**Subject:** L070090-00: In-vacuum weld quality
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**Date:** Wed, 24 Oct 2007 00:32:14
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Reference LIGO-L070090-00

Vacuum Review Board,
For the large initial LIGO aluminum weldments in the SEI system we developed the weld process (machining preparation for the weld, fixtures, cleaning protocols, shield gas purity & ratio, etc.) and qualified our welders using non-destructive & destructive evaluation on sample welds. The only criteria was full penetration and full fusion welds. Once the weld process was set, we did the entire production with only visual inspection (consistent with Class C welds per Mil-Std-2219, although we did not even require certification of pore and inclusion limits per class C).

I used Rai's conservative and simple model in (Notes on Virtual Leaks in the Beam Tube Spiral Welds, LIGO-T940070-00) to determine the allowable weld porosity for Adv. LIGO
(see
http://lhocds.ligo-wa.caltech.edu:8000/advligo/UHVWelding?action=AttachFile&do=get&target=justify_classA_mil-std-2219.pdf).
The result is a requirement on weld porosity of 0.76 mm maximum surface porosity flaw at a minimum spacing of 6.08 mm, consistent with class A welds per Mil-Std-2219. It turns out that imposing this weld quality level means, as a practical matter, x-ray inspection after a first weld pass, machining out unacceptable weld regions discovered in the x-rays, repeating the weld pass and continuing this iteration until the x-ray passes class A requirements, which generally requires 2 or 3 passes for aluminum. This is expensive in time and money (but may be tolerable for Adv. LIGO if truly needed). It is likely that the acid cleaning required as preparation for the welding, as well as the h igh heat required to cause fusion, completely eliminates any residual hydrocarbons of concern for outgassing in the weld region. If so, high porosity is only a concern if the conductance of the path into any cavities or pores in the weld, and the capacity of these defects, are such that any contamination that occurs after welding (for example during cleaning) is such that it presents a hydrocarbon outgassing even after bake out. This seems unlikely.

The existing OMC weldment would pass Class C (which only requires visual inspection) if it were not for the fact that we had the weldment x-rayed. We found 20 weld areas where there is incomplete fusion. These non-fused areas are buried in the welds, i.e. sealed from cleaning fluids and the vacuum. I would argue that this OMC weldment should be accepted as-is for enhanced (maybe even advanced) LIGO on the basis that it is of comparable quality to the many aluminum welds in the system now.
Do you accept this argument?

If not, then the next best approach is likely to put the OMC structure into a large vacuum bake oven with an RGA. We have found one large enough at JPL (hopefully not too large, hopefully clean enough and hopefully they can do the work in a timely way). The cost is outrageous (about $20K for one bakeout and RGA measurement). Nonetheless, if this can verify what I think will be the case, that the outgassing from this OMC weldment is acceptable, then it might be worth the expense just to prevent delay to ELI.
Comments?

Dennis