LIGO-L080072-00-V

Subject: Re: L080045: Limits to high vapor pressure elements in alloys
From: John Worden <worden_j@ligo-wa.caltech.edu>
Date: Wed, 09 Jul 2008 11:46:19 -0700
To: Mike Zucker <mike@ligo.mit.edu>, Fred Raab <fjr@ligo-wa.caltech.edu>, Riccardo DeSalvo <desalvo_r@ligo.caltech.edu>, Rainer Weiss <weiss@ligo.mit.edu>, John Worden <worden@ligo.caltech.edu>, Dennis Coyne <coyne@ligo.caltech.edu>, Dennis Coyne <coyne@ligo.caltech.edu>

Refer to L080072-00-V

Vacuum Review Board,

I have not seen any strong objections to Dennis' recommendations and proposal as outlined below. Therefore, the VRB approves this proposal as written.

John

-------- Original Message --------
Subject:[Fwd: Re: L080045: Limits to high vapor pressure elements in alloys]
Date: Tue, 08 Jul 2008 15:26:51 -0700
From: Dennis Coyne <coyne@ligo.caltech.edu>
To: John Worden <worden_j@ligo-wa.caltech.edu>
CC: Rainer Weiss <weiss@ligo.mit.edu>, Mike Zucker <mike@ligo.mit.edu>, Fred Raab <raab_f@ligo-wa.caltech.edu>, Riccardo DeSalvo <desalvo@ligo.caltech.edu>, Calum Torrie <c.torrie@physics.gla.ac.uk>

John,
I submitted a request (L080045, as modified by a 4/30 email) to the vacuum review board to consider the following proposal:

1) Alloys with maximum of Cd, Pb, P, Se, S or Zn < 0.5% are acceptable for UHV service and standard vacuum bake processing.
2) Alloys with P, Se, and S > 0.5% are typically unacceptable.
3) Alloys with maximum of Cd, Pb or Zn <= 5% may be proposed for review by the Vacuum Review Board (VRB), with sufficient justification (i.e. no reasonable alternate materials/parts).
4) Phosphor-Bronze alloys with P <= 0.35 %, Pb <= 1%, Zn <= 1% are acceptable for UHV service at 1 m or more from any optics, when the surface area is limited to ~10^3 cm^2 with sufficient justification (i.e. no reasonable alternate materials/parts). However these parts must be air baked (not vacuum baked) and require FTIR (not RGA) qualification.

The email dialog related to this request is included below. Of course this request is closely related to the 303 stainless steel (S or Se alloy) question as well (another open VRB request). I think the VRB had no objection to my proposal. I recommend accepting the above guidance. What is the VRB's response to L080045?

In particular, we have two specific parts proposed for use by the RAL/UK group for use in the AdL suspensions which require resolution of this question:
1) Small phosphor-bronze IRLED lens retainer (spring clip, D060115) used in the BOSEMs.
http://www.ligo.caltech.edu/docs/D/D060115-C.pdf
This part is approx. a tube with .25" dia. by .25" long with .016" wall thickness and cut-outs to make it compliant. There will be approximately 550 of these parts installed in the vacuum system.

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The British Standard grades of Phosphor Bronze can be found on the following link:-
http://www.bronze-ingot.com/phosphorbronze.htm
UK vendors used the PB1 material for fabricating the OSEM lens retainer
for the Noise Prototypes. However, due to the 'high' Phosphorous content
of PB1 (1% max) maybe using PB2 grade would be a better choice (0.6 % max phosphorus).

2) BOSEM alignment adjustment cams (photo attached).
These parts are roughly 0.5" dia. by 0.5" long. We plan to use about 1100 of these parts in the vacuum system.
I'm unsure of the material alloy, but would ask RAL/UK to make them from PB2.

I recommend approving both of these parts for LIGO UHV service (even though the P content is slightly higher than in the proposed guidelines given above). Please let me know the VRB's response as soon as possible.
Dennis

-------- Original Message --------
Subject: Upper limits on amu 31(P) and amu 32(S) from 304L SS
Date: Mon, 19 May 2008 18:04:39 -0400 (EDT)
From: Rainer Weiss <weiss@ligo.mit.edu>
To: Dennis Coyne <coyne@ligo.caltech.edu>
CC: worden_j@ligo-wa.caltech.edu, Mike Zucker <mike@ligo.mit.edu>, wooley_r@ligo-la.caltech.edu
References: <Pine.GSO.4.56.0805172137430.16558@ligo.mit.edu> <4830C4CE.7030307@ligo.caltech.edu>

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Dennis et al,
I went back to the original rga spectra from the beamtube bakeout.
The only ones I have in the counter mode are after the bakeout
in which one sees nothing at amu 31 (phosphorus) or amu 32 (sulfur,
molecular oxygen) at the level:

    p(mb) < 2 x 10^-14 mb

this would correspond to to < 2 x 10^-18 amps if one could measure
such a small current in Faraday mode.

Note that we never see anything at amu 32 in the beamtube after the bake
because the bakeout has made the surface of the steel an active getter for
oxygen.
That was one of the reasons we had to use the argon (40,20) and nitrogen
and carbon monoxide (28,14,16,12) for the final beamtube leak
qualification.

I realize that the beamtube steel had been processed to remove the
hydrogen before hand. I do not believe that all the sulfur and
phosphorus had been removed from the steel in this process. We had
enough trouble getting rid of the bulk of the hydrogen which has
a much larger diffusion constant than S or P.
Nevertheless, it is different than the 304 of the chambers.

Two responses: Dennis, it hardly matters whether the 304 is
upto its concentration limit in P and S, we have so much margin in the rga
spectra and could have even more if we want to set up one
of the rga in the counter mode. Mike, the process of water
outgassing is very different. That has to do with the statistical
dynamics of the surface adsorption sites. The process of
hydrogen is closer, the big differences are the large diffusion
constant of the hydrogen atom and the need to recombine into
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molecules at the surface in order to evaporate. There are
probably subtleties such as that sulfur travels fastest
along grain boundaries and the phosphorus chemisorbs on the
surface- all different than the hydrogen. But there is
no way to beat the argument that the flow of the P and S
to the surface from the interior must slow things down considerably.
(I suspect kills it)

If you want to be sure let's setup an RGA in the counter mode
in one of the LIGO chambers.

RW

-------- Original Message --------

Subject: Re: L080045: Limits to high vapor pressure elements in alloys
Date: Wed, 30 Apr 2008 18:09:24 -0700
From: Dennis Coyne <coyne@ligo.caltech.edu>
To: Riccardo DeSalvo <desalvo@ligo.caltech.edu>, John Worden <worden_j@ligo-wa.caltech.edu>, Mike Zucker <mike@ligo.mit.edu>, Rainer Weiss <weiss@ligo.mit.edu>, Fred Raab <raab_f@ligo-wa.caltech.edu>
CC: Norna Robertson <nroberts@ligo.caltech.edu>, Janeen Romie <janeen@ligo-la.caltech.edu>, Calum Torrie <c.torrie@physics.gla.ac.uk>, Justin Greenhalgh <J.Greenhalgh@rl.ac.uk>, Stuart Aston <sma@star.sr.bham.ac.uk>, Bram Slagmolen <bram.slagmolen@ligo.org>, Peter Fritschel <pf@ligo.mit.edu>, David Shoemaker <dhs@ligo.mit.edu>, Amanda Brummitt <A.J.Brummitt@rl.ac.uk>
References: <481104E7.4070907@ligo.caltech.edu> <4816F34B.50605@ligo.caltech.edu> <50372DAD-F84D-4E2F-9AD2-526751491E84@ligo.caltech.edu>

Ric, thanks for the reply. I think S and P (maybe Se) are readily
oxidized. However if Zn were readily oxidized then why did you have to
scrap the entire vacuum system that you accidentally contaminated?
Couldn't you have just exposed it to air, or hot air?
I too am far more concerned about the plastics introduced into the
system. However, I do not think we can ignore the potential for metallic
films degrading our optics. I'm eager to hear from the other VRB members
as well.
Dennis

BTW, I mistyped in my original email. Items 1 and 2 of my
recommendations should state < 0.5% and > 0.5% respectively.

Riccardo DeSalvo wrote:
> I have the feeling that the key point here is air bake.
> And we are going beyond the necessary limits. We also have to be
> careful to allow the use of necessary materials necessary for
> precision mechanics.
> Most of the prescriptions were developed for accelerometers and
> colliders that like to trap ions in the stored electron beam. For us
> probably the tightest constraint comes from the ion pumps, that
> permanently draw current after being exposed to zinc or other volatile
> metal vapors.
>
> Years back I made a lot of damage because a machine shop used zinc
> hardened aluminum instead of 6061, and I baked it under vacuum at high
> temperature (~200C).
> The zinc coated all surfaces and the entire vacuum system had to be
> replaced because after that the surface outgassing zinc was

> essentially 100%.
> But it took high temperature baking under ion pump UHV to make the damage.
> Until bakeout the ion pump had no objections. immediately after
> heating it was wrecked.
> Note that even in that extreme case, the ion pump was drawing abnormal
> current (self sputtering and ionizing the vapors) thus indicating bad
> vacuum, but it was not clear that the vacuum wasn't actually good
> elsewhere.
> Of course for prudence we junked everything, and we should be prudent
> here, but there is danger in exceeding.
>
> As Ray pointed out, practically all of these materials are reactive
> and oxyde easily. After oxydation they pose no further significant
> risk for vacuum (the oxydes have much lower sublimation pressure),
> except for the possible dust.
> In presence of oxygen these metals get oxyded, and thus neutralized,
> even at the surface of the part containing them, which means that
> baked in oxygen parts probably pose very little actual danger.
> I am less worried by the risk from these metals than by the outgassing
> of the many plastics and resins that we allow in the system by simply
> putting a piece of plastic for some time in one of our Fabry Perot
> test cavities.
> Perhaps we should simply limit the percent of the volatile metals in
> permissible alloys (maybe somewhat more loosely than Dennis suggests)
> but prescribe basic etch followed by air bake for all of the parts
> containing volatile materials, and forbid vacuum bake of them.
>
> On the side, we could simply make some Fabry Perot tests with alloys
> containing a volatile metals (and even heat the sample some) and
> quantize how dangerous are these metal vapors to the optics.
> R
>
> On Apr 29, 2008, at 3:07 AM, Dennis Coyne wrote:
>
>> LIGO-L080045-00
>> Limits to high vapor pressure elements in alloys for LIGO UHV components
>>
>> To the Vacuum Review Board (VRB):
>>
>> The current LIGO Vacuum Compatible Materials List:
>> http://www.ligo.caltech.edu/docs/E/E960050-B/E960050-B.pdf
>> states that phosphor bronze is an acceptable material. According to
>> typical UHV practice alloys containing cadmium, lead, phosphorous,
>> selenium, sulfur and zinc are not considered UHV-compatible (e.g.
>> O'Hanlon, A User's Guide to Vacuum Technology, 2nd ed., p. 280).
>> However, many alloys considered acceptable contain some, albeit
>> small, levels of these elements. For example, Aluminum alloy 6061 is
>> considered an acceptable UHV alloy by O'Hanlon and it contains a
>> maximum of 0.25% Zn; 304 Stainless Steel contains up to 0.045% P and
>> 0.03 % S. Based on an analysis (in the attached technical memo
>> T080106-00) of the outgassing rates for these high vapor pressure
>> elements in alloys, a conservative estimate of the deposition rate
>> onto sensitive optics and a criteria for the maximum allowable
>> deposition thickness (1 nm in 10 yrs), I recommend the following:
>>
>> 1) Alloys with maximum of Cd, Pb, P, Se, S or Zn < 0.05% are
>> acceptable for UHV service and standard vacuum bake processing.
>> 2) Alloys with P, Se, and S > 0.05% are never acceptable.
>> 3) Alloys with maximum of Cd, Pb or Zn <= 5% may be proposed for
>> review by the Vacuum Review Board (VRB), with sufficient
>> justification (i.e. no reasonable alternate materials/parts).
>> 4) Phosphor-Bronze alloys with P <= 0.35 %, Pb <= 1%, Zn <= 1% are
>> acceptable for UHV service at 1 m or more from any optics, when the
>> surface area is limited to ~10^3 cm^2 with sufficient justification
>> (i.e. no reasonable alternate materials/parts). However these parts
>> must be air baked (not vacuum baked) and require FTIR (not RGA)
>> qualification.
>>
>> Are these reasonable/acceptable recommendations? Can we accept even

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>> higher levels of lead, for example up to 10% and thereby allow some
>> bronzes in vacuum? Can we permit even more P in phosphor-bronze and
>> open up the choices of available alloys?
>>   Dennis
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>> <T080106-00.pdf>
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http://www.ligo.caltech.edu/docs/T/T080106-00/T080106-00.pdf

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