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Notes on Reasons for Incorporating Gate Valves in Test Mass Tanks, and on possible scenario near start of LIGO operations.

The gate valves make it possible to insert or remove from the vacuum system, or work on, any of the test masses or other components of an interferometer without significantly affecting operation of any other interferometer. If there were no gate valves, removal or insertion of a test mass of any one interferometer would entail letting up to atmospheric pressure test masses of all the other interferometers. This would at the very least put all of the interferometers out of operation for the time that the test mass system being worked on was open plus the subsequent pump-down time - which would probably be several hours at the minimum. However the disturbance to the running interferometers might be expected to extend over a time much longer than this, for two main reasons:-

(a) The equilibrium between heating of the mirrors by the laser beams and radiation of the heat by the test masses will be disturbed, giving changes in the shape of the mirrors and in stresses in any joints between mirrors and test masses which may take a long time to recover. This can affect optical mode-matching and alignment, and may possibly also lead to mechanical noise.

(b) Experience with gravity-wave detectors of both the bar and laser interferometer type does suggest that these instruments generally do not exhibit their best performance immediately after pumping out - levels of noise, spurious pulse rates, and drift have appeared to be degraded, sometimes for several days. Precise data on this is not available, partly because it usually takes some time to get the detectors working at their best in any case, but it would not seem surprising for these extremely sensitive pieces of apparatus to require some settling time after exposure of mirrors, test masses, suspension wires, or compliant vibration isolation systems to a relatively large pressure change and to air or some other backfilling gas.

In general, the chances of the operation of sensitive measuring apparatus of this type being degraded by spurious phenomena are reduced if the system is disturbed as little as possible, and time is allowed for steady thermal and other conditions to be re-established after any disturbance.

The practical significance of interruptions depends on how frequently they occur. I think that for the first few years of operation of the system, when a major effort is going into making an early detection of gravity waves and there is a lot of experience to be gained, work requiring access to at least one of the test masses might take place at a rate varying from a few times per week to several times per month. Interruptions of operation of all of the interferometers at these rates would be very undesirable. The rate of interruptions may

fall of after several years - but I would expect it to remain significant indefinitely since new experiments and techniques would be continue to be introduced and developed.

In this connection it may be useful to indicate a possible scenario for work with the interferometers near the start of operation of the facilities.

Possible Scenario near Start of Operation.

The prime aim of the early work will almost certainly be achieving the detection of gravity waves or the setting of useful upper limits as early as possible, and the whole strategy of the early phase is envisaged as designed to do this. A possible program could be as follows:

The first interferometer is put into the facilities as soon as they become accessible, and is then debugged and made operational as rapidly as possible. Although the system will have been pretested in a prototype facility, it can only be expected that some new problems will be encountered on first putting light through this 100-times-longer system. A major effort will go into overcoming or avoiding these problems rapidly; and the interferometer will be run at all practicable times at this stage, with data being collected and analyzed as far as possible even though it may be imperfect and limited. As soon as this first temporary interferometer is working well enough to allow some effort to be switched into upgrading a second copy according to the experience gained, then the second would be installed in another tank and work would go into getting this to run reliably and well. At this stage frequent access to the second interferometer would likely be necessary - perhaps daily at first, then perhaps a few times per week, with perhaps work lasting a day or two at a time on some of the openings. Eventually access times might stretch out to a few per month, but for all this period the possibility of working on one of the instruments while running of the other one continues without disturbance could be very important indeed.

As soon as the second interferometer is working reliably enough for steady use it in turn would go into continuous operation, and then effort would be switched to renovating and upgrading the initial one, or beginning the debugging of a third.

A process similar to this might well continue for several years at least, with a new interferometer being debugged or an old one renovated while existing ones continue to collect data. I would expect opening of one or other of the tanks to occur at least once per week - and possibly more often - for several years, until the technology gets mature. And possibly fairly frequent openings would continue even then.

I would expect a process somewhat similar to that outlined to take place at both the first site to go into operation and at the second, and indeed to be fairly general. I think it is an effective way to maximize chances for earliest possible discovery of signals, while covering as far as practicable the possibility of occurrence of an unexpected supernova or other event very soon after startup of the system - an event which could make the project look bad if all interferometers at one site were out of action at the time. This kind of strategy is only feasible with certainty if we have gated tanks as planned -and I think the small fractional increase in cost incurred over that of the whole project will be well justified by the increased probability of early discovery of gravity waves, as well as by the continued improved efficiency of operation over the whole life of the facilities.

R. Drever. (10/5/88).