

Exhibit IV
Cleaning Qualification Test
LIGO-E970166-00-D

LIGO SEI In-Vacuum Hardware Cleaning Qualification Test LIGO-E970166-00-D

The LIGO Fabrication Process Specification provides a specification for cleaning and baking of the in-vacuum hardware; however, the final processes will need to be developed and qualified. The supplier will be required to work with LIGO in development of such processes, which include fabrication of welded specimens and iterating with such process variables as temperature, wash/rinse duration, detergent spray rate, type of nozzle, and wash/rinse sequence. The final cleaning processes will be qualified by a series of Fourier Transform Infrared (FTIR) and Residual Gas Analysis (RGA) tests.

1. Welded Test Specimens

The specimens used for the development of cleaning processes should be of a small welded construction, capturing all the important design features of the actual optical table, notably blind tapped holes (2"x2" arrays of 1/4-20 UNC-2B, 1/2" depth), enclosed cells, gussets designed with stress relief, and access holes. A typical segment of the BSC optical table, approximately 1'x1' in size, will meet the requirements. The specimens should be made of AL6061-T651 and fabricated in accordance with the LIGO fabrication specifications.

2. Development of Cleaning Process

The initial cleaning tests will concentrate on the wash/rinse portion of the cleaning process. The process variables in the wash/rinse steps include operating temperature and pressure, wash/rinse duration, type of nozzle, and wash/rinse sequence. The LIGO Fabrication Process Specification includes a cleaning specification which delineates a set of process variables for initial consideration. Trials using variations of these variables will be made (in consultation with LIGO staff) to achieve the final cleaning process. A new welded specimen should be used for each cleaning trial; approximately six (6) cleaning trials are planned.

In addition to the process variables mentioned in the Fabrication and Process Specification, the type of nozzle also needs to be considered. The consideration should include spray characteristics (solid stream, full cone, flat spray, or hollow cone), operating pressure, viscosity, temperature, and spray angle and capacity. Depending on the type of surface to be cleaned, the type of nozzle or a combination of different nozzles for sequential cleaning need to be selected. Of particular concern is the type of nozzle to be used for cleaning the blind tapped holes.

After each trial cleaning process, an alcohol solution must be applied to various locations of the specimen and the samples thereof collected for FTIR (Fourier Transform Infra Red) analysis. The precise locations, amount of alcohol and method of application will be developed in conjunction with LIGO staff. The FTIR analysis measures the contaminant level of the cleaned surface, and will be used to establish the acceptance criteria for the production run once the process is qualified. Many chemical labs provide services for FTIR analysis. LIGO will provide names of these labs upon request.

The cleaned specimens identified with records of the cleaning processes that have been performed should be sent to LIGO for final testing. These samples will undergo air baking in an ultra clean oven in accordance with LIGO Fabrication and Process Specification and an RGA (residual gas analysis) test. The RGA test evaluates the outgassing rate of the test specimen, the results of which will determine the acceptability of the cleaning process.

3. Qualification of Baking Oven

The baking oven (filtered air bake oven) of the production hardware will also need to be qualified after the final cleaning process has been defined. Two (2) FTIR tests, before and after baking, of a test specimen cleaned with the qualified process are necessary. The comparison of the results from these tests will indicate the cleanliness of the oven. The baked specimen should be sent to LIGO for the final RGA testing.