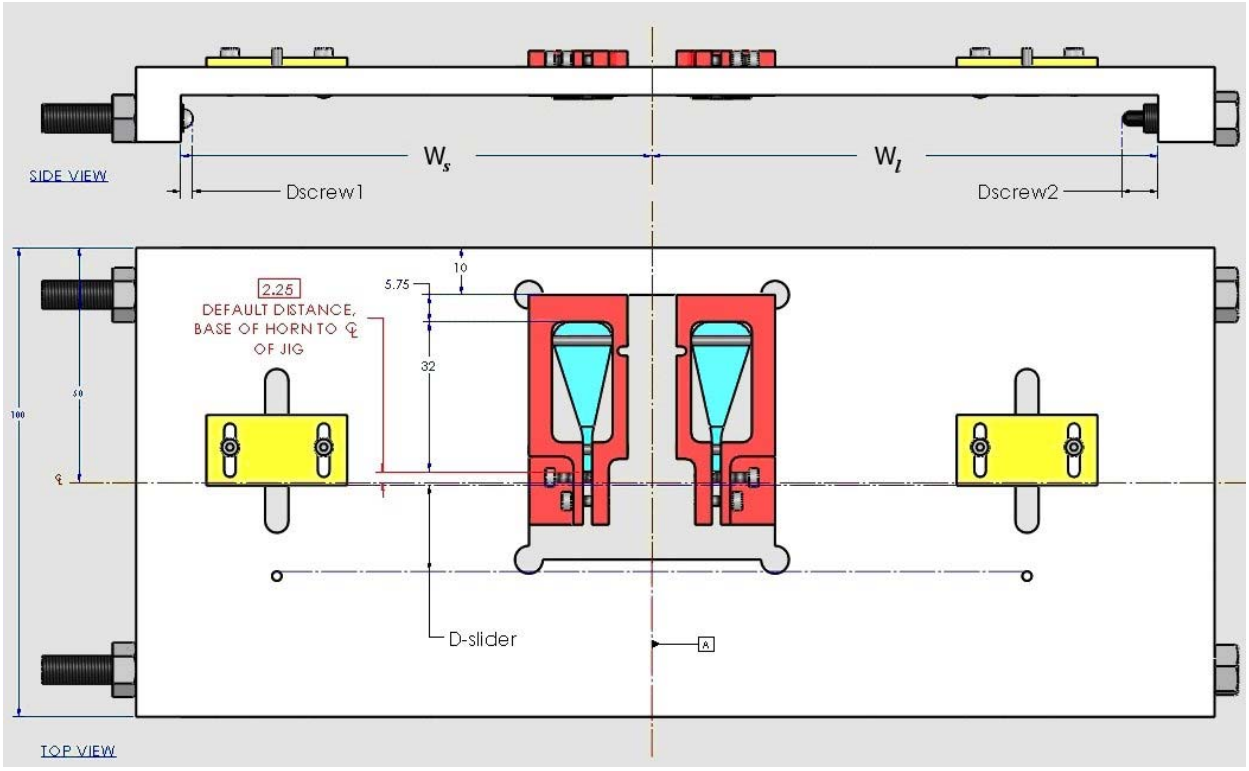

Figure 4.1 Bonding Jig: Critical Reference dimensions

- D-slider for the 2nd penultimate mass will be set as has been done for the 1st penultimate mass: D-slider = 18.6 mm[5] (confirmed by Ken Strain at Glasgow suspensions meeting 22nd November 2007)
- The average width of the 2nd penultimate mass $W_{2nd\ PM}$ = 200.415 mm[6]
- For the 1st penultimate mass the position of D-screw1 and D-screw 2 was based on the position of the grooves which were slightly off-centre.
- The position of the ears on the second penultimate mass must be based on the centre of mass in principle, but if the position of the ears on the test mass deviates from its centre of mass, the position of the ears on the 2nd penultimate mass must be made as to counteract the introduced moment. Therefore, the expected position of the ears on the test mass must be backtracked and also measured, after weighing.
- The distances W_s and W_l of the jig sides from the centre line are W_s = 100.5 mm and W_l = 107.96 mm (TBC at LASTI).

[5] T070223-00-D "ALIGO NP-type: - Report on Ear Bonding at LASTI 27th August – 31st August"

T070138-00-K "Ribbon/Fibre Length Budget"

[6] GNL-4027-R2 "2nd Penultimate mass measurements"

Based on perfect alignment of the ears on the test mass, the settings of the screws can be calculated from:

Bonding on flat 1 D-screw1 = $W_s - W_{2nd\ PM}/2 - c_h = 0.293$ mm

Bonding on flat 2 D-screw2 = $W_l - W_{2nd\ PM}/2 - c_h = 7.753$ mm

- The distances D-slider1 and D-slider2 are to be set using a set of calipers and a screw driver.
- The distances D-screw1 for flat 1, and D-screw 2 for flat 2 are to be set using a combination of slip gauges and feeler gauges and Allen keys and a spanner.

Table 4.2 Bonding jig setup for the 2nd penultimate mass (TBC)

	2nd Penultimate Mass[7]	
	Flat 1[8]	**Flat 2**[9]
D-slider1 or D-slider 2	18.6 mm	18.6 mm
D-jig (new)[10]	2.65mm (above)	2.65 mm (above)
D-screw1	0.29 mm (±0.1)	(contact with sprung bolts)
D-screw2	(contact with sprung bolts)	7.75 mm (±0.1)

4.3.3 Ear bonding

- Prepare ears
- Move mass to washing bath
- Wash side 1 of mass
- Move mass back to bonding table
- Prepare bonding solution / pipette
- Wash ear 1
- Wash ear 2
- Setting template on mass
- Put ears in holders
- Bond ear 1
- Initial inspection/photographs bond 1
- Bond ear 2
- Initial inspection photographs bond 2

4.3.4 Back track position of ears on the test mass

The bonding template was referenced to surface 1 “S1”, with HR coating, which is the front face.

The average thickness of the TM according to measurements is:

[7] D050421-05-K_Serial number 002 (the second of the two penultimate masses).

[8] D050421-05-D_Surface “S2” in zone “D8”. Template referenced to front face, surface “S3”.

[9] D050421-05-D_Surface “S1” in zone “D8”. Template referenced to front face, surface “S3”.

[10] Distance from tip of the ear to the reference line on the flat (+/-0.25mm, the width of the reference line)

$$t_{TM} = \frac{200.431 + 199.466}{2} = 199.95 \text{ mm}$$

The centerline distance d_{CL} from surface 1 to the centre of mass:

$$d_{CL} = \frac{t_{TM}}{2} = \frac{199.95}{2} = 99.98 \text{ mm}$$

The reference screws on the bonding template were set to d-screw1 = 0.5 mm (see Table 1, p. 15, T070223-00-K).

The width of the template to the centerline of the template is: 100.5 mm.

Therefore, the distance from the contact point to the centerline of the template was:

$d_{template} = 100.5 - 0.5 = 100$ mm.

Provided the distances mentioned above, are correct the ears on the test mass have been aligned correctly.

4.3.5 Measure position of the ears on TM

Measure the distance of the outer part of the weld horn of the ear closest to surface 1 to surface 1 (d_{ear} in Figure 4.2).

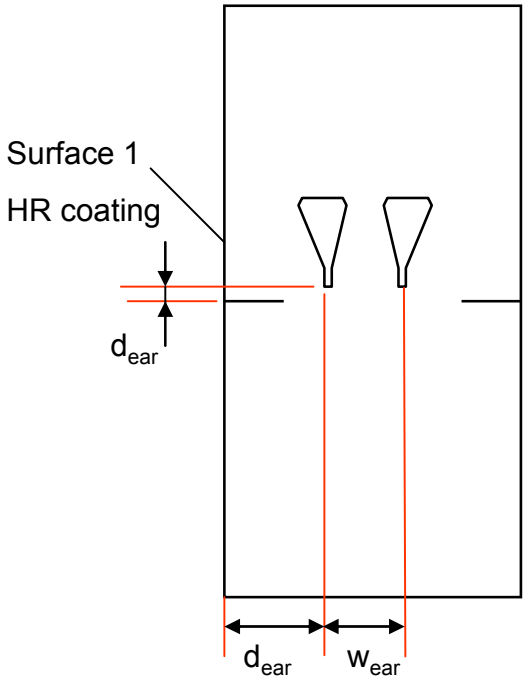

Figure 4.2 Measurement of position of ears

$w_{ear\text{-}front}$ and $w_{ear\text{-}back}$ should be 100 – 14.75 = 85.25 mm

w_{ears} should be 29.5 mm

The vertical position of the ears should be:

d_{ear} = d-pin + d_{jig} – d-slider = 19.0 + 2.25– 18.7 = 2.55 mm

Table 4.3 Fill in table for measurements of the position of the ears on the TM

Parameter	**Measured value [mm]**
$w_{ear\text{-}front}$	
w_{ears}	
$w_{ear\text{-}back}$	
$d_{ear\ 1}$	
$d_{ear\ 2}$	
	Error value [mm]
$\varepsilon_h = 100 - (w_{ear\text{-}front} + w_{ears}/2)/2$	

4.3.6 Back track position of ears on the 1st penultimate mass

The bonding template was referenced to surface 1 “S1”, with HR coating, which is the front face.

The measured thickness of the 1st PM according to measurements is:

$t_{1stPM} = 200.5$ mm

The centerline distance d_{CL} from surface 1 to the centre of mass:

$$d_{CL} = \frac{t_{1stPM}}{2} = \frac{200.5}{2} = 100.25 \text{ mm}$$

The reference screws on the bonding template were set to d-screw1 = 0.5 mm (see Table 1, p. 15, T070223-00-K).

The width of the template to the centerline of the template is: 100.5 mm.

Therefore, the distance from the contact point to the centerline of the template was:

$d_{template} = 100.5 - 0.5 = 100$ mm.

This means that the alignment of the ears is -0.25 mm with respect to the centre of mass.

4.3.7 Measure position of the ears on 1st PM

Measure the distance of the outer part of the weld horn of the ear closest to surface 1 to surface 1 (d_{ear} in Figure 4.2).

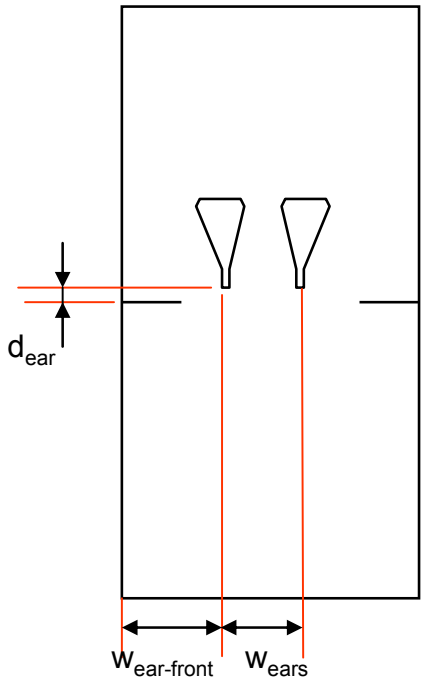

Figure 4.3 Measurement of position of ears

$w_{ear\text{-}front}$ and $w_{ear\text{-}back}$ should be 100.25 – 14.75 = 85.50 mm

w_{ears} should be 29.5 mm

The vertical position of the ears should be:

d_{ear} = d-pin + d_{jig} – d-slider = 19.0 + 2.25 – 18.6 = 2.65 mm

Table 4.4 Fill in table for measurements of the position of the ears on the 1st PM

Parameter	**Measured value [mm]**
$w_{ear\text{-}front}$	
w_{ears}	
$w_{ear\text{-}back}$	
$d_{ear\ 1}$	
$d_{ear\ 2}$	
	Error value [mm]
$\varepsilon_h = 100 - (w_{ear\text{-}front} + w_{ears}/2)/2$	

4.3.8 Correction if ears have not been aligned correctly

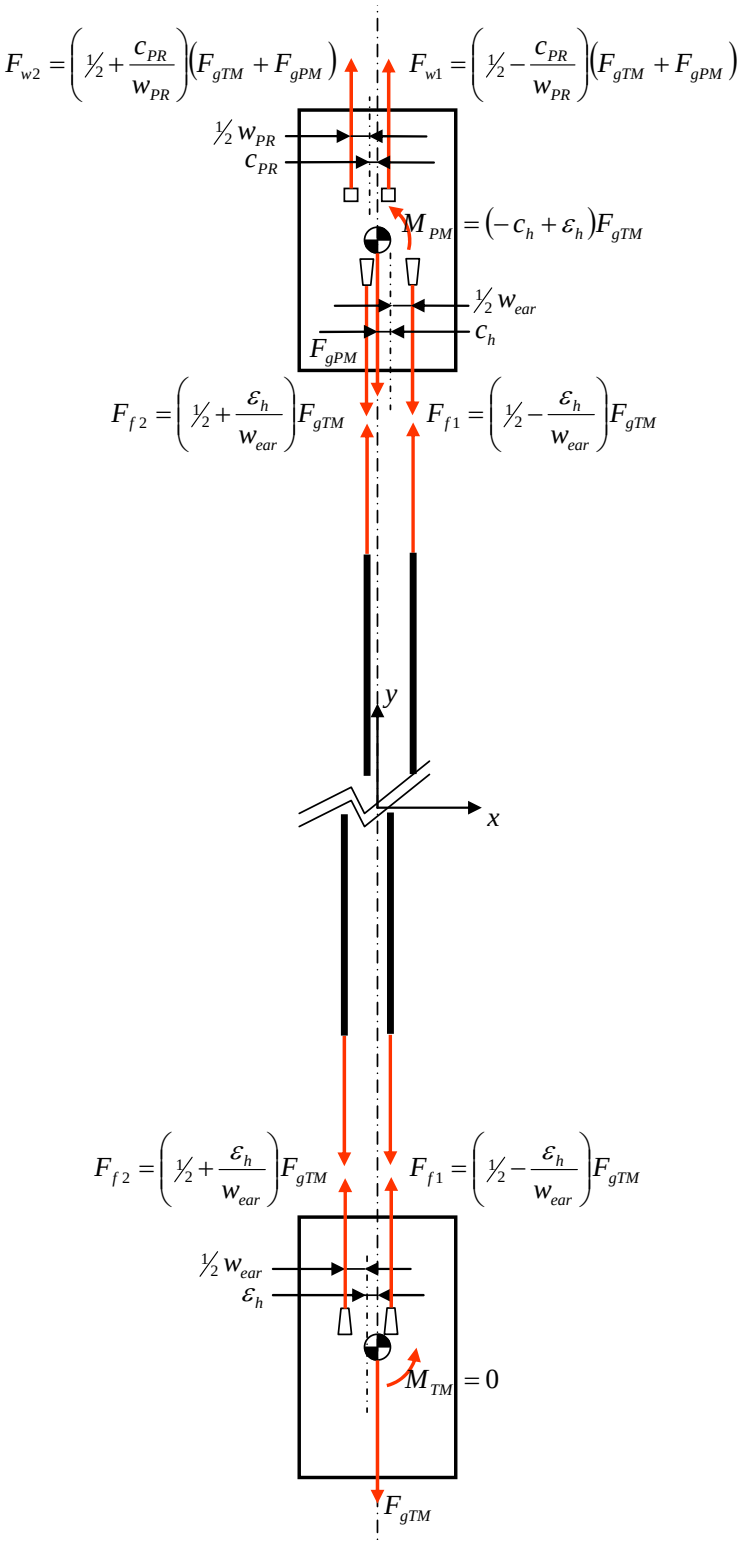

Figure 4.4 Mechanics picture of two lower masses of the LASTI suspension

For

$M_{PM} = 0$

$c_h = \varepsilon_h$

The correction of the horizontal position of the ears on the second penultimate mass should therefore be equal to the error on the test mass.

Table 4.5 Settings for D-screw in case of a correction

	2nd Penultimate Mass	
	Flat 1	**Flat 2**
D-screw1	0.29 mm (±0.1) – c_h	(contact with sprung bolts)
D-screw2	(contact with sprung bolts)	7.75 mm (±0.1) – c_h

4.4 Check electrical conductivity of gold coating on the reaction mass

Using a multimeter the electrical conductivity of the gold coating on the reaction mass should be checked. The resistance should be less than 1 Ohm.

5 List of required items

Essentials

- Ears (2x D060055 + 2x D060056 for the 2nd penultimate mass, plus spares)
- Masses (2 penultimate masses, the test mass and reaction mass)

Bonding Jig

- 2 full bonding jigs are available for use (including templates, holders, t-pieces etc)
- Tools for setting up jig (Allen keys/wrench/tweezers)

Bonding equipment and consumables

- Flowing de-ionised water
- Methanol
- Deionising gun with pure, filtered nitrogen (low pressure)
- Centrifuge tubes (15 ml)
- Small centrifuge tubes (1.5 ml)
- Centrifuge
- Optical wipes
- Cerium oxide powder
- Sodium bicarbonate powder
- Petri dishes
- Sodium silicate solution (10% NaOH, 27 % SiO_2, Riedel-de Haën)
- 10 µl pipettes
- 10 µl pipette points

Large items

- Ergo arm and ring clamp

- Washing trolley (trolley with ultrasonic bath)
- V-blocks
- 2 tables (one for set-up and one for bonding)

Measuring devices

- Plastic ruler
- Digital calipers
- Height gauge
- Metric Feeler gauges
- Metric Slip gauges

Other items

- Lighting: Osram LED work light
- Magnifying glass
- Clothing: Clean room suits, overshoes, gloves, hairnets, face covers
- First Contact™ surface polymer
- Crash mat: used below ergo arm when manipulating the mass in free space
- Photo camera
- UHV aluminium foil