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The review of production drawings for the ALIGO ETM Penultimate Mass: support notes

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Rev 00	*22nd February 2008*	*First draft, response required to action list in conclusions (R. Jones)*
Rev 01	*10th March 2008*	*Alterations to conclusion section based on drawing/spec review by G. Billingsley and I. Wilmut (R. Jones)*

1 Introduction

This document introduces the key features of the ALIGO ETM Penultimate Mass for review purposes.

Production drawings are based on drawings used for the ALIGO noise prototype[1],[2] (NP-type). The drawing of the finished mass is to be used as the main source of manufacturing information, supported by the material selection and inspection information described in the associated specification.

The changes to the form of the final ETM penultimate mass (as compared to the form of the NP-type penultimate mass) are as follows:

- **Change to the tolerance on wire groove position (use of symmetry tolerance, regardless of feature size, or RFS)**
- **Extension of wire grooves around full barrel of mass**
- **Extension of lambda/10 bond area on flat, and its associated specification.**

The following issues required confirmation before the completion of specifications:

- Confirm approach to specifying flat length (flat length versus width of mass, flat to flat) (*not yet confirmed)
- Size and positional tolerance required for shielded magnet recesses (*confirmed)
- Quantity, size and position of reference grooved (*not yet confirmed)
- Confirmation of wire sizes (*not yet confirmed, but not a critical issue)
- The ITM penultimate mass drawing is believed[3] to be identical to the ETM penultimate mass. (*awaiting final confirmation)

***A list of actions has been tabulated in the conclusion.**

2 Review documents

D080117	**ALIGO SUS ETM QUAD Penultimate Mass**
E080090	**ALIGO SUS ETM QUAD Penultimate Mass component specification**

[1] D050421-A ALIGO ETM NP-type Penultimate Mass

[2] E060235-00_DCN_NP-type Penultimate and Reaction Masses

[3] J. Greenhalgh indicated on 14th March in email to R. Jones that a RODA covering this issue is in progress, and is likely to be finalised imminently.

3 Format of production specification

- Drawing[4] to be used as main source of manufacturing information
- No billet drawing provided
- Specification[5] supports drawing, with material selection information and inspection requirements

Key production requirements:

- Precise knowledge of centre of mass position (for the bonding, and suspension in turn)
    - Wire grooves accurately positioned with respect to COM
- Polish area must be appropriate for ear bonding (NOTE: existing NP-type ear footprint "D060555-02"can be represented within a 13mm x 22mm MIN.)
- Shielded magnet recesses: position/size and shape to suit mating design.

4 List of main drawing features

- Diameter
- Thickness
- Chamfer size
- Flat length
- (Penultimate)Wire grooves
- Associated (penultimate) wire diameter
- Shielded magnet recesses
- Reference lines/markings
- Polishing

5 Discussion and clarification of features

5.1 Diameter: ø340.0mm +/-0.25mm (With cylindricity tolerance of 0.1mm)

Justification: Maintained in accordance with NP-type penultimate mass drawings (dimension and tolerance employed for both penultimate mass and test mass), where this specification was easily met in both cases.

ACTION 1-P (DONE): Confirmed by successful NP-type deliverable (Glasgow)

[4] D080117 ALIGO SUS ETM QUAD Penultimate Mass

[5] E080090-ALIGO SUS ETM QUAD Penultimate Mass component specification

5.2 Thickness: 200.0mm +/-0.25mm

Justification: Maintained in accordance with NP-type penultimate mass drawings.

In a meeting between IGR representatives, material suppliers and the polishing company prior to the manufacture of NP-type masses concern was raised over this aspect of the drawing, with the polishers keen to minimize the amount of machining required. As a result, a large tolerance was placed on the feature in order to reduce the likelihood of this feature becoming a cost driver.

Following inspection of the NP-type masses, thickness was within specification in all cases, but always at the high end of the tolerance (E.g. mean thickness of D050421-002 = 200.42mm)

ACTION 2-P (DONE): Confirm thickness and tolerance (RJ / KS, Following drawing check, plus discussion with SUS colleagues and at ALUK weekly meeting 14/03/08)

5.3 Chamfer size: 2.0mm +/-0.2mm, x 45 degree +/- 5 degrees ALL ROUND

Justification: Maintained in accordance with NP-type penultimate mass drawings. This was not an inspected dimension.

ACTION 3-P (DONE): Confirmed by successful NP-type deliverable (Glasgow)

5.4 Flat Length: 2x, 95.0mm (SHARP TO SHARP)

Justification: Maintained in accordance with NP-type penultimate mass drawings *at this stage* (dimension and tolerance employed for both penultimate mass and test mass).

Discussion point: What matters more, the width of the mass or the length of the flat?

A change in approach to specifying flat length may be worth considering. (Question for Garilynn: How is this being specified for the ETM optic?)

The accuracy of the current specification is reliant on the combined effect of:

- Accuracy of manufacture of the finished diameter (ø340.0mm +/-0.25mm)
- Accuracy of the flat length (95.0+/-0.1mm)
- Table 1 describes the effect of the tolerance limits on the (flat to flat) width of the mass. (Numbers were produced using 2-D sketches in SolidWorks.)
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▪ ▪ Diameter ø (mm)	▪ Flat length (mm) ▪ **94.9** (low end of tolerance)	▪ Flat length (mm) ▪ **95.1** (high end of tolerance)
▪ **ø339.75** (low end of tolerance)	▪ Mass width = 326.23mm ▪	▪ Mass width = **326.17**mm ▪ (LOWER LIMIT)
▪ **ø340.25** (high end of tolerance)	▪ Mass width = **326.75**mm ▪ (UPPER LIMIT)	▪ Mass width = 326.69mm

***Table 1**: SolidWorks assessment of mass width (within specification).*

The width of the mass can change by up to a total of 0.58mm and still be within the existing specification.

Background: For both NP-type penultimate masses, the flat lengths were out of specification (undersized by 0.5mm in three of the four cases), but the measured diameters were very close to ø340 (all within 0.1mm). The resulting (nominal) measured width[6] of the each mass was still within the limits set by the cases above (326.17mm < Width (flat to flat) < 326.75).

Specifying the width of the mass[7] (flat to flat when looking from surface 'S3') is an alternative worth considering. For a given range of finished diameters this would leave a clearly defined range of acceptable flat lengths. (I.e. the flat length will be appropriate if the width of the mass is within a chosen specification.)

ACTION 4-P: Discuss/confirm approach to this specification with SUS colleagues (Glasgow/SUS). NOT YET CONFIRMED.

5.5 Wire Grooves: 6.0mm+/-0.1mm (symmetrical within 0.1 relative to datum C, regardless of feature size, RFS)

Justification: The NP-type drawing specified the wire grooves such that in the worst case, the COM could be 0.5mm from the suspension point which is undesirable[8]. Of the two masses provided for the NP-type, the grooves on the first mass exhibited position that were close to worst case, where as the groove positions on the second mass (which will be used in the NP-type) were much improved.

The use of the symmetry positional tolerance should minimize the error in position regardless of the eventual thickness of the mass (RFS).

ACTION 5-P (DONE): Confirmed, following discussion with I. Wilmut (Glasgow/RAL)

5.6 Wire diameters: ø 0.62mm (+/-0.1mm)

Justification: Maintained in accordance with NP-type penultimate mass drawings.

ACTION 6-P: Confirm that this is the correct wire diameter applicable to the ETM penultimate mass. *Not yet confirmed, but not a cause for concern. (RAL)

5.7 Shielded magnet recesses: ø 10 mm hole depth 2.0mm (+/-0.1mm)

Justification: Maintained in accordance with NP-type penultimate mass drawings (specification agreed at UK project weekly meeting ALUK Weekly Project Meeting (07/07/06)

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[6] D050421-SN-001, measured width (flat to flat) = 326.6mm, D050421-SN-002, measured width (flat to flat) = 326.7mm (both taken from NP-type penultimate mass inspection documents)

[7] D080117_ ALIGO SUS ETM QUAD Penultimate Mass

[8] Email from I. Wilmut to R. Jones 25th January 2008 "RE: DCN for PM and ERM"

ACTION 7-P (DONE): Increase to depth of recess confirmed with colleagues at RAL in ALUK weekly meeting, 14/03/08. (RAL)

5.8 Reference Markings: 2 off along centre-line of each flat, 1 off @ 12 o' clock, 1 off @ 6 o' clock

Justification: Size and shape of marking on flats (used during bonding process) maintained in accordance with NP-type penultimate mass drawings, with the exception of a tightened tolerance on the width of the reference marking (change from 0.25mm +/-0.1, to 0.25mm +/-0.05).

Reference markings at 12 o'clock and 6 o'clock differ from NP-type penultimate mass drawings (where markings covered the full width of each the mass, top and bottom). Reduction in size of each marking should improve accuracy over their length.

The addition of vertical reference markings to each flat signifying the centre of mass position (to aid the bonding process) was previously considered. However, through the combined effect of more accurate wire groove positions and more in depth inspection information, this was not thought necessary for the bonding process.

ACTION 8-P: Discuss/confirm with SUS colleagues, *not yet confirmed(Glasgow/SUS)

5.9 Polishing: lambda/10 bond area changed to 55mm x 75mm centered on flat

Justification: NP-type penultimate mass drawings set the lambda/10 polish region to be biased towards the upper portion of the flat with a minimum clear aperture of 70mm x 55mm.

Note also that the NP-type ETM silica test mass specified a bond area of 100mm x 75mm centered on the flat. In each instance, the bond position is either located above the COM (in the case of the penultimate mass) or below (for the optic).

Changing to a bond area which is centered on the flat (combined with wire grooves around the full mass) adds value to each mass. In the event of a suspension failure causing damage to an ear or bond, the penultimate mass could be reworked/re-used by rotating through a period of 180 degrees.

E.g.

SURFACE S1 AND S2:

POLISH FLAT TO λ/10 PEAK TO VALLEY OVER APERTURE ZONE 1 (55mm x 75mm BOND AREA CENTERED ON FLAT).

ACTION 9-P (DONE): Altered by RJ / KS (Glasgow) following input from G. Billingsley. Reference to super-polish removed (Glasgow/SUS).

6 Conclusion

The changes to the form of the ETM penultimate mass (as compared to the form of the Noise Prototype) are as follows:

- **Change to the tolerance on wire groove position (use of symmetry tolerance RFS)**
- **Extension of wire grooves around full barrel of mass**
- **Extension of lambda/10 bond area on flat, and its associated specification.**
- **Increase to depth of shielded magnet recesses (request from RAL).**

Precise knowledge of centre of mass position shall be achieved by assessment of detailed inspection information.

All issues in the table below must be resolved before tender process can begin.

FEATURES	**SIZE**	**Change from NP-type**	**ACTION No. / who**	**Confirmed**
Diameter	ø340.0mm +/-0.25mm	None.	**1-P/ Glasgow**	**Yes**
Thickness	200.0mm +/-0.25mm	Reduced tolerance (from +/-0.5mm) to match tolerance on diameter	**2-P/ Glasgow /SUS**	**Yes**
Chamfer size	2.0mm +/-0.2mm, x 45 degree +/- 5 degrees ALL ROUND	None.	**3-P/ Glasgow**	**Yes**
Flat length	**2x, 95.0mm** (sharp to sharp)	No change yet **(DISCUSS)**	**4-P/ Glasgow/ SUS**	**No**
Wire Grooves	6.0mm+/-0.1mm (with 0.25 symmetrical tolerance)	Symmetric tolerance to reduce positional error. Reduction to radius at base of groove (from R0.3mm to R0.25mm MAX.)	**5-P/ Glasgow/ RAL**	**Yes**
Associated wire diameters	ø 0.62mm	No confirmation, but not a concern.	**6-P/ RAL**	**No**
Shielded magnet recesses	ø 10 mm hole depth 2.0mm (+/-0.1mm)	Hole-depth changed to 2mm (from 1mm). RAL confirmed specification in relation to mating components at ALUK weekly meeting (14/03/08).	**7-P/ RAL**	**Yes (14/03/07 ALUK Meeting)**

Reference lines	2 off along centre-line of each flat, 1 off @ 12 o' clock, 1 off @ 6 o' clock	2x, Lines traverse full barrel. (12 o'clock and 6 o'clock). Arrow to front face top.	**8-P/ Glasgow/ SUS**	**No**
Polishing	λ/10 bond area changed to 55mm x 75mm centered on flat	Increase bond area, symmetric about both central axes. Add radius (R5) to corners of aperture zone 1.	**9-P/ Glasgow/ SUS**	**Yes (RJ/KS, 12/03/08)**

- It must also be confirmed (or otherwise) that the ITM penultimate mass is to be identical to the ETM penultimate mass (**ACTION: still to be officially confirmed**.

(Note: Justin Greenhalgh sent a RODA to Dennis Coyne on 6th March.)

No reference has been made in this document to the need for transportation containers following manufacture.