Considerations for tracer gas in sealed SEI pods

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A. Summary recommendations/questions

1. proceed with 0.1 atm Ne fill as specified in SEI requirements docs

2. rigorously stress test production instrument pods and samples, especially electrical feedthroughs, for possible endemic defects or process/installation damage susceptibility

3. consider adding accessible tubulation for a final "in situ" leak test

4. research what is a reasonable expectation for partial pressures of putative contaminants inside a pod

5. consider including an activated carbon getter to sequester HC's inside each pod

6. if not too difficult, consider also adding Kr in 2 or 3 different relative concentrations to each of the different pod varieties, to guide diagnostics in event of a leak problem

B. Leak prevention

The obvious goal is for the most probable number of leaking pods to be zero. This is sometimes assumed to imply the probability of _two_ leakers is still far less, which is unjustified. There's no reason to presume failures are independent; many plausible modes are correlated.

With 100% leak check QA on all assemblies, we can at least assume zero leaks initially. Thus we are concerned with "acquired," i.e. operation- or age-induced failures.

To my knowledge we have never seen such an acquired leak in tested welds or tested Conflat joints (unless there was a large stress like a high-temp bake). However I have seen two acquired leakage problems in electrical feedthroughs. One was on ISI BNC feedthroughs for the 40-meter back in ~1990, the other was on Accuglass feedthroughs on LASTI just recently.

Each of these episodes affected more than one instance of the same type of feedthrough part, purchased from the same "batch," at the same time, and processed identically through installation (we think... in both cases we kept insufficient records of precisely what had happened to the parts between initial test and discovery of leaks in situ).

To avoid such a scenario I would recommend, in addition to 100% leakchecking of finished modules, stress testing of sample modules USING

THE EXACT FEEDTHROUGHS, sampled from THE SAME BATCHES considered for production, and assembled/welded by the ACTUAL production process. As examples, I suggest we simulate:

- cleaning and baking
- testing (NASA's nemesis: "one final test before launch" toasts the payload!)
- shipping
- handling and installation

as well as in situ process, such as

- mounting torques and distortion
- numerous connector attachment/detachment cycles
- cable yankoffs
- ohming out pins
- internal shorts or other worst-case overcurrents
- worst-case overvoltages or HV arcs

In particular some tests should be performed with an internal 1 atm overpressure (or more) to simulate barometric stresses in the operating environment.

We should also consider the possibility of a final "end of the line" leak test. For example, we could plumb a copper pinch tube from each pod to an accessible point in the chamber, so it can be He tested in situ (and then sealed permanently by swaging).

C. Leak detection

After doing the above, the remaining mission threat is "sudden" onset of a leak after some period of normal operation.

The maximum tolerable leak is defined by optics contamination potential, under the assumption that internal pod components produce unacceptable outgas products.

The AdL limit for HC partial pressure is ~ 1e-12 torr, so for 1,000 l/s equivalent system pump speed and 1 torr partial pressure of "contaminant," leakage must be less than 1e-9 l/s or 1e-7 atm-cc/s air equivalent. This could be detectable from its air signature alone, although of course it would be ambiguous.

* I could not decide what a realistic contaminant concentration might be in a sealed pod. On the one hand, 1 torr seems high, since the threshold of odor for aromatic HC's is about 1e-3 of that (~ppm). Does a GS-13 smell bad when you open the housing? On the other hand, a pool of acetone would equilibrate at its ~100 torr vapor pressure.

** In any case we should consider sealing an activated charcoal cartridge inside each pod. This would sequester volatile HC's and reduce the "source" term, whatever it is.

When tuned up properly in EM mode, the Balzers RGA's at the sites and in LASTI achieve a background equivalent to about 3e-13 torr in a clear channel. A peak a factor of ten larger should be reliably detected. For 1,000 l/s pump speed (presuming the tracer is nonreactive and

noncondensible), one can thus detect 3e-9 tl/s of tracer gas. The permissible leak rate of 1e-9 l/s is then exposed at SNR=10 if the tracer inside the pod has a partial pressure of 3 torr.

9.25 % of natural Neon is the 22Ne isotope. 22 AMU is apparently clear in LASTI, LLO, and LHO spectra (although I have not verified this all the way down to the 3e-13 torr noise). 32 torr of natural neon will provide 3 torr of 22Ne as required. I think the SEI specification doubles or triples this concentration (something like 1/10 atmosphere).

In conclusion I think a neon/air mix should be adequate for detection of a "new" leak in situ at a protective level, unless the pod contents are extraordinarily nasty.

D. Leak localization

The question arises what to do if a leak should appear, especially say in the corner section where dozens of pods share a common volume. The default would be to vent and sequentially deinstall and test all SEI pods until the offending unit is discovered, potentially months of downtime. Unlike the beam tube, there is no appreciable flow resistance in the VE volume to enable localization through pressure gradients.

Instead it's been suggested that a means for "coding" the tracer gas could help prune the search tree in the event of a leak.

Krypton or heavier noble gases are condensible on the cold traps. Their effective pump speed is unpredictable and depends on the surface physics (prior adsorption) of the traps. This makes Kr less reliable for the detection problem, since in normal operation the traps are exposed. However once a leak is discovered, the traps can be sealed. Also a turbomolecular pump can replace the ion pumps to provide a nearly mass-independent pump rate (or even no pump for short periods, i.e. accumulation).

This could enable differentiation of some number of binary mixtures, limited perhaps by stability of the RGA's sensitivity ratio between 22 and ~84 AMU (plus any backgrounds at these masses). For leaks near threshold I would never believe it, but for a real whopper it could be helpful.

As a result I suggest we consider specifying two or three concentrations of Kr in addition to the Ne (say zero, 25 and 50 torr). Although it's tempting to vary composition by chamber, this will complicate interchangeability of parts and could bog down assembly flow; it could be just as helpful to differentiate by pod type (L4c, STS or GS13), especially since a problem will (should) cast a spotlight on all units of similar type.

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