COMMENTS ON THE DOCUMENT TITLED "LIGO Internal Report 88-1" DATED APRIL 28, 1988 WRITTEN BY Boude Moore

Reviewer: Yekta Gürsel July 21, 1988

In the reviewer's opinion this document is reasonably well prepared. However it fails to address several issues which are crucial for the timely operation of the Laser Interferometric Gravitational Wave Detectors after they are built. These issues are listed below:

1) A small section of the 4-foot diameter LIGO tubes will be constructed using a stainless steel plate which is helically wound into a cylinder and then welded along the edges. A 2 km main section of the beam tube is constructed out of these small sections welded to each other at the ends. This implies that the main 2 km section will contain a large number of welded edges. This document does not say anything about the leak-proofness of these welds. No data is supplied about the probability of having a number of leaks of a given size. If the small sections are going to be leak tested as they are manufactured, this should be mentioned because it might be a major cost item. If they will not be leak tested as manufactured, then one may consider leak testing a structure which contains several of these small sections. This also may turn out to be too costly. If no leak testing will be performed until the main 2 km section is complete, then one must have an idea of how many leaks of a given size will appear. If there are too many small leaks in the main section it may take an inordinately long time to find them and to seal them once they are found.

2) Although this document describes the leak testing apparatus it says nothing about how the leak testing is going to be performed. This is not a trivial question though it may sound like one at first sight. Given the fact that the cover for the main beam tubes may have to be "non man-rated" to reduce the cost of building the observatory, i.e. one is not allowed to send a person with a canister of helium under the cover along the tube, it is not clear how the leak testing is going to be accomplished. This is especially worrisome if the main sections turn out to contain numerous small leaks. Even if one is allowed to send a person along the tube to squirt helium around, it is still not clear how to hunt for all those leaks in a reasonable time span.

3) In the document it is emphasized that one needs "rugged" mass spectrometers because one needs to use them in the "field". If one adheres to the design given in the document, then there is no reason to move the mass spectrometer more than once to test all four 2 km sections of the beam tubes. Since the leak testing apparatus is connected to the exhaust of one of the main turbo pumps, all one has to do is to use the "mid-station" buildings as the mass spectrometer locations. Once

it is installed in one of those buildings, it can check both of the 2 km sections along that arm. It then has to be moved only once to check the other arm. This may enable us to dispense with the "ruggedness" of the instrument and to buy a more sensitive one which may shorten testing time. As a matter of fact it may be wise to buy two and to leave them installed in the mid-stations to continuously check the state of the affairs in the main beam tubes and chambers.

4) The reviewer heard that in the prior designs for the main beam tubes there were quite a few ion pumps on the main sections. If this is the case in the current designs then one can estimate the positions of the leaks by looking at the ion pump currents and by interpolating between the two pumps that are straddling a leak. This will surely make hunting for the small leaks much less time consuming.

5) It would be really useful if this document made it clear how long it would take to get a leak-tested vacuum system with the required pressures after all of the construction of the tubes and the chambers had been completed. This will directly impact the schedule of the science team since it will be rather sad to have a functioning interferometer waiting for a good vacuum for a long time in order to reach the required sensitivity.

The reviewer would be delighted to see the resolution of these issues. This will make this document a very useful guide in designing the LIGO system.

Pasadena, July 21, 1988

→ Boude Moore December 1, 198

Boude;

Here are my comments about the "Aspects of leak detection in LIGO beam tubes" paper as we discussed them today:

I. Scope:

Here the statement #2 should be modified to read:

2. Can a leak in the beam tube be found?

a) } These are as they were
b) } in the paper.

II. General / Background:

b) Here; it is a good idea to mention that the argon accumulation in the ion pumps have been observed for large leaks, and we expect the same thing to happen if the leak is small but it is active for a long time.

IV. Flow of Helium from leak to detector:

The pressure distribution given in this section:

$$C(x,t) = \frac{Q}{2(\pi DCt)^{1/2}} \times \frac{1}{2CM} \times e^{-\frac{x^2}{(4DCt)}}$$

is the solution of the diffusion equation:

$$\frac{1}{DC}\frac{\partial C(x,t)}{\partial t} = \frac{\partial^2 C(x,t)}{\partial x^2}$$

with the boundary conditions suitable for an infinite tube. It is normalized so that at $t=0$ and $x=0$; $C(0,0)$ corresponds to a finite amount Q of tracer gas admitted through the leak.

Integrated Transients:

Here it is very useful to give the equations used in computing the integrated transients.

(3)

Leak Detector Equipment:

There are various pump speeds mentioned in the document. Please make them consistent and please put in the most recent values considered in the design. You also mentioned that the pumping effect of the RGA itself was not considered. It would be very nice to include this effect now. This will make the paper very complete.

Helium Background:

Please mention that the 600 CFM pump is the roughing pump for the main turbo; and update the diagram as well. (Also put in the most recent Speed in the design under consideration)

This is all.

Best,
Yelda