

This document covers a detailed review of specifications and drawings by the review team for Input Optics long lead procurement readiness review. Comments are grouped by reviewer. Authors: Coyne, Smith, Fritschel, Gustafson, Harry, Billingsley, Tyler

Dennis Coyne:

1) General Specification comments; applies to:

E080125, TGG

E080128, RTP

E070071, -72, -73, -77, E080133, -134, mirror blanks for MC, SM, PMMT

- a) Before procurement must be released with a DCN as revision A (best to also release the associated drawing with the same DCN). A single DCN can release the entire set.
- b) The specification must reference the associated drawing (missing from E080125 and E080128)
- c) I'm not too keen on redundant specification of dimensions in the drawing and the specification, but it is OK. Likewise, dimensional information which is captured in the specification but not in the drawing is not good practice either. However as long as the spec references the drawing and vice versa and the union of the two is a complete specification and has no conflicts, then it should be acceptable.
- d) "Measurement Matrix" should be "Verification Matrix" I think
- e) " $\lambda/10$ wave at xxx nm" should read "1/10 wave at xxx nm"

2) General Drawing comments:

- a) Scale should be marked as "NTS" not full, half or other. (especially since the drawing page size isn't even indicated).
- b) There must be a Revision History Block (usually upper right corner) with reference to the DCN(s) that releases the revision(s).
- c) There must be a note on the drawing referencing the associated specification.
- d) The units for dimensions must be called out in the title/template block.
- e) Tolerances must be indicated -- best to use a default tolerance in the title/template block and then call out tighter or looser requirements if/as needed.

3) E080125, TGG

- a) Orientation is [111] within 5 degrees of what? of the cylinder axis?
- b) reflectivity where? I suspect this should read "Reflectivity on plane faces"
- c) Add to the requirements table: Drawing: D080154-A
- d) change "Adhesion and Durability" to "AR Coating Adhesion and Durability"
- e) Verification methods for CW threshold, Verdet constant, Absorption, AR reflectivity?

4) D080154, TGG

- a) Uses mixed units! Inches and mm. Stick to mm (for optics).
- b) Should really call out parallelism & perpendicularity

5) E080128, RTP

- a) The orientation callout does not specify crystal axes -- what does this mean?
- b) "10-5" does not need to be colored red

c) Change physical dimension verification from "visual inspection" to "measurement"

6) Mirror Blank specifications

a) Clear Aperture: Central 140 mm -- add "diameter"

b) "No inclusions within clear aperture of center 100 mm".

No inclusions to what precision?

The clear aperture is stated as 140 mm -- is this clause really for the central 100 mm diameter or 140 mm diameter?

7) Mirror Substrate Drawings

a) Are the markings standard? Check with Janeen.

b) Does the IMC expect symmetric wedge (as drawn) -- I think so -- check with Janeen.

LIGO convention Arrow at thickest point aiming at side 1

Should not call out the quantity on the drawings

Review markings with SUS, perhaps keeping center clear?

Note specific locations for alignment marks

Note symmetrical wedge

More obvious thickness call out

Michael Smith

1. Mirror Blank Material IMC1, specification

a. Material: Grade 0C is a Corning designation, not industry standard, and should not be used; this is also a redundant specification, because the details are already spelled out in the inclusion and homogeneity specifications

b. Homogeneity: is 3E-6 good enough? (this is standard Suprasil 311)

c. Birefringence: is 5 nm/cm good enough? (this is standard Suprasil 311, 312)

d. Inclusions: are inclusions with diameter < 0.08 mm disregarded? (this is standard Suprasil 311)

e. Maximum inclusion: are 0.15 mm allowed? (this is standard Suprasil 311, 312)

2. Mirror Blank Material IMC2, specification

a. Material: delete Grade 2F designation

b. Birefringence: is 5 nm/cm good enough? (this is standard Suprasil 311, 312)

c. Inclusions: are inclusions with diameter < 0.08 mm disregarded? (this is standard Suprasil 311)

3. Mirror Blank Material IMC3, specification

a. General: same as IMC1

4. Mirror Blank Material Steering Mirror, specification

a. Why does this have to be better than IMC2?

5. Mirror Blank Material PMMT1, specification

a. Why does this have to be better than IMC2?

6. Mirror Blank Material PMMT1, specification

- a. Why does this have to be better than IMC2?
7. Substrate IMC1
- a. Registration marks: Change to read—"Registration marks and serial numbers shall be etched, ground or sandblasted as specified in D070091". It is not possible to preserve the arrow orientation on the blank because it will be ground away.
 - b. Side and Bevel Polish: change to scratch and dig specification 80-50?
 - c. Scratches and Point defects:
 - i. Surface 1:
 - 1. scratches:
 - a. delete "be as small as possible"
 - 2. point defects: last sentence delete "must be less than or equal with 1 per 4 mm², add "shall be \leq 1 per 4 mm²
 - ii. Surface 2: same comments
 - d. Inspection method: change 'will' to 'shall'
8. Substrate PMMT1
- a. Surface Figure
 - i. Surface 2: why is radius of curvature so large?
9. Substrate PMMT: same comments
10. Blank Drawing:
- a. Add note 1 "Part is symmetrically wedged" and place at 0.5 deg and 90.25 deg dimensions.
 - b. Add note 2 regarding etch and grind features and point to the two locations for the scribed mark.
 - c. Add note 3 regarding the arrow feature and point to the location for the arrow
 - d. Specify the height of the serial numbers

Peter Fritschel

Beam in MCCM surface 1 is small but 80mm aperture, is large – why?

Also MCFMs

Why phase maps on mirrors with these beams this small?

Eric Gustafson

Fractional variation in R required???

Suggest asking for 1 witness sample per substrate

Gregg Harry

If scatter and absorption are to be measured at CIT you should specify shipping and handling instructions for the vendor.

GariLynn Billingsley

These comments are limited to the component specifications only.

BLANKS

Blank size should be 2-3 mm over on each dimension. The IMCM1 is 6mm

Serial number, should be written in indelible ink.

The material call out (with grade xx and equivalent) is redundant with the homogeneity and bubble class specification. Not a problem, but not necessary.

The beam size on all of these optics is so small, homogeneity deviations are so large in scale by comparison, consider the lowest grade homogeneity for all but the most sensitive (mode cleaner) optics

Clear aperture

Your beam sizes are small, realistically define your clear apertures. It will save a lot of money. IMCM1 has conflicting clear aperture numbers 140 or 100. Which is it.

Absorption

You may not need to specify blank absorption at all, if so, only on the transmitting optics. If the absorption can be 15 ppm then you need not specify it. That is the Corning 7980 default. In the case that you find it imperative, it should be specified as OH content. The slope of the Absorption/OH content line is roughly 62.5, so an OH content of 800 ppm results in absorption of 12.8ppm/cm.

IMCM2 blanks do not require phase fidelity in the transmission? Consider removing homogeneity, birefringence, bubble, striae and absorption requirements, certainly the requirements for reporting on all of these.

IMCM3 is redundant with IMCM1 except for serialization. Not a problem, but you might save spares if you call them a more generic name. It might save your vendors some confusion as well.

Steering mirror blanks – if they don't require phase fidelity in transmission, drop the homogeneity requirements.

Pre-mode matching telescope mirror 1 & 2

The blanks appear the same. You could use one spec if you choose.

POLISHING

All specifications:

With such a small beam, it is not necessary to track the orientation of homogeneity data, you do not need to require them to orient the clocking of the blank.

Scratches and Point defects:

5×10^{-3} within the central 40 mm = 0.4ppm. This is an incredibly tight spec. Better to make the requirement over the beam diameter or $\sim 2x$ beam diameter. Aim for a reasonable number, of a few ppm in the region. See the 40m specs for examples <http://www.ligo.caltech.edu/%7Egari/40MAsBuilt.htm>

Same for the “outside the central 40” spec. It’s currently set at 0.6ppm. Unnecessary. Aim for 10 ppm or more here.

“average density defects” = 0.8 ppm, this should only be in your central 5-10mm

Surface Errors:

P-V spec is redundant, and confusing for a vendor.

For the optics that do not require phase fidelity in transmission, the side 2 polish seems stringent. Perhaps a ROC $> 2\text{Km}$ (1/2) is a sufficient spec for the entire surface.

Microroughness:

0.5 nm rms is an achievable result, but is quite stringent as a specification. A vendor needs some room for instrument calibration. Suggest a spec of 0.1 nm, perhaps with a goal of 0.05nm in the mode cleaner cavity.

Microroughness on non-cavity surfaces should be $\sim 0.2 - 0.4$ nm. This includes side two of the mode cleaner mirrors 1 & 2.

The microroughness measurement locations should be relevant to your area of concern. 80mm diameter circle is probably outside of what is interesting to you.

Certification data:

Scratches and point defects – the deliverable data should include a hand drawn map of the scratch and defect locations.

Suggest that you don’t need them to certify the following:

Registration mark dimensions

Identification location

Identification serial number

Data format: Suggest:

In addition to the hard copy, the surface maps shall be delivered in electronic form in ASCII, OPD or .DAT format. Include a data description: aperture size, pixel size, height units.

Individual specifications

Mode Cleaner Mirror #2

Surface 1 radius of curvature tolerance is phenomenally tight for manufacturing. Try .5% or .1% if at all possible.

Side 2 Surface errors are over spec'd for such a small beam. Suggest 1/2 or 1/4. Microroughness should still be ~.5 nm, you do take some data out this way???. If no data then don't bother specifying microroughness.

Steering mirror

Scratches and point defects are over specified, considering you will have a ~4000 ppm transmission on one of these. You can afford loss of ~20-30 ppm surely?

COATINGS – general

I note that none of our LIGO coating specs require coating by ion beam deposition; perhaps the scatter and absorption specs imply that. Perhaps it is wise to add it for posterity if you're already modifying the specs.

Don't need to reference the blank drawing under applicable documents, it is not referenced. You DO reference the polishing spec though, so that should be included IF you choose to keep that as a requirement (more on that later.)

Uniformity

Your beams are small, so you do not need to require coating uniformity (our concern in COC is changing the radius of curvature of the optic) The same is true for the transmission uniformity.

Absorption

While 0.5 ppm is achievable, current technology does not provide enough of a buffer to make that a realistic specification, since the vendor must maintain a margin for calibration and manufacture. Suggest < 0.5 ppm as a goal, < 1 ppm as a requirement. Suggest that you do not need an absorption requirement on optics that are not in a resonant cavity.

Surface quality

The spec is redundant with the scatter specification on page 1. ALSO – since it is the same spec used for polishers, it allows no margin for coating error; the polisher might use up all of the allowed scatter. Coating makes it worse, not better.

Data

You should ask for more data delivered than this – at least certifications (if not data) of the requirements; angle, polarization, transmission, scatter, absorption. Also ask for spectrophotometer graphs of the AR on coatings where it matters (mode cleaner; 1&3)

Steering mirror:

Scatter spec is quite restrictive considering 4000 ppm transmission in this leg.

Tyler

With regard to today's IO Procurement Review, my comments/questions are mostly QA/QC related.

Some of the items should be considered for inclusion in the RFP to get vendor response and some of the items relate to how LIGO will be involved after placement of the "contracts/procurements".

Comments/Questions:

1. Are there plans to have "in-process" monitoring of vendors by LIGO personnel for the blanks, shaping, polishing and coatings ?
2. How does LIGO plan to disposition "non-conforming" material ?
3. What are LIGO plans for pre-ship review of vendor acceptance and test data including "end-item data package" content ?
4. Are there coating abrasion tests actually performed and are they done on the witness plates or what test article ?
5. Are all test articles delivered to LIGO ?
6. How are the witness plates/test articles identified for future reference to coating run and optic ?
7. How is the coating run process controlled and monitored batch/run to run, i.e., how are Quality Controls implemented for the coating processes ?
8. Is coating rework permitted and what is the process ?
9. What are the quality controls and who monitors the polishing processes ?
10. Who are the "observers" for the visual surface inspections ? Should list there names on the inspection records with dates for future reference if necessary.