Subject: Re: Urgent Waiver Request from Suspensions - room temp out-gassing cure of EP-30-2 on ITM-Y only
From: Dennis Coyne <coyne@ligo.caltech.edu>
Date: 4/7/2012 10:07 AM
To: John Worden <worden_j@ligo-wa.caltech.edu>
CC: Rai Weiss <weiss@ligo.mit.edu>, fred.raab@ligo.org, Norna Robertson <nroberts@ligo.caltech.edu>, Zucker Michael <zucker_m@ligo.mit.edu>, Betsy Bland <bland_b@ligo-wa.caltech.edu>, Mike Zucker <mike@ligo.mit.edu>, Calum Torrie <ctorrie@ligo.caltech.edu>, Fred Raab <fjr@ligo-wa.caltech.edu>, Michael Meyer <mmeyer@ligo-la.caltech.edu>, John Worden <worden@ligo.caltech.edu>

John,
One could bond & cure the parts at an elevated temperature and this temperature would then be the "zero stress state". However, upon cooling to room temperature one would get compressive stress in the optic under the standoff (good), but also tensile stresses in the optic at the perimeter of the standoff (bad). I did some quick FEA calculations which suggest that the tensile stresses are in fact twice as high for the case of cool down from 50C (stress free) to 22C, versus going from 22C (stress free) to 50C. This is counter-intuitive, so I will repeat the calculation and check it. I think one should be able to select an elevated temperature for bonding to reduce the locked-in tensile stress at room temperature, but not eliminate the tensile stress.

Dennis Coyne
Chief Engineer, Advanced LIGO & LIGO Laboratory
California Institute of Technology
MC 100-36, 1200 E. California Blvd.
Pasadena, CA 91125 USA
Telephone 626.395.2034

On 4/5/2012 8:36 PM, John Worden wrote:
> Dennis
>
> Do you think that the entire optic could be preheated to 50C, then glue the metal standoff on, hold this temperature while the glue cures and then cool. This might result in localized compressive stress in the glass in the vicinity of the joint once cooled.
>
> John
>
> On 4/5/2012 8:05 PM, Dennis Coyne wrote:
> > Rai,
> > Unfortunately there was no RGA scan prior to the 50C bake. (At the time

we considered the 50C bake to be so low as to be almost negligible and just a convenient way to accelerate the pump-down to enable a sensitive RGA scan.) I also think the risk is low and we should proceed without an elevated temperature cure.

One more wrinkle for the VRB to consider. The SUS group apparently did not consider the differential thermal expansion between their metal standoffs and fused silica optics for the triple suspensions either. Since these are smaller stand-offs (than the temporary wire standoffs for the WBSC8 ITMy unit), the stresses are lower but still may be a problem (under investigation). As a consequence the SUS group may wish to propose no elevated temperature cure for the same EP-30 epoxy adhesive when used to bond the sapphire and metal stand-offs on the triple suspensions. So, rather than a one-time, temporary, event for WBSC8 ITMY, this may be proposed as routine for bonded standoffs. What say you to this "wrinkle"?

Dennis Coyne
Chief Engineer, Advanced LIGO& LIGO Laboratory
California Institute of Technology
MC 100-36, 1200 E. California Blvd.
Pasadena, CA 91125 USA
Telephone 626.395.2034

On 4/5/2012 7:56 PM, Rai Weiss wrote:

There is a LIGO RGA scan of the EP30-2. It is in the collection associated with LIGO-E1000386-v1. The RGA scan was made after air curing a 10:1 mix and after a 50C bake to "get rid of water". The scan looks very good - no hydrocrbon signature is evident. Dennis may know if there was a scan taken without the 50C bake.

My guess is that the epoxy is OK even without the airbake if given enough curing time. I am willing to go along with Fred's suggestion.
RW

On Thu, 5 Apr 2012, Fred Raab wrote:

Thanks, Norna. This is very helpful. Having read the sheet, I would feel reasonably OK if and only if:
    1. We very carefully measured and mixed in the 10/1 ration by weight
as specified in the epoxy procedure and
    2. we ensured that we waited more than 7 days at ambient temperature
between applying the epoxy and pumping the chamber.

I expect 2 will happen naturally. The purpose of 1 and 2 is to ensure that no unreacted components are left behind in the joint. Mike Z. is correct that an important process going on during heat application is an
increase in the diffusion and outgassing of any unreacted chemicals left
behind in the bulk. This implies that we cannot trust the

contamination test that was done after heat-treatment to qualify the non-heat-treated epoxy. However it appears that the epoxy was formulated not to leave behind unreacted residues if applied carefully and fully cured. Given that this mirror will not remain in situ permanently, we don't need to preserve it from contamination on its surface that would disqualify it from achieving ultimate aLIGO sensitivity.

The big risks are:
a. Contaminating BSC8 or the SUS parts that would be re-used.
b. Losing a lot more schedule and not moving on to learn what other
problems we need to solve before running out of time and money.

I suggest we follow procedure items 1 and 2 and that after the OAT we FTIR test the quad metal components nearby and a patch of chamber nearest to a reasonable line of sight to the epoxy joint. I am expecting the FTIR tests will pass. If they don't, then after we move the cartridge to the correct H1 chamber we re-clean BSC8 and the lower quad. In the event we do need to re-clean, we probably do not lose much
more time than we lose if we stand still now and I am betting that we don't need to re-clean.

Do other VRB members think this sounds reasonable?

Fred

On 4/5/12 2:24 PM, Norna Robertson wrote:

> Mike and colleagues
> I attach the data sheet for your information.
>
> Norna
>
> On 4/5/2012 1:59 PM, Zucker Michael wrote:
>
> > Indeed the crosslinking that hardens the epoxy is accelerated by heat.
> >
> > I think here we're more concerned in another process, incidental to gluing and sticking, which is also accelerated by heat.
> >
> > Bakeout insures complete evaporation of VOC's that are not really part of the eventual cured matrix, including viscosity agents, catalysts, accelerants etc. (such as acetone, MEK peroxide, amines, urea, acids etc.). These will always be trapped to some degree in the
> > glue, and serve no function after it's cured. Heat helps them diffuse
> > out.
> >
> > One more cool fact (learned the hard way); blobs or cups of "leftovers" harden up WAY before the miniscule application on your workpiece, because they retain and concentrate reaction heat generated by curing. Wait AT LEAST as long as the datasheet says for

> the measured ambient temperature!
>
> HTH,
>
> Mike
>
> On Apr 5, 2012, at 4:35 PM, Betsy Bland wrote:
>
> > Hi Rai -
> > The epoxy cures over a few days at room temp. It is liquid and goes
> > tacky over a few hours, and then hard over ~24 hours. Isn't it
> > kinda like concrete in that it continues to cure for a long time?
> > That said, I glued it yesterday morning, and today my leftover
> > puddle was brittle.
> > Does that answer your question?
> > -Betsy
> >
> > On 4/5/2012 12:31 PM, Rai Weiss wrote:
> > > Betsy,
> > > Is the Epoxy hard on the surface when you are finished?
> > > RW
> > >
> > > On Thu, 5 Apr 2012, John Worden wrote:
> > >
> > > > Rai and Mike - are you comfortable with this given that the
> > > > proposal is for no heat lamp at all?
> > > >
> > > > John
> > > >
> > > > On 4/5/2012 11:33 AM, Betsy Bland wrote:
> > > > > Yes, the waiver request is to install the additional ~30mm^2 of
> > > > > epoxy without any heat outgassing.
> > > > > -Betsy
> > > > >
> > > > > On 4/5/2012 11:14 AM, John Worden wrote:
> > > > > > Calum, Betsy,
> > > > > > Would you confirm that the proposed additional epoxy will NOT
> > > > > > receive any heat lamp treatment?
> > > > > >
> > > > > > thanks
> > > > > >
> > > > > > John
> > > > > >
> > > > > > On 4/5/2012 8:56 AM, John Worden wrote:
> > > > > > > Rai - I believe the proposal is to NOT perform the gently heat
> > > > > > > lamp bake.
> > > > > > >
> > > > > > > John
> > > > > > >
> > > > > > > On 4/5/2012 8:44 AM, Rai Weiss wrote:

Fred,
I do not know much about this but am willing to take the gamble. The optic will come out again after the one arm test. The chance that condensibles will come out of the epoxy to coat the chamber is small. Even a gentle heat lamp bake will get rid of most of the binders.
RW

On Thu, 5 Apr 2012, Fred Raab wrote:

> What do we know about the outgassing vs curing time at the lower temperature?
> Fred
>
> On 4/4/12 4:13 PM, John Worden wrote:
> Comments please.
>
> john
>
> -------- Original Message --------
> Subject:
> Urgent Waiver Request from Suspensions - room temp out-gassing cure of EP-30-2 on ITM-Y only
> Date:
> Wed, 04 Apr 2012 10:45:19 -0700
> From:
> Calum Torrie<ctorrie@ligo.caltech.edu>
> To:
> John Worden<worden_j@ligo-wa.caltech.edu>, Dennis Coyne<coyne@ligo.caltech.edu>
> CC:
> Betsy Bland<bland_b@ligo-wa.caltech.edu>, Norna Robertson<nroberts@ligo.caltech.edu>, Michael Landry <landry_m@ligo-wa.caltech.edu>, Calum Torrie<ctorrie@ligo.caltech.edu>
>
> Dear John (and Dennis)
>
> John - Following our discussions earlier, can you pass
> to VRB as needed?
>
> While gluing the replacement metal prisms on ITM-Y to
> carry out a wire suspension, suspensions have experienced two
> failed
> joints out of eight, where the glass has been pulled forming a divot under those 2 corners. We believe this has been caused by
> thermal stress by differential contraction. Clearly suspensions need to re-consider the procedures for future metal to glass
> bonds. In the mean time we are requesting a waiver

as
detailed below so that we can proceed with the ITM-Y immediately, so
that we do not further delay the single arm test.

Suspensions would like a waiver to add ~ 30 mm^2 surface area of EP-30-2 epoxy between the prism LIGO-D080697-v1 and the ITM
optic with only a room temperature out-gassing cure. This leaves out the required elevated out-gassing cure as per
LIGO-E1000386-v1. It is worth pointing out that strength is not a driving factor in this application.

So far Suspensions entire dosage of EP-30-2 to WBSC8 is
~ 320 mm^2. All of these joints were out-gassed cured for ~ 24 hours
at ~ 40 deg C via a heat lamp.

cheers, Calum (with Betsy and Norna) on behalf of Suspensions.

--
Calum I. Torrie
LIGO Project California Institute of Technology
MC 100-36, Pasadena, CA, 91125
626 395 4629 (office)
626 394 8116 (cell)
Skype - calumiaintorrie

--

Dr. Frederick J. Raab, Head
LIGO Hanford Observatory
P.O. Box 159
Richland, WA 99352

phone: 509-372-8125
FAX: 509-372-8137

--

John Worden
Observatory Manager Office: (509) 372-8136
LIGO Hanford Observatory Fax: (509) 372-8137
P.O. Box 159 worden_j@ligo-wa.caltech.edu
Richland, WA 99352 www.ligo-wa.caltech.edu

Shipping address:

LIGO Hanford Observatory
127124 N Rt 10

Richland, WA 99354

--
Betsy Bland
Advanced LIGO Suspensions
LIGO Hanford Observatory
127124 N Route 10
Richland, WA 99354

Rarely here:
Office (509) 372-8191

So try here:
aLIGO Labs (509) 372-8316 or 372-8325

--

Dr. Frederick J. Raab, Head
LIGO Hanford Observatory
P.O. Box 159
Richland, WA 99352

phone: 509-372-8125
FAX: 509-372-8137