Refer to L080075 (Use of 303 stainless steel in ADL)

The VRB's response to the 303 stainless steel issue:

For ADL only, LIGO should avoid fabricating new parts or reusing Initial LIGO parts made from 303 SS unless there is significant functionality or cost impact involved. If 303 SS is to be used then a waiver should be requested from the VRB. Catalog fasteners of 303 SS are allowed since their surface areas are small.
This means we would NOT reuse the small suspensions unless a waiver is granted.
Also, we recommend that optics are baked in dedicated ovens or that other means are used to protect against contamination from S, Se, and P (such as exposing the hot oven to O2).

No changes are required for Eligo beyond what has been done already.

John

-------- Original Message --------
Subject: Re: L080042: Is 303 stainless steel acceptable in the LIGO Vacuum system?
Date: Sun, 18 May 2008 12:03:45 -0700
From: Fred Raab <raab_f@ligo-wa.caltech.edu>
Reply-To: raab_f@ligo-wa.caltech.edu
Organization: LiIGO Hanford Observatory / Caltech
To: John Worden <worden_j@ligo-wa.caltech.edu>
CC: Dennis Coyne <coyne@ligo.caltech.edu>, Rainer Weiss <weiss@ligo.mit.edu>, Mike Zucker <mike@ligo.mit.edu>, Riccardo DeSalvo <desalvo@ligo.caltech.edu>, 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>
References: <481104E7.4070907@ligo.caltech.edu> <48110CF8.3080606@ligo-wa.caltech.edu> <4811FD8B.4030507@ligo.caltech.edu> <481209BF.7050903@ligo-wa.caltech.edu> <48120EF6.4010109@ligo-wa.caltech.edu> <536F5318-5187-49AD-A6BB-C11171DC0A1C@ligo.mit.edu> <6.2.3.4.2.20080425113008.02834150@regulus.ligo.caltech.edu> <28F7264C-F24C-4D1A-B3BF-3DBFF8E3F1BB@ligo.mit.edu> <4815FD8B.7040507@ligo-wa.caltech.edu> <481B78ED.4080508@ligo.caltech.edu> <482DB4A9.4060303@ligo.caltech.edu>

```
I have not seen an objection to prohibiting any new use and replacing
when possible previously used components. Perhaps two issues are
unclear. One was what to do about eLIGO components, where replacement of
parts awaiting installation could cause delays. I think the response was
that part replacement would not seriously affect schedule. The second
had to do with affording the replacement of parts that might be
eventually re-used in aLIGO, where the answer was it was affordable.

I would be happy with "no new use; replace existing when feasible".

Fred
---
Dennis Coyne wrote:
> John,
> Ken Mason reports that there are some turned components, in the 2
> recently installed eLIGO HAM-ISI assemblies, which are comprised of
> 303 SS. They could be switched to 304 for future builds with some
> small cost increase (for the additional machining cost).
>
> *Has the VRB come to a revised determination with regard to the
> prohibition against 303 and 303Se (issued as L080044, 4/28), in light
> of the realization that there is quite a bit of this material already
> in Initial LIGO (question raised in 5/6 email)? I need to issue clear
> direction to the design/procurement teams quite soon.*
>    Dennis
>
> Dennis Coyne wrote:
>> VRB:
>> As it turns out there are other components comprised of 303 stainless
>> steel in the Enhanced and Initial LIGO system. The basic structure of
>> the SOS suspensions (D960001-D) is called out as 300 series SS and
>> was actually machined from 303. The eLIGO input Faraday Isolator
>> (D080250) also has parts machined from 303 SS. The AOS group used
>> mostly aluminum, but there are some small parts comprised of 303 SS.
>> Most SS fasteners are either 18-8 or 303 (both with S content),
>> although one can readily get 316 SS fasteners. Perhaps the total
>> surface area represented by the fasteners is too small to be
>> concerned about.
>>
>> So, my follow up questions are as follows:
>> 1) Are the SOS suspensions currently in use for eLIGO OK for use in
>> aLIGO, or must they all be replaced?
>> 2) Should we switch to 316 hardware wherever possible in aLIGO?
>>    Dennis
>>
>> John Worden wrote:
>>> Refer to L080044  (This document).In response to L080042: Is 303
>>> stainless steel acceptable in the LIGO Vacuum system?
>>>
```

>>> The VRB response is:
>>>
>>> 1. Existing 303SS already installed at LLO will remain in HAM6 until
>>> we need to remove the septum or install ADL. At this time the 303SS
>>> parts are replaced at LLO.
>>> 2. All 303SS parts (if possible) for LHO will be remade with cost
>>> and schedule impact addressed via CCB.
>>> 3. E960050 receives an edit to remove 303SS from the acceptable
>>> materials list.
>>>
>>> John Worden for the VRB.
>>>
>>>
>>> Michael Zucker wrote:
>>>> Aha! OK Norna, I just read OMC, not OMC SUS!
>>>>
>>>> Now I know where to look, is it the upper mass block D060491 under
>>>> the assembly D070024? the small hardware clamps
>>>> associated? or the tablecloth? or all of the above? The edrawing
>>>> doesn't show the material callouts.
>>>>
>>>> I suggest calling up ASAP to figure out where they are on each
>>>> questionable part and, exercising some judgment,
>>>> have them order new material for those not started. Also might
>>>> consider just
>>>> remaking (in parallel) those already begun or completed, if
>>>> necessary going to another shop so
>>>> as not to compete with ourselves. Is this job still with Mike
>>>> Gerfen over in CES or did we sub it out?
>>>>
>>>> I'll presume we (maybe I?) can prepare a defensible CCB for the
>>>> cost impact. Schedule impact needs to be
>>>> estimated, but even if the delay proves to be unjustified by the
>>>> present issue, there's always finite chance of some unrelated
>>>> delay.
>>>>
>>>> Not that we should wish for one...
>>>>
>>>> Thanks for clarifying,
>>>>
>>>> mike
>>>>
>>>> On Apr 25, 2008, at 2:30 PM, Norna Robertson wrote:
>>>>
>>>>> Dear Mike and colleagues
>>>>>
>>>>> Just to clarify - the 303 stainless part(s) in the OMC is(are) in
>>>>> the top mass above the double pendulum. So even if Sam changed the
>>>>> silica bench to correct the problems mentioned below, the 303
>>>>> would NOT get replaced unless and until we have replacement metal
>>>>> parts for the *whole* suspension.
>>>>> Here is the status. We are are currently underway in making the
>>>>> LHO suspension using 303 - which of course we can halt and change
>>>>> to another steel if that is the wisdom of this group, noting this
>>>>> will hit cost and schedule. (For your info we have been informed
>>>>> by the workshop that 304 takes considerably more effort to work -
>>>>> I think someone questioned this.) We have no plans at present to
>>>>> remake the LLO suspension until it is done as part of the Advanced
>>>>> LIGO project and that is not scheduled for another year or two (
>>>>> e.g. final design review is currently scheduled May 2009 and
>>>>> production of all HAM suspensions starts April 2010). So changing
>>>>> the schedule to produce another OMC suspension for LLO without 303
>>>>> in it before then would require availability of $$ and effort
>>>>> earlier than planned.
>>>>>
>>>>> Norna
>>>>>
>>>>> At 10:23 AM 4/25/2008, Michael Zucker wrote:
>>>>>> John-
>>>>>>
>>>>>> Yes I think that's a possibility we can't rule out. It's a
>>>>>> while away yet, but may be needed for S6 (for example, if we get
>>>>>> into
>>>>>> VIRGO-like troubles with phase noise
>>>>>> from the window). As you know, we've been pretty religious about
>>>>>> allowing no vacuum
>>>>>> compromise in HAM6, precisely to maintain this option.
>>>>>>
>>>>>> We've had other issues with this OMC , it being the
>>>>>> "prototype" (thermal actuator fell apart, mirrors got
>>>>>> contaminated, one
>>>>>> mirror mount shifted while curing...) but things got patched up one
>>>>>> way or another and it hung in there.
>>>>>> Nevertheless, there are now enough parts laid in to set up a
>>>>>> replacement if we wish.
>>>>>>
>>>>>> I'm thinking to ask Sam to proceed along those lines and replace the
>>>>>> prototype on L1 before we consider
>>>>>> removing the window. I'll send him a note.
>>>>>>
>>>>>> Mike
>>>>>>
>>>>>>
>>>>>>
>>>>>>
>>>>>>
>>>>>> On Apr 25, 2008, at 1:03 PM, John Worden wrote:

>>>>>>
>>>>>>> Fred,
>>>>>>>
>>>>>>> Isn't it possible that we remove the septum window sooner rather
>>>>>>> than later - say the window becomes the limiting component either
>>>>>>> for commissioning or sensitivity reasons in S6? In this case the
>>>>>>> 303
>>>>>>> material would be exposed to our main volume. I don't know if this
>>>>>>> is a concern given the quantities.
>>>>>>>
>>>>>>> john
>>>>>>>
>>>>>>>
>>>>>>> Fred Raab wrote:
>>>>>>>> Thanks, Dennis. It seems like the best action is to remove 303 SS
>>>>>>>> from the approved list, fix drawings that spec it (red lines
>>>>>>>> should
>>>>>>>> be a good start, but rev's in reasonable time would be needed to
>>>>>>>> ensure it does not creep back in). It sounds like the stuff
>>>>>>>> already
>>>>>>>> in the main vacuum volumes is small amounts, if any, and we should
>>>>>>>> not worry about that. It'll come out by 2011. As for the OMC
>>>>>>>> parts,
>>>>>>>> I propose we waiver them, so as not to delay testing of DC
>>>>>>>> read- out. My understanding is that eventually the HAM 6
>>>>>>>> septums will go
>>>>>>>> away, but the current OMCs will go away first. We might want to
>>>>>>>> replace those parts later if the OMCs were ever recycled for
>>>>>>>> use in
>>>>>>>> our main, highest-quality, vacuum volumes.
>>>>>>>>
>>>>>>>> Fred
>>>>>>>> ----
>>>>>>>>
>>>>>>>> Dennis Coyne wrote:
>>>>>>>>> Some replies to your questions below
>>>>>>>>>
>>>>>>>>> Fred Raab wrote:
>>>>>>>>>> Dennis,
>>>>>>>>>>
>>>>>>>>>> Do we already have significant 303 SS components in the LIGO
>>>>>>>>>> vacuum system?
>>>>>>>>> The only components composed of 303 (or "300 series" without
>>>>>>>>> knowledge of the specific grade) in order system at present to my
>>>>>>>>> knowledge are parts of the OMC and (as Mike points out) possibly
>>>>>>>>> SS fasteners.
>>>>>>>>>> Presumably the LLO OMC has already gone through a bake oven?
>>>>>>>>> Yes.
>>>>>>>>>> Can the oven be baked clean now?
>>>>>>>>> As Rai suggests we can bake our ovens with air in the chamber to
>>>>>>>>> oxidize the S, Se and P.
>>>>>>>>>>
>>>>>>>>>> >From your note, it appears that we would have good reason to
>>>>>>>>>> exclude 303 SS from the list of acceptable materials. One could
>>>>>>>>>> imagine a waiver for the septum-separated HAM with OMC for now.
>>>>>>>>>> My feeling is that LIGO faces a bigger risk right now from the
>>>>>>>>>> OMC and DC detection not working out well than from irreversible
>>>>>>>>>> vacuum contamination of HAM 6. My concern is whether we can
>>>>>>>>>> still
>>>>>>>>>> prevent future contamination of the rest of the vacuum system or
>>>>>>>>>> have we already "bought the pig".
>>>>>>>>> I think we can prevent future contamination of the main vacuum
>>>>>>>>> volumes if we act now. As for the isolated HAM6 volumes, there
>>>>>>>>> may
>>>>>>>>> be some contamination but the vapor pressure is fairly low. Worst
>>>>>>>>> case scenario is we consider a bake of the HAM6 chamber with air
>>>>>>>>> in it to oxidize the S, Se and P. However, this is perhaps
>>>>>>>>> overkill.
>>>>>>>>>>
>>>>>>>>>> Is there any indication that we had positive evidence when the
>>>>>>>>>> list was made up that 303 was OK, despite what O'Hanlon and SLAC
>>>>>>>>>> say?
>>>>>>>>> Mike gave you his recollection in a separate email.
>>>>>>>>> In addition to O'Hanlon and SLAC:
>>>>>>>>>
>>>>>>>>> 1) Phil Danielson, "Choosing the Right Vacuum Materials", R&D
>>>>>>>>> Magazine, April 2003.
>>>>>>>>> "Free-machining alloys such as 303 SS contain sulfur (S), but the
>>>>>>>>> vapor pressure of the S is too high for high vacuum systems."
>>>>>>>>> http://www.vacuumlab.com/Articles/VacLab36.pdf
>>>>>>>>>
>>>>>>>>> 2) The Advanced Light Source (ALS) Vacuum Policy and Vacuum
>>>>>>>>> Guidelines for Beamlines and Experiment Endstations, section 5:
>>>>>>>>> http://www-als.lbl.gov/als/quickguide/
>>>>>>>>> vacuumpolicy.html#anchor9792047
>>>>>>>>> Lists this note under "marginal" materials: "Stainless Steel: SS
>>>>>>>>> containing excessive amounts of sulfur or selenium must be
>>>>>>>>> avoided."
>>>>>>>>>
>>>>>>>>> 3) HASYLAB Vacuum Guidelines for Beamlines and Experiments
>>>>>>>>> Prefers 316L and 316LN. Does not prohibit other stainless steels,
>>>>>>>>> other than by the statement "Standard UHV-compatible materials
>>>>>>>>> have to be used for all vacuum components."
>>>>>>>>> http://hasylab.desy.de/infrastructure/vacuum_group/guidelines/vacuum_guidelines/index_eng.html
>>>>>>>>>
>>>>>>>>>
>>>>>>>>>

>>>>>>>>>> Fred
>>>>>>>>>> ---
>>>>>>>>>>
>>>>>>>>>> Dennis Coyne wrote:
>>>>>>>>>>> LIGO-L080042-00
>>>>>>>>>>>
>>>>>>>>>>> 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 303 stainless steel is acceptable. However,
>>>>>>>>>>> O'Hanlon's "A User's Guide to Vacuum Technology" clearly states
>>>>>>>>>>> that 303 should be avoided in UHV applications due to the
>>>>>>>>>>> addition of sulfur, phosphorous or selenium. In addition, the
>>>>>>>>>>> SLAC Vacuum Department Guidelines for Vacuum Systems:
>>>>>>>>>>> http://lhocds.ligo-wa.caltech.edu:8000/advligo/UHVWelding?action=AttachFile&do=get&target=SLAC-I-007-12004-001-R1.pdf
>>>>>>>>>>>
>>>>>>>>>>> states in section 3.1:
>>>>>>>>>>> "Types 303, 303S, and 303Se contain excessive amounts of sulfur
>>>>>>>>>>> or selenium and are not acceptable."
>>>>>>>>>>> It should also be noted that all of our welded vacuum chambers
>>>>>>>>>>> are comprised of 304L.
>>>>>>>>>>>
>>>>>>>>>>> It might be argued that this prohibition is very likely due to
>>>>>>>>>>> high vapor pressure and diffusion associated with these alloys
>>>>>>>>>>> when baked to clean up the parts. Since we do not plan to do
>>>>>>>>>>> in- situ vacuum baking we might in principal get around this
>>>>>>>>>>> restriction by baking in air and performing FTIR cleanliness
>>>>>>>>>>> certification tests (rather than RGA tests). Could this
>>>>>>>>>>> approach
>>>>>>>>>>> be acceptable? A rather simplistic analysis (given below)
>>>>>>>>>>> indicates that this may not be acceptable. The exceedingly high
>>>>>>>>>>> vapor pressures for the elements Se, S and P suggest that even
>>>>>>>>>>> at room temperature there is a risk of plating optics to
>>>>>>>>>>> significant thickness in short durations.
>>>>>>>>>>>
>>>>>>>>>>> Can we permit (continue to permit) 303 and 303 Se stainless
>>>>>>>>>>> steel into the LIGO vacuum system? One of the parts of the LLO
>>>>>>>>>>> OMC is comprised of 303 and others were called out as 300
>>>>>>>>>>> series. Presently we are machining parts for the LHO OMC.
>>>>>>>>>>> Can we
>>>>>>>>>>> accept these parts? Should we remove 303 and 303 Se from the
>>>>>>>>>>> LIGO UHV approved materials list? This decision will have
>>>>>>>>>>> significant consequences since there are many drawings which
>>>>>>>>>>> call out 303 or 300 series SS and their are many prototype
>>>>>>>>>>> parts
>>>>>>>>>>> which have used 300 series SS. Moreover the machining costs for
>>>>>>>>>>> 302, 304 or 316 are higher.
>>>>>>>>>>>
>>>>>>>>>>> I request a rapid reply from the VRB given the time critical
>>>>>>>>>>> nature of the OMC work for enhanced LIGO.
>>>>>>>>>>>
>>>>>>>>>>> _The simplistic analysis follows:_
>>>>>>>>>>> The composition of 303 stainless steel is as follows (source is
>>>>>>>>>>> matweb.com):
>>>>>>>>>>> Carbon, C <= 0.150 %
>>>>>>>>>>> Chromium, Cr 18.0 %
>>>>>>>>>>> Iron, Fe 69.0 %
>>>>>>>>>>> Manganese, Mn <= 2.00 %
>>>>>>>>>>> Molybdenum, Mo <= 0.600 %
>>>>>>>>>>> Nickel, Ni 9.00 %
>>>>>>>>>>> Phosphorous, P <= 0.200 % [very small amount]
>>>>>>>>>>> Silicon, Si <= 1.00 %
>>>>>>>>>>> Sulfur, S >= 0.150 % [*Note no upper limit*; I couldn't find
>>>>>>>>>>> typical values]
>>>>>>>>>>>
>>>>>>>>>>> The percentages of the three elements of concern in the
>>>>>>>>>>> composition of 303 SE is as follows:
>>>>>>>>>>> Phosphorous, P <= 0.200 %
>>>>>>>>>>> Selenium, Se <= 0.150 %
>>>>>>>>>>> Sulfur, S <= 0.0600 %
>>>>>>>>>>> All rather small percentages.
>>>>>>>>>>>
>>>>>>>>>>> The percentages of the three elements of concern in the
>>>>>>>>>>> composition of 303 MA is as follows:
>>>>>>>>>>> Phosphorous, P 0.0400 %
>>>>>>>>>>> Sulfur, S 0.140 %
>>>>>>>>>>> Also all rather small percentages.
>>>>>>>>>>>
>>>>>>>>>>> For the purpose of getting some idea of the potential harm of
>>>>>>>>>>> these three elements in a 303 SE alloy, let's assume ~0.2 %
>>>>>>>>>>> maximum amount by weight. N.B.: This does not allow a 303 SS,
>>>>>>>>>>> which is likely (?) to have a few % of S.
>>>>>>>>>>>
>>>>>>>>>>> The vapor pressures of sulfur, phosphorous and selenium
>>>>>>>>>>> (over an
>>>>>>>>>>> elemental solid) are:
>>>>>>>>>>> Po = {1e-10 Se, 2.0e-6 S, 2.0e-10 Pred) torr @ 20C
>>>>>>>>>>> Po = {2.0e-3 Se, 2.0 S, 5e-2 P} torr @ 200C
>>>>>>>>>>> N.B.: I've used red Phosphorous in these calculations. White
>>>>>>>>>>> Phosphorous has a vapor pressure even higher than Sulfur. I'm
>>>>>>>>>>> not sure which allotropic form to use in the calculation.
>>>>>>>>>>>
>>>>>>>>>>> The vapor pressure of these elements over a 303 alloy (with c =
>>>>>>>>>>> % Se, % S, %P by Wt.) will be lower than the vapor pressure
>>>>>>>>>>> over
>>>>>>>>>>> a solid of the pure element. For an ideal solution (alloy),

>>>>>>>>>>> with
>>>>>>>>>>> low molar fraction, the vapor pressure lowering is given by
>>>>>>>>>>> Raoult's law:
>>>>>>>>>>>
>>>>>>>>>>> p = x(Z) * Po, where x(Z) is the mole fraction of the
>>>>>>>>>>> element Z
>>>>>>>>>>> x(Z) ~ c*Ar(Fe)/Ar(Z), where Ar is the relative atomic mass.
>>>>>>>>>>>
>>>>>>>>>>> Ar(Z) = {78.96 Se, 32.066 S, 30.97 P, 55.845 Fe)
>>>>>>>>>>> x(Z) = {1.4e-3 Se, 3.5e-3 S, 3.6e-3 P}
>>>>>>>>>>> p = {1.4e-13 Se, 7.0e-9 S, 7.2e-13 P} torr @ 20C
>>>>>>>>>>> p = {2.8e-6 Se, 7.0e-3 S, 1.8e-4 P} torr @ 200C
>>>>>>>>>>>
>>>>>>>>>>> Although I could not find a reference for the vapor pressure of
>>>>>>>>>>> these elements over an alloy, I did find a reference for Fe
>>>>>>>>>>> vapor pressure over a solid Vanadium-Fe alloy (Myles & Aldred,
>>>>>>>>>>> "Thermodynamic Properties of Solid Vanadium-Iron Alloys", J of
>>>>>>>>>>> Physical Chem, v68, n1, Jan 1964). At ~10% molar fraction, the
>>>>>>>>>>> vapor pressure is in close agreement with Raoult's law; The
>>>>>>>>>>> non- ideal deviation further lowered the vapor pressure. The
>>>>>>>>>>> vapor
>>>>>>>>>>> pressure will also be lowered by any diffusion rate limited
>>>>>>>>>>> process through the condensed solid alloy.
>>>>>>>>>>>
>>>>>>>>>>> On the issue of physical vapor deposition of Z onto our optics
>>>>>>>>>>> (and other chamber surfaces), the mass rate of evaporation is
>>>>>>>>>>> given by the Hertz-Knudsen equation (H. Lee, _Fundamentals of
>>>>>>>>>>> Microelectronics Processing_, 1989):
>>>>>>>>>>>
>>>>>>>>>>> V [g/cm^2/s] = 5.834E-2 * Sqrt(M/T) * p
>>>>>>>>>>>
>>>>>>>>>>> where T is in K, the molecular weight M = {78.96 Se, 256.5 S,
>>>>>>>>>>> 123.9 P} and where p is the partial pressure (torr)
>>>>>>>>>>> V = {4.2e-15 Se, 3.7e-10 S, 2.7e-14 P} gm/cm^2/s @ 20C
>>>>>>>>>>> V = {6.7e-8 Se, 3.0e-4 S, 5.3e-6 P} gm/cm^2/s @ 200C
>>>>>>>>>>>
>>>>>>>>>>> The maximum deposition rate, assuming direct free-molecular
>>>>>>>>>>> streaming (no adsorption/desorption), disregarding solid angles
>>>>>>>>>>> and view factors, and no condensation rate-limited processes
>>>>>>>>>>> (if
>>>>>>>>>>> any), i.e. worst case, is then given as
>>>>>>>>>>>
>>>>>>>>>>> rd = V*As/(Pi * r^2)
>>>>>>>>>>> where As is the source area and r is the distance to the target
>>>>>>>>>>> (optic). Assuming a ~10^3 cm^2 source area at a distance of ~10
>>>>>>>>>>> cm from the optic, then
>>>>>>>>>>> rd = {1.3e-14 Se, 1.2e-9 S, 8.6e-14 P} gm/cm^2/s at 20C
>>>>>>>>>>> rd = {2.1e-7 Se, 9.4e-4 S, 1.7e-5 P} gm/cm^2/s at 200C
>>>>>>>>>>>
>>>>>>>>>>> With a Z density of {4.79 Se, 2.07 S, 1.82 P} gm/cc this
>>>>>>>>>>> corresponds to a maximum deposition rate of
>>>>>>>>>>> {2.8e-15 Se, 5.8e-10 S, 4.7e-14 P} cm/s at 20C
>>>>>>>>>>> {4.4e-8 Se, 4.6e-4 S, 9.3e-6 P} cm/s at 200C
>>>>>>>>>>>
>>>>>>>>>>> If we assume a maximum tolerable thickness of ~1 nm (about 1
>>>>>>>>>>> monolayer), then the minimum time to achieve this layer is
>>>>>>>>>>> {9922 Se, 0.05 S, 590 P} hr at 20C
>>>>>>>>>>> ~1 sec at 200C
>>>>>>>>>>> Obviously the vapor evolution (including diffusion out of the
>>>>>>>>>>> parent alloy) and deposition process is much more complicated,
>>>>>>>>>>> but this simple and conservative analysis leads me to the
>>>>>>>>>>> following conclusions:
>>>>>>>>>>>
>>>>>>>>>>> * The use of any 303 or 303-SE stainless steel should not be
>>>>>>>>>>>   permitted in the LIGO vacuum system. (Perhaps in small
>>>>>>>>>>> quantity
>>>>>>>>>>>   for compelling reasons and for applications distant from
>>>>>>>>>>> optics it
>>>>>>>>>>>   could be permitted with a waiver.)
>>>>>>>>>>> * We must not bake 303 SS in a vacuum bake oven; This will
>>>>>>>>>>> cause
>>>>>>>>>>>   contaminate the oven and likely contaminate subsequent
>>>>>>>>>>> loads.
>>>>>>>>>>>
>>>>>>>>>>> Dennis
>>>>>>>>>>>
>>>>>>>>
>>>>>>>>
>>>>>>>>
>>>>
>>> OTHER EMAILS:
>>>
>>> -------- Original Message --------
>>> Subject: Re: L080042: Is 303 stainless steel acceptable in the
>>> LIGO Vacuum system?
>>> Date: Fri, 25 Apr 2008 07:15:43 -0700
>>> From: Riccardo DeSalvo <desalvo@ligo.caltech.edu>
>>> To: Dennis Coyne <coyne@ligo.caltech.edu>
>>> CC: john Worden <worden_j@ligo-wa.caltech.edu>, Rainer Weiss
>>> <weiss@ligo.mit.edu>, Mike Zucker <mike@ligo.mit.edu>, Fred Raab
>>> <raab_f@ligo-wa.caltech.edu>, 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>
>>> References: <481104E7.4070907@ligo.caltech.edu>
>>> <Pine.GSO.4.56.0804250009540.8270@ligo.mit.edu>
>>>

>>>
>>>
>>> For what it is worth, I asked a few questions, and so far I found
>>> nobody in Virgo that recalls having used 303 in Virgo.
>>> Apparently they staid out of it, either because they knew of, or
>>> because of luck. It is no a common steel in any case.
>>> R
>>>
>>> -------- Original Message --------
>>>   Subject: Re: L080042: Is 303 stainless steel acceptable in the
>>> LIGO Vacuum system?
>>> Date: Fri, 25 Apr 2008 00:24:51 -0400 (EDT)
>>> From: Rainer Weiss <weiss@ligo.mit.edu>
>>> To: Dennis Coyne <coyne@ligo.caltech.edu>
>>> CC: John Worden <worden_j@ligo-wa.caltech.edu>, Mike Zucker
>>> <mike@ligo.mit.edu>, Fred Raab <raab_f@ligo-wa.caltech.edu>,
>>> Riccardo DeSalvo <desalvo@ligo.caltech.edu>, 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>
>>> References: <481104E7.4070907@ligo.caltech.edu>
>>>
>>>
>>>
>>> Dennis and others,
>>> I also did not realize that 303 had sulfur, phosphorous and selenium in
>>> it. It would be sensible to remove 303 from the list of vacuum
>>> compatible
>>> materials but I see no reason to panic.
>>>
>>> The vapor pressure of the three constituents at room T when diluted by
>>> their fraction in the base material is small and does not pose a
>>> problem. The most serious problem
>>> could arise in contamination of the bakeout ovens. A simple fix, should
>>> an oven have been contaminated, is to run the oven at bake temperature
>>> filled with some air (oxygen). Phosphorous and sulfur will oxidize into
>>> volatile compounds that are easily removed by pumping or entrapment
>>> into
>>> the gas. Selenium will form a non volatile oxide which may leave
>>> some dust
>>> behind.
>>>
>>> RW
>>> -------- Original Message --------
>>> Subject: Re: L080042: Is 303 stainless steel acceptable in the
>>> LIGO Vacuum system?
>>> Date: Thu, 24 Apr 2008 21:38:51 -0400
>>> From: Michael Zucker <zucker_m@ligo.mit.edu>
>>> To: Dennis Coyne <coyne@ligo.caltech.edu>
>>> CC: John Worden <worden_j@ligo-wa.caltech.edu>, 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>, 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>
>>> References: <481104E7.4070907@ligo.caltech.edu>
>>>
>>>
>>>
>>> Dennis-
>>>
>>> I basically follow your logic and agree, it seems an unnecessary
>>> risk for new hardware.
>>>
>>> I'd balk at yanking out stuff already installed, because honestly
>>> there seems to be a lot of
>>> conservatism (e.g., barring direct line of sight to an optic, every
>>> other surface should be a perfect pump
>>> for these metals, right?).
>>>
>>> It's harder to evaluate the response for parts currently in fab,
>>> depends on details. For future
>>> construction, I think just redlining "don't care" or "generic 300
>>> series"
>>> drawings to change the material designation would be reasonable, as
>>> long as everyone sending
>>> out for bids knows ahead of time to do it.
>>>
>>> Did we get a (recent) direct indication shops would really charge a
>>> premium for calling out 304?
>>> My impression is these days the fabrication advantage of free-
>>> machining alloy should be less
>>> important. Tools are much tougher now, machines more rigid. Screw
>>> machines might still
>>> enjoy longer tool life, but I wonder if we ever make enough of
>>> anything to care (OK maybe barrel nuts...
>>> but anything cuts better than nitronic 60!)
>>>
>>> Speaking of which, if I'm not mistaken, our SS fasteners are
>>> usually thread-rolled of nominal 18-8, which is
>>> supposed to be loose-rated 304. But that would be worth checking.
>>>
>>> 304 (not L) is also generally cheaper and stronger, which could partly
>>> offset any fabrication penalty (316's neither cheaper nor stronger,
>>> of course).
>>>

>>> I am assuming anything
>>> to be welded is always spec'd 304L or 316, with 308 or 316 rod, is
>>> that right?
>>>
>>> Bottom line, I'll buy into your recommendations, and raise you two:
>>>
>>> * put out an all-call to the engineering group see what we have in
>>> fabrication that uses 303 (and
>>> how much/how long it would take to remake in 304)
>>>
>>> * check fasteners too
>>>
>>> Mike
>>>
>>>
>>>
>>
>

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