ATTACHMENT 5

4. SHOCK, VIBRATION, AND ACOUSTICS ANALYSIS

5. DESIGN GOALS/REQUIREMENTS **V049-2-095** **REV. 0**

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Main Turbomolecular Pump Carts	V049-2-002	4
Auxiliary Turbomolecular Pump Carts	V049-2-003	3
Ion Pumps	V049-2-004	2
112 and 122 cm Gate Valves	V049-2-005	3
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Vacuum Gauges	V049-2-007	0
Bakeout Blanket System	V049-2-009	1
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Clean Air Supplies	V049-2-011	1
LN_2 Dewars	V049-2-013	1
Vacuum Jacketed Piping	V049-2-016	P1
Bellows Expansion Joints	V049-2-017	1
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80K Pump Regeneration Heater	V049-2-056	0
Small Vacuum Valves	V049-2-059	0
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LIGO VACUUM EQUIPMENT
FINAL DESIGN REPORT
CDRL 03
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MEASUREMENT AND ANALYSIS OF LIGO VACUUM SYSTEM SHOCK VIBRATION, AND ACOUSTIC NOISE

(Rev. 1)

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I. INTRODUCTION AND SUMMARY

The LIGO specification places special operational constraints on the functioning of a number of devices that make up the interferometer vacuum system. Consideration has been given to these devices as sources of noise, vibration, and shock and their effect on the sensitivity and alignment of the interferometer. In conjunction with Process Systems International, Inc. a plan was proposed in PSI's proposal of June 19, 1995 to reduce the risks associated with these issues. The plan included selecting the proper equipment, measuring the noise, vibration and shock of the equipment, designing the first order mitigation treatments and analyzing performance with the treatment in place to determine the degree of compliance with the LIGO specification.

At this time there is no equipment available to obtain actual source strengths and the design of the vacuum equipment system is just being finalized. The analysis is therefore preliminary using extrapolated data provided by the turbo pump vendor to estimate the source level. The focus of the analysis is the end station. The end station is the least complicated to model, contains all the sources, and is anticipated to produce the highest levels at the receiver because of the close proximity between source and receiver with a minimum number of discontinuities.

The analysis of the vibration and shock path utilizes three different models to predict the receiver response over the entire frequency range. The first model is a low frequency finite element beam and plate model. This model is extended large distances to capture the primarily low frequency influence of the boundary on the transmission path. In the frequency range where the influence of the boundaries is less important but the response of the path structure still exhibits distinct modal peaks, a mid frequency finite element shell model is used. In the high frequency region where modal overlap is strong a statistical energy analysis is performed.

Results for the turbo pump nearest the beamsplitter indicate that in the low-to mid frequency range where modal peaks are dominate, the predicted levels exceed the LIGO specification by 20-40 dB. The beam tube manifold between this particular turbo pump and the beamsplitter does not have a bellows in contrast to the situation at most of the other locations. It is estimated that such a bellows will reduce the levels by 20-40 dB

except at the very low frequencies.

A transmission path/room acoustics model has been used to estimate the noise level in the end station's vacuum equipment area. This model indicates that 1) noise from the turbo pump will produce a 27 dB excess re: NC-20 in the 500 Hz octave band frequency; 2) noise from equipment in the vacuum support equipment room will cause levels to exceed the NC-20 criteria by 8 to 10 dB. The latter transmission of this noise is due to leakage via the pass door between the two rooms.

Transmission path analyses are scheduled to be completed by the end of May 1996. Included in the analyses will be low and high frequency vibration models and acoustic models of the corner, mid and end stations. The mid frequency vibration analysis will be performed for selected worst case locations in the three stations.

Source measurements for the turbo pump are scheduled for June, the gate valves will be tested in June and July and the ion pump, cryo pump and vent and purge system will be tested in August. The equipment source levels and measured impedances will be input to our transmission models to predict the levels at the various receivers.

II. LIGO SPECIFICATIONS

A. VIBRATION

The LIGO vibration specification (Ref. 1) for the spectral density of the allowable displacement δ on the walls of any vacuum chamber or on the floor within 1 meter of any chamber is shown on Fig. 1a. This spectral density represents the allowable level of a tone having a bandwidth of 1 Hertz at any frequency between 0.1 Hz and 10 kHz. Because acceleration sensors are used more commonly than displacement sensors to measure equipment vibrations, it is useful to recast the displacement specification of Fig. 1a as an acceleration specification by multiplying by ω^2 (where ω is radian frequency) and expressing the result in $\mu g/\sqrt{Hz}$. The resulting acceleration spectral density is shown on Fig. 1b.

B. NOISE

The specified acoustic noise limit from all simultaneously operating vacuum equipment in normal operation at any location within the LIGO vacuum equipment and laser areas is NC-20 (Noise Criterion) (Ref. 2). This noise criterion, shown on Fig. 2 is defined in terms of octave band levels starting at the 63 Hz center frequency band and extending to the 8 kHz band.

C. SHOCK

Valve actuation or other intermittent device operation shall induce no more than 0.01 g peak-to-peak acceleration at any point within 1 meter of any vacuum chamber.

III. APPROACH TO SPECIFICATION COMPLIANCE

A. OVERALL PLAN

A comprehensive plan has been put in place to identify all potential sources of significant areas of noise, vibration, and shock, in the vacuum equipment, to determine the degree of compliance with specifications, to design and evaluate control measures proposed in PSI's proposal, and to test installed vacuum equipment operation in the LIGO facility. The objective is to achieve the lowest possible impact on the gravity wave instrumentation. This plan, which is under way, consists of the following four parts:

1. Vacuum system equipment is evaluated with respect to vendors' stated vibration, noise, and shock performance and the inherent equipment design features that impact these characteristics.

2. Tests will be made on selected operating equipment in a qualified test facility to verify vendor claims and to supplement vendor data with detailed measurements to cover the full range of the LIGO specifications. Because the specified vibration levels are extremely low, low noise instrumentation and specialized equipment mountings will be used to enhance the capability to obtain measurements over the full frequency range specified.

3. Vibration, noise, and shock mitigation requirements as defined by PSI's proposal will be implemented. Constraints imposed by the LIGO facility will be incorporated into the treatment design.

4. Transmission of shock, vibration, and sound from the sources to the vacuum chambers and to the laboratory floor within one meter of any vacuum chamber are analyzed mathematically. Estimated levels with first order treatment in place are compared with LIGO specifications. Regions where compliance with specifications is not achievable are identified for further review and assessment.

B. SOURCES OF EQUIPMENT VIBRATION, NOISE, AND SHOCK

1. Mechanical Roughing Pumps

These first stage roughing pumps are not subject to vibration specifications.

2. Turbomolecular Roughing Pumps

Turbomolecular roughing pumps achieve their pumping capability by multi-stage vanes rotating at high speed (approx. 27,000 RPM). Pump shafts are driven by brushless motors. Shaft bearing designs include ceramic ball and magnetic.

The principal vibration source of these pumps is the unbalance in the rotor which produces a spectrum with a line at the rotational speed and at its odd and even harmonics. Vibrations at the power line frequency, typically around 1 kHz, and its harmonics result from magnetostrictive effects in the stator pole structure. Finally, with non-magnetically levitated bearings, broadband noise, (e.g., due to the interaction of the balls with the lubricant) is generated.

3. Ion Pumps

Ion pumps operate without moving parts. They are energized by high voltage DC from an AC powered controller. Ion pump vibration and noise is primarily associated with the high voltage power supply and controller which incorporate cooling fans and transformers.

4. Cryogenic 80K Pumps

These pumps consist of exposed surfaces refrigerated to a cryogenic temperature upon which gases are condensed. The proposed pumps use liquid nitrogen that boils at atmospheric pressure at a temperature of 80°K. The boiling action of liquid nitrogen involves cavitation (i.e., vapor bubble formation and collapse) which produces broad spectrum pressure pulses that act on vessel and liquid/air surfaces to produce noise and vibrations.

5. Purging and Venting Compressors

Non-reciprocating screw compressors are planned for this purpose and will be located in adjacent Mechanical Equipment Rooms.

6. Gate Valves

Gate valves are subject to the shock specification which limits the peak vibrational amplitude induced by their operation. Primary mechanisms of shock are deceleration and seating. Both electric and pneumatic valve actuators are used for various LIGO locations.

C. VERIFICATION TESTING

1. Test Chambers

The background acoustic and vibration levels of the test areas must be equal to or less than equipment levels being measured. A special acoustically treated chamber has been built at PSI to test the Turbomolecular pump, its backing pump and the ion pump. A prototype beamsplitter is being built to test the short cryopump. The gate valves with actuators and the vent and purge system have higher levels of noise and vibration and will be tested at the vendors' facility.

2. Equipment Mounting

Equipment to be tested will be suspended or supported compliantly to isolate it from the test chamber and allow the measurement quasi-free vibration levels required for

the analysis.

3. Test Instrumentation - Sensors

a. Vibration

When equipment levels are below the measurement capability of general purpose accelerometers, high-sensitivity ultra low-noise accelerometers will be used to define equipment vibration levels. Two such sensors are available to span the full frequency range of the LIGO specifications. The Wilcoxon Research model 731A accelerometer (10V/g, 600 gm) has a useful bandwidth from 0.1-300 Hz. The Wilcoxon Research model 916BTO-1 (7.5 V/g, 700 gm) provides low noise capability above 300 Hz. The equivalent acceleration spectral densities corresponding to the electronic noise floors of these sensors are shown on Fig. 1b. Above 10 Hz, the noise floor of the model 731A is lower than the specified amplitude. Above 300 Hz, the noise floor of the 916BTO-1 is below the specified amplitude. When a measurement equals the sensor's noise floor, the vibrating amplitude of the test device is at least a factor of 3 dB lower than the noise amplitude.

Low noise measurements require limiting the electronic noise that occurs outside the frequency bandwidth of interest by using high-order bandpass filters.

b. Noise

Operating equipment noise will be measured using a Bruel and Kjaer type model 2236 Precision Sound Level Meter octave band analyzer. Acoustic power measurements will be made for use in assessing the overall sound pressure level in the Laser and Vacuum areas of the LIGO facility.

c. Shock

Shock measurements will be performed at the gate valve vendor site using small, lower sensitivity accelerometers such as Bruel and Kjaer model 4384 or 4366.

4. Test Instrumentation Data Analysis and Processing

a. Vibration

Vibration signals will be acquired on a digital recorder and processed to obtain frequency spectra in the form of spectral densities. Acquisition and processing of these signals will be performed using a CAA's computer-based SIGNAL system.

The duration of the signal acquired must be sufficiently long to insure confidence in the measured spectral amplitudes. Signal duration criteria for autospectral density functions are given in Ref. 3. The variance of the estimated autospectral density function ($\hat{G}(f)$) for a band-limited Gaussian noise signal is related to the resolution bandwidth B in Hertz and the total signal duration T in seconds as follows:

$$Var[\hat{G}(f) \approx \frac{G^2(f)}{BT} \qquad (1)$$

where $G(f)$ is the actual autospectral density. Therefore, a time-bandwidth product (BT) of unity yields a variance equal to the actual function. For purposes of estimating test requirements, we select a time-bandwidth product of 10. This yields signal acquisition requirements of 100 seconds for a 0.1 Hz bandwidth and 10 seconds for 1 Hz resolution. During these acquisition times, the equipment would have to be stable in its operation, and the test would have to be free from outside interference.

b. Noise

Acoustic measurements will be made using a Bruel and Kjaer type 2236 precision sound level meter. Noise levels in the octave bands between 63 Hz and 8 kHz will be recorded. This meter has a noise floor corresponding to less than NC-10.

c. Shock

Measurements of shock-induced vibration due to operation of the gate valves will be made by recording the output of accelerometers oriented in three

orthogonal directions and mounted on the gate valve fixture. The signal will be recorded during the entire duration of the closing event, and the peak acceleration amplitude will be obtained.

D. VIBRATION MITIGATION

1. Design Approach

The overall approach to mitigating equipment induced vibration encompasses both the equipment source and the vibration transmission paths to the LIGO test hardware. In the initial review of vendor-supplied information, recommendations were provided for treatments that are easily applied to the equipment. Vibration transmission paths are treated using the approaches described in the following sub-sections.

The equipment vibration measurements will be used to characterize the source levels. The LIGO specification limits the vibration level at the receiver, on the chamber or on the ground within 1 meter of any chamber. To determine the extent of the mitigation required analyses are performed to predict the vibration level at the receiver.

When the source can be effectively isolated, the equipment vibrations characterize the source output. When the path from the equipment to the receiver is not capable of being effectively isolated, it will be necessary to supplement the vibration levels measured on the equipment with estimates or measurements of the structural impedance of the equipment at its attachment. Estimates of vibration transmission will then make use of an equivalent vibration source using Thevenin or Norton equivalent system representations (Ref. 5).

The method of modeling the path between the source and receiver is determined by its complexity and the frequency range of interest. For simple paths analytical models are used. For more complex paths, finite element methods are used at the low-mid frequencies where the modes of vibration are well separated. Statistical energy analysis (SEA) methods are used for the higher frequencies where modal overlap is strong.

Because vibration limits are specified over a broad frequency range (i.e., 5 decades), multiple strategies may be necessary to reduce equipment vibration across the entire range. Structural elements having low stiffness relative to their mating structures provide effective vibration isolation at frequencies below the range where the elements become resonant or wave-bearing structures. Compound equipment mounts obtained by connecting multiple isolator stages in series can be used to enhance vibration isolation effectiveness. Use of compound mounts is primarily limited by space availability.

Above the frequency range where isolators behave as simple compliant elements, vibration energy is transmitted along these elements in the form of propagating structural waves. This mode of energy transmission can be reduced with a combination of "blocking" masses and damping. The concept of blocking masses is to provide an impedance discontinuity along the energy transmission path to reflect propagating waves. Since this approach does not dissipate structural energy, damping treatments are added to the isolator. Damping treatments using viscoelastic materials applied to the external surfaces of the isolator can be designed in the form of both unconstrained and constrained layers.

2. Mitigation for Specific Equipment

a. Main Turbomolecular Pumps

Each of the main turbomolecular pumps is separated from its backing pump. The turbopump is placed on its own cart and separated from the interferometer by a soft bellows. The turbopump/cart is anchored to the floor to prevent the bellows from compressing axially due to the external pressure. High frequency isolators in the form of rubber bushings and washers isolate the turbopump from the cart.

The backing pump, which is a much greater source of vibration than the turbopump, is placed on its own cart and located in the Mechanical Equipment Room. The backing pump cart has its own vibration isolators.

b. Ion Pump Power Supplies

The source of vibration with the ion pumps are the power supplies. For the large ion pumps the power supplies are located in the Mechanical Equipment Room. Vibration isolators will be used if needed. The small ion pumps' power supplies are located in the Vacuum Equipment Room and rest on vibration isolators. The cable will be flexible and incorporate "drip loops" to enhance flexibility.

c. Cryogenic Pumps

The 80K pumps will produce vibrations due to the formation and collapse of bubbles in the liquid nitrogen. An experiment using air and water to simulate the two phase flow of the nitrogen entering the 80K pump showed that the generation of large bubbles via the inlet pipe can be reduced by bringing the stratified flow from the inlet pipe above the liquid reservoir. The incoming liquid flows gently down a chute into the reservoir while the gas escapes without bubbling through the liquid. The bubbles generated from the boiling liquid in the reservoir are smaller and generate higher frequencies. Vibration transmission into the interferometer resulting from this action is reduced by low frequency isolators.

An additional source of vibration from the 80 K pump operation is due to vibration in the supply and return lines. Flex lines are used to attenuate the vibration.

d. Purging and Venting Compressors

The vent and purge system will be skidded and placed inside the Mechanical Equipment Room. The skid is mounted on vibration isolators. The discharge and suction side of the system in the corner station have mufflers or sound attenuators. The mid and end station's systems are not operated during interferometer operation.

e. Equipment Located in Adjacent Mechanical Equipment Rooms

The turbomolecular backing pumps, vent and purge compressor skids, and the ion pump controllers are located in Mechanical Equipment rooms. These rooms are

located adjacent to the vacuum equipment area on separate floor slabs. All lines going from the mechanical room to the vacuum equipment area will have flex connectors.

E. NOISE MITIGATION

1. Design Approach

Noise radiated by operating pumps and electronics can be mitigated by reducing the vibrations of the external structural surfaces of the equipment. Measures to accomplish this include externally applied structural damping treatments. Vibration isolation may also be required as a component of noise control.

2. Implementation

A computer model of the vacuum equipment areas is utilized to predict the combined noise levels in the specified NC contour octave bands from 63 Hz to 8 kHz from the various vacuum pumps and auxiliary equipment located in these areas. The input to this model is the acoustic power measurements performed on the operating equipment. Any remotely located equipment that could contribute to the noise via transmission through walls, doors, ductwork, and other flanking paths is also included. The model includes the sound absorption and scattering effects of major equipment such as chambers, beam tubes, large diameter piping, and other large objects, as well as the sound absorbing properties of the room boundaries. Equipment identified by the model as exceeding the NC-20 noise specification will be evaluated for 2nd order noise reduction treatment (if authorized by LIGO).

Noise measurements on representative vacuum system components will be made either at PSI, a vendor's facility, if suitable, or at a commercial acoustical laboratory. Measurements will include octave or third octave band over the NC frequency range. Depending on the test facility, either sound pressure at a given distance and at various positions around the source or sound power will be measured. From this data and the room model discussed above an initial prediction of total noise at various locations in

the Laser and Vacuum area will be made.

Specific noise control second order options for the vacuum system components are indicated below (note these options are not included in the current contract).

a. Main Turbomolecular Pumps

If necessary the pump and motor housing will be shrouded with loaded vinyl sheet laminated to open cell foam. Damping treatments, discussed above, can also be used to reduce sound radiation from support structures.

b. Cryogenic 80K Pumps

The magnitude of acoustic noise emissions of the boiling nitrogen inside the shroud needs to be measured. It is anticipated that the insulating vessel required for the shroud may be sufficient to preclude the need for further noise reduction.

c. Equipment Located in Adjacent Mechanical Equipment Rooms

The turbomolecular backing pumps, vent and purge compressor skids, and the ion pump controllers are located in Mechanical Equipment rooms. These units can take advantage of the noise control provisions required to adequately isolate auxiliary equipment (e.g., fans, chillers, pumps) located in these rooms from the vacuum equipment areas. Airborne noise isolation required for mechanical equipment to achieve the project noise goal in the vacuum equipment areas through walls, doors, windows, ducts, and roof/ceiling design is assumed to be adequate for isolation of the vacuum equipment to be located in the Mechanical Equipment rooms as well. If authorized by LIGO, supplementary noise control treatments, recommendations of the vacuum equipment can be provided should the noise isolation in the Mechanical Rooms be found to be inadequate for meeting the project noise goals in the vacuum equipment areas.

F. SHOCK MITIGATION

The gate valves are located in close proximity to the chambers. With the exception of adding a short flexible bellows, blocking the shock path is not an option. In this regard

therefore we have required the valve manufacture to reduce the shock at the source. The valves will be compliantly supported from below to isolate them from the facility floor.

IV. SOURCE MEASUREMENTS

At this time there is no equipment available to obtain source measurements. The turbomolecular pump vendor provided vibration data for a similar pump. This will be used to estimate vibration levels at the end station. The vibration levels used for the analysis is shown in Figure 3. For the acoustic analysis, estimates of sound levels were obtain by either measurements on similar equipment at vendors facility or from experience.

V. TRANSMISSION ANALYSIS

A. VIBRATION

The modeling of the transmission path between the source and receiver is divided into three frequency regions, low, mid and high. In the low frequency or large structural wavelengths region the vacuum equipment and connecting manifolds are model with beam finite elements, the foundation slab is represented by plate elements and lossy springs represents the soil. The model can be extended large distances and captures the primarily low frequency influence of the boundary on the transmission path.

The transition from the low to mid frequency region begins when the structural behavior is no longer compact and circumferential shell modes exist in the equipment or the manifold. In the mid frequency region the transmission path is modeled with axisymmetric finite elements. The model assumes the structure is symmetric but applied loads, boundary conditions and displacements need not be axisymmetric. The mid frequency model is limited by size of the model and the influence of the boundaries where the model is artificially terminated. Typically boundaries become less important with increasing frequency. By varying the boundary conditions, the impact of the

boundary is determine in the analysis.

The limitation of CAA's computer and the Nastran finite element program determines upper frequency limit of the mid range. Above this frequency statistical energy analysis is performed. With this technique the structure is divided into subsystems and the power flow between subsystems is calculated based on coupling loss factors.

Transmission path models of the vacuum system are currently being developed. The following sections describe preliminary models and results for the vacuum equipment in the end station (Figure 4).

1. Low Frequency Model

A Nastran [6] finite element beam representation of the equipment is plotted in Figure 5. Beam cross sectional properties are calculate for all the equipment and their supports. Stiffeners, flanges and non-structural parts are modeled as mass. The 30" concrete floor is model with plate elements and the soil is model as lossy springs. The soil properties were obtain from Parsons report [7].

The upper frequency limit of this model is approximately 50 Hz. Above this frequency circumferential shell modes occur. Below this frequency the body of equipment and the manifolds behave as a rigid mass on the flexibility of the supports and bellows.

Unit forces in each of three directions are applied at the two turbo pump locations, the floor below the turbo cart and at the cryopump. Observation locations were with 1 meter of the beamsplitter on both the manifold and the concrete slab. Large transmission losses are observed across the bellows and via the concrete slab path.

Estimates for source levels are available for only the turbomolecular pump (see Figure 3). Norton theorem is used to convert the acceleration levels to forces. The pump is connected to the manifold tube by a soft bellows. The bellows axial spring rate (60 lb/in) is much less than the stiffness of the pump. The pump then can be consider a pure

velocity source and a force across the spring into the manifold can be computed. Results are listed in section 4.

2. Mid Frequency Model

The purpose of this section is to describe the finite element analysis that we performed to study the mid-frequency behavior of a portion of the end-station structure adjacent to the beam-splitter. Figure 4 is a sketch of the portion of the LIGO vacuum equipment that we refer to as the end-station structure. We developed a finite element model of a portion of end-station structure, indicated in Figure 6, for a preliminary study of the vibration levels produced near the beam splitter due to mid-frequency vibrations from the turbopump. The Nastran computer plot of the model is shown in Figure 7.

The mid-frequency model consists of Nastran axisymmetric conical shell and trapezoidal solid elements. These Nastran elements can only in themselves model axisymmetric structures; however, the applied loads and displacements need not be axisymmetric, as the element formulations use a Fourier expansion about the azimuthal coordinate [6]. The conical shell element, used primarily to model the thin shell/plating that predominates the structure, includes both membrane and bending flexibility (with the possible inclusion of transverse shear flexibility). The non-axisymmetric features of the structure, such as the ion pump and supports, are not modeled in this stage in the analysis, but it would be a straightforward task in the future to model some of these features via concentrated loads simulating lumped impedances, such as simple inertia or compliance. The attachment of the manifold tube to the beam splitter is modeled at this time as a fixed boundary condition. Future models would possibly include other boundary conditions at the beam splitter end or the use of a terminating structure simulating the impedance seen by the manifold tube at the splitter. The bellows, on the other end of the structure, is modeled with conical shell elements fixed at the far end with properties assigned to give an effective axial stiffness of 6514 lb/in (specified by bellows manufacturer) and a

negligible bending stiffness.

The vibration of the turbo-pump was simulated by point loads in the radial, axial, circumferential direction applied at the center point of the location of the turbo-pump. The Nastran direct frequency formulation was used for these calculations. The analysis was performed to 500 Hz. Higher frequencies will be computed in the future.

We obtained the radial, axial and tangential components of the acceleration response of the model at various azimuthal locations and axial locations within 1 meter of the splitter end. We examined these results and present those that appear to represent the "worst" cases of vibration transmission in Section 4.

3. High Frequency Model

a. Introduction

In this section we present a high frequency analysis of structureborne noise propagation along an end section structure from a gate valve to the beam splitter. For the thin shell and plated box-like structures along this path the predominant high frequency wave motion tends to be flexural. By high frequency we mean frequencies at which the flexural wavelengths are small relative to the structural scales, such as the lengths and diameters of the tubular sections. For thin steel plating the flexural wavelength is given by

$$\lambda_f = 2\pi/k_f = 6x10^2\sqrt{h(in.)/f(Hz.)} \qquad (2)$$

where h is the plating thickness and f is frequency. To illustrate, with 1/4 in. plating at 1 kHz., $\lambda_f \approx 12.$ in. Structureborne noise levels will attenuate as they propagate from a noise source to a receiver. The overall attenuation is the result of both a spreading of the vibration energy and its dissipation, that is conversion to heat. Along two dimensional plated structures the spreading is cylindrical with acceleration levels decreasing as $r^{-1/2}$

where r is the distance (range) along the plating from source to receiver. Dissipation associated with flexural wave propagation is conveniently expressed in terms of a structural loss factor η. Here the associated attenuation is of the form $\exp(k_f r\eta/4)\ \exp(\pi\eta r/2\lambda_f)$. Dissipation may also be associated with parallel propagation paths that do not measurably couple to the receiver. For example for the problem of interest, the vibrational energy transmitted to the concrete slabs and in turn the ground via the manifold tube supports is believed to fall into this category.

Statistical energy analysis (SEA) is an analytical formulation that captures the phenomena described above and allows one to estimate absolute levels at receiver locations, e.g., the beam splitter, in terms of the noise source strength (input power). The technique is briefly outlined below and applied to the end station in the following section.

b. Statistical Energy Analysis (SEA) Concepts

With this technique the structure to be analyzed is divided into subsystems each "large" in terms of the characteristic wavelengths. For each subsystem "j" a steady state power balance is imposed

$$\Pi_j^i \quad \Pi_j^d \quad \sum \Pi_{j,k}^c \tag{3}$$

where Π_j^i is power input to the subsystem, Π_j^d is the power it dissipates and $\Pi_{j,k}^c$ the power "lost" to neighboring subsystems. A fundamental SEA concept is that the above dissipated and "coupled" powers are proportional to the space-averaged stored energy of the subsystem, <E>. Specifically [8],

$$\Pi_j^d \quad \omega\eta_j \langle E_j \rangle \tag{4}$$

and

$$\Pi^c_{j,k} = \omega[\eta_{j,k}<E_j> - \eta_{k,j}<E_k>] \quad (5)$$

here ω $2\pi f$ and η_j and $\eta_{j,k}$ are defined as dissipation and coupling loss factors. For structureborne noise

$$<\ddot{w}_j> = \omega^2<E_j>/M_j \quad (6)$$

where $<\ddot{w}_j>$ is the subsystem space-averaged squared acceleration and M_j the subsystem mass. The analysis is executed by defining the appropriate subsystems, using Eq. 2 to formulate a set of simultaneous equations in the unknown stored energies, obtaining the required loss factors [9], defining the source strength(s) solving the equations and finally using Eq. 5 to obtain the desired response. This is described below for the end section structure pictured in Fig 8.

c. SEA Model of LIGO End Section Structure

The section being analyzed is shown in Fig 8. There are twelve subsystems in our SEA representation, each a uniform section of the tubular manifold. Power is coupled among them across structural discontinuities of various types, viz., stiffening ribs modeled by their inertia, bellows characterized by their compliance, and section radius changes. Power may also be transmitted through the supports and lost to the floor slab. In addition it propagates beyond the modeled sections where it is "lost" to the beam splitter on one end and the continuation of the manifold on the other.

As is common practice with this approach, we obtain the required coupling loss factor expressions from the analytical solutions to highly idealized, so called "canonical", problems. For coupling from one manifold section (i) to another (j) we take all such problems to be one-dimensional with a loss factor of the form $\omega\eta_{i,j}$ $\Pi^c{}_{i,j}/M_i<v_i^2>$

where $\langle v_i^2 \rangle$ is the mean squared velocity of subsystem i. Also manifold curvature is ignored, thus limiting the validity of the analyses to frequencies above the ring frequency ($\Omega \quad \omega a/c \quad 1$) of the smallest diameter (44 in.) manifold section, roughly 1.4 kHz.

For coupling across a bellows the coupling loss factor is obtained from the model sketched in Fig 9a. Coupling is through shear forces inducing flexural vibrations. Assuming a high performance bellows and in turn "weak" coupling the result is

$$\omega \eta_{i,j} = 2(k_{bel}/\omega)^2 Re[Y_j]/m_i \qquad (7)$$

where k_{bel} $K_{bel}/2\pi a_i$ and m_i $M_i/2\pi a_i$ are respectively the spring constant of the bellows and the total mass of subsystem i both per unit distance around the circumference. $Y_j \quad (Z_j)^{-1} \quad [(1\ i)\omega(\rho h/k_f)_j/2]^{-1}$ is the admittance of the subsystem j plating taken to be semi-infinite in extent with k_f $\gamma\sqrt{3.46\omega/ch}$ the flexural wavenumber in the plating, c is the material sound speed and h the plating thickness [10]. The factor γ $[1 \quad \Omega^{-2}]^{1/4}$ is introduced to account for the stiffening of a tube owing to its curvature as the frequency approaches its ring frequency from above [11].

Coupling across a rib or a flange at a section radius change, modeled via their mass per circumferential distance (m_{rib}), is analyzed similarly as shown in Fig 9b. Here the coupling loss factor is given by

$$\omega \eta_{i,j} = |Z_i Z_j / Z_{rib}|^2 Re[Y_j]/m_i \qquad (8)$$

with $Z_{rib} \quad i\omega m_{rib}$ and again we have assumed a strong discontinuity and hence weak coupling.

Finally, in Fig 9c we sketch the model for estimating the coupling loss factor from manifold plating into the floor slab via a support. The plating and slab are modeled as

effectively infinite plates and the (point) support is massless and rigid. The plating discontinuity provided by the support nulls the motion at the interface and in so doing generates a force that is transmitted to the slab where the energy dissipates. Here the coupling loss factor becomes

$$\omega \eta_{i,slab} = 2(Z_{pltg}/M_i)(Z_{pltg}/Z_{slab}) \qquad (9)$$

where Z_{pltg} $(4/\sqrt{3}(\rho c h^2)_i$ is the drive point impedance of the manifold plating assumed to be of infinite extent [12] and Z_{pltg}/Z_{slab} $(\rho c h^2)_i/(\rho c h^2)_{slab}$«1. is the ratio of plating to slab point impedances.

For this preliminary evaluation, 1. we let η_d 0.04 for all subsystems typical of fabricated structures, and 2. the parallel path through the concrete slab is ignored. Our excitation source is the turbomolecular pump located in subsystem 5. The input power is taken to be that for a compact radial force, $F_{TP(5)}$, driving the tube plating as if of infinite extent, P_i $F^2_{TP(5)}/Z_{pltg}$.

In the following section results are presented for the mean squared accelerations in the driven section (5) and downstream in Section 1, closest to the beam-splitter.

4. Results

In the implementation of all three models a force is applied to the turbomolecular pump's connection to the manifold tube in the radial direction. The drive point accelerance at this location, or the averaged drive compartment accelerance in the high frequency range, is plotted in Figure 10. The data from the three models collapse at the drive point. The transfer function accelerance from the drive point to locations within one meter of the beamsplitter is plotted in Figure 11. In the low to mid frequency range there is a 10-20 dB reduction from the drive point location. In the high frequency range the discontinuities in the system, as modeled, produce much greater reductions.

The turbo pump source levels shown in Figure 3 have been applied to the models

and the estimated accelerations near the beamsplitter computed. These levels are compared to the LIGO specification levels in Figure 12. In the low- to mid-frequency range where the source levels can only be roughly approximated from the available information, the predicted levels exceed the LIGO specification by 20-40 dB.

B. NOISE

1. Acoustical Modelling for Airborne Noise in LVEA's Overview

The purpose of the acoustical models is to predict the noise level at specific receptor locations in the various Laser Vacuum Equipment Areas of the LIGO End Station at the Washington Site generated by vacuum pumps and auxiliary equipment provided to LIGO by PSI to which the project specified operational noise criterion spectrum of NC-20 applies. Noise from other ventilation and other machinery or personnel is not included in this acoustical analysis.

The elements incorporated in the model include the following:

Noise Sources - sound power [or equivalent sound pressure and distance] in octave bands from 31.5 to 8 kHz center frequencies.

Room Acoustics of Vacuum Support Equipment Rooms [VSER] - The End Station has a room dedicated to vacuum pump support equipment.

Noise Reduction of Envelope of VSER - partition, door, and other components of VSER's contributing to airborne sound transmission to the LVEA..

Room Acoustics of LVEA - acoustical treatment of ceiling and sound absorption of other surfaces; effect of scattering by large equipment; distances between sources and receptors.

These model elements are handled by spreadsheet computer programs [Lotus 123] customized for this project. Source noise outputs are based on either manufacturers' data, measurements performed by CAA / PSI as described in the statement of work, or estimates based on information in our files of the closest equivalent equipment where information is

not available at the time of the initial computations.

2. Equipment Included in the Acoustic Models

As previously stated, the sources included in the acoustical models are vacuum pumps and auxiliary equipment manufactured or procured by PSI for the LIGO project to which the project specified operational noise criterion spectrum of NC-20 applies. In Corner Stations a segment of the LIGO system may be in operation while another is sealed off temporarily from the operational segment for repairs or modifications. In such situations the Vent and Purge Equipment would be in operation and it's noise sources must be included in determining the acoustic levels at critical operational vacuum components. segments.

It is assumed, initially for lack of complete noise level information, that the Small Ion Pump Controllers produce no significant noise; that the Cryopump produces a noise spectrum that matches the ambient noise level, and that the Vent and Purge Compressor noise equals that of a specific Siemens Side Channel Compressor [2CH4] having a capacity similar to that of the compressor in the selected system. For the Large Ion Pump Controller a haystack spectrum of modest level similar to typical fan cooled electronic equipment is used. The TMP is assumed to be operating, however, the calculation can be repeated without its contribution, to model the more typical condition.

3. Room Acoustical Models

a. Model of vacuum support equipment rooms

The acoustical model of these equipment spaces assume that there is no special sound absorbing treatment installed and that all room surfaces have very low sound absorption coefficients over the frequency range of the model [31.5 Hz to 8 kHz, octave band center frequencies]. However, due to the closely spaced array of equipment there is considerable diffusion and multiple reflection of sound waves resulting in an effective sound absorption coefficient for the nominal room boundary surfaces, i.e., floor, ceiling/roof, and walls, that is typically found to be higher than that for surface. The model uses absorption coefficients that lie between 10 and 20%,

varying with frequency. If a particular machine or the dominant noise source of a machine is close to a wall there is no reduction due to room reverberation and, in fact, a small enhancement of the sound pressure on such a surface may occur.

Basically, the sound power of each source is reduced by the effective absorption characteristic of the equipment room, taking note of any non-qualifying machine locations. It is further reduced by the combined sound transmission loss of the room envelope components in common with the receiving space, the LVEA. The resulting sound pressure is assumed to radiate from the envelope into the LVEA with an equivalent acoustic power in proportion to the associated radiating area.

b. Model of end station laser vacuum equipment areas

The most critical receiver locations in the LVEA's are Beam Splitter Chamber vessels and beam tubes or beam manifolds which intercept the airborne sound and transmit them [as structureborne sound or vibrations] to nearby sensitive optical components in the LIGO system. The sound sources include the envelope elements of the VSER as well as equipment located directly in the LVEA, including Small Ion Pump Controllers, 80K Cryopumps.

The acoustical nature of the larger LVEA's, especially the Corner Stations, have larger volumes which contribute to longer reverberation times, however, this undesirable effect is largely cancelled out by the sound absorbing ceilings which have relatively high absorption coefficients [averaging around 60%].

Acoustic levels from sources that are *not* directly adjacent to the sensitive receptors will decrease substantially with distance, primarily because of the absorptive ceiling but also because the large vacuum equipment will provide the scattering and multiple reflection effects described above for the VSER's. The room corrections in each octave band and for each source - receiver pair incorporate both the distance and sound absorption factors as well as small adjustments, as appropriate, based on experience.

4. Sound Transmission Calculations

The primary paths of sound transmission *from* VSER to the LVEA are the common partition and the single access door. Their construction, e.g., thickness and type of material, e.g. gypsum wall board [GWB] determines the transmission loss versus frequency obtained through laboratory measurements of specific partitions. Using information on these partitions obtained from the Ralph M. Parsons Co., the facility designer, we can determine the needed information even if the exact construction does not precisely duplicate any of the tested partitions using our prior job files and a large quantity of published information on this subject. For the door, a standard office door that is fully gasketed is assumed and, as will be seen, a special acoustically rated door may be desirable for meeting the noise criterion.

5. Results of Initial Calculations

The results of the noise analysis for end station is shown in Figure 13. The calculations indicate that 1) the TMP cart creates sound levels at the vacuum vessel or beam tube which it is servicing that exceed the noise criterion by as much as 27 dB [in the 500 Hz Octave Band] and 2) that noise from support equipment in the VSER exceeds the criterion by 8 to 10 dB in most octave bands. The latter transmission is, however, dominated by leakage via the pass door between the VSER and the LVEA.

VI. LIGO COMMISSION TESTING

During the commissioning process of the installations in Hanford, WA and Livingston, LA, measurements of vibration and noise generated by vacuum system equipment will be conducted. Vibration measurements will be made on one each of the following chambers: horizontal access module; beam splitter module (WA site only). At each chamber, normal vibration (i.e., single axis) measurements will be made at one location on the floor within 1 meter of the chamber. Tri-axis measurements will be made at two locations on each chamber. Measurements will be made with and without operating auxiliary equipment for the purpose of establishing ambient levels.

Additionally, sound pressure levels will be measured in the vicinity of each chamber with all vacuum system components in normal operation.

Shock measurements will be made on representative chambers during the operation of the gate valves. For the baseline tests, the beam-splitter chamber located at the vertex will be instrumented for tri-axis shock measurements during the operation of the 35 and 15 cm gate valves on the chamber and of the nearby 122 cm gate valve. Tri-axis shock measurements will also be made on the following: (1) one mid or end station chamber during the operation of a nearby 112 cm gate valve.

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4 Summary of Concepts and Reference Design for LIGO, Cal. Instit. of Tech, February 1992.

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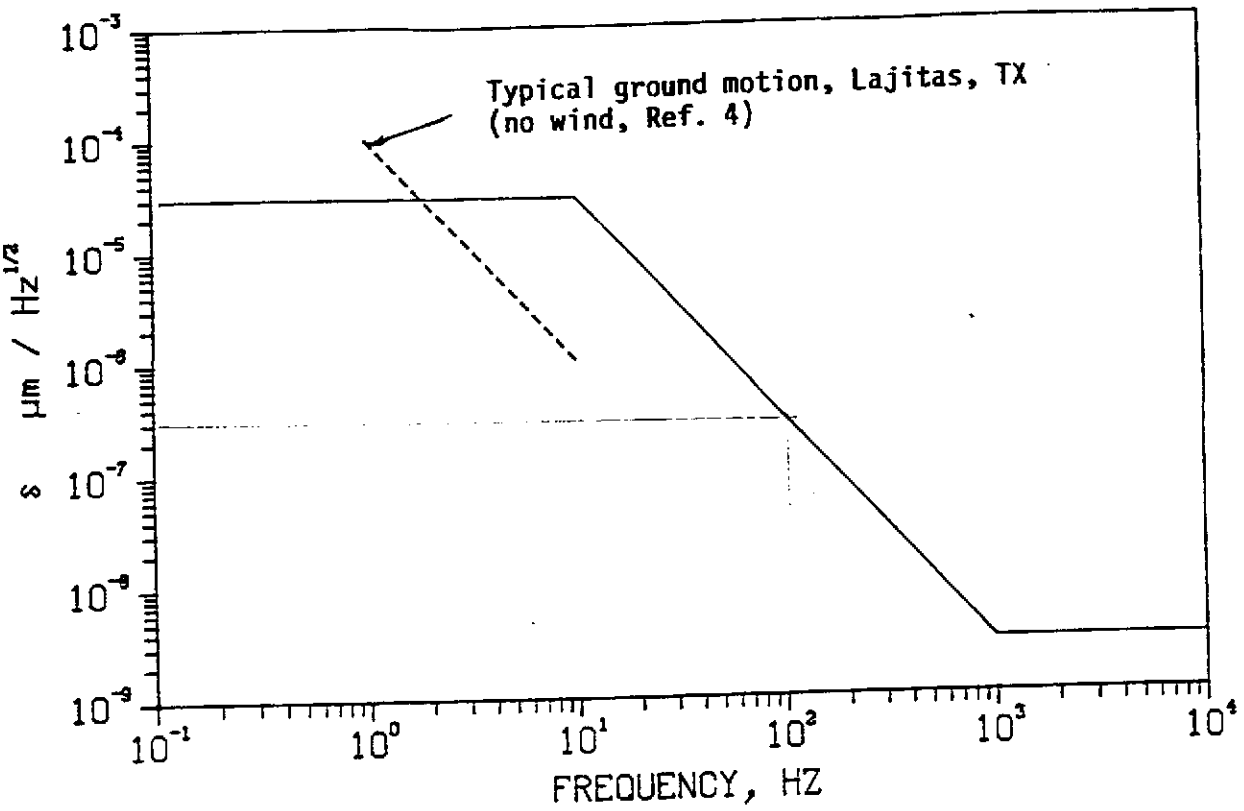
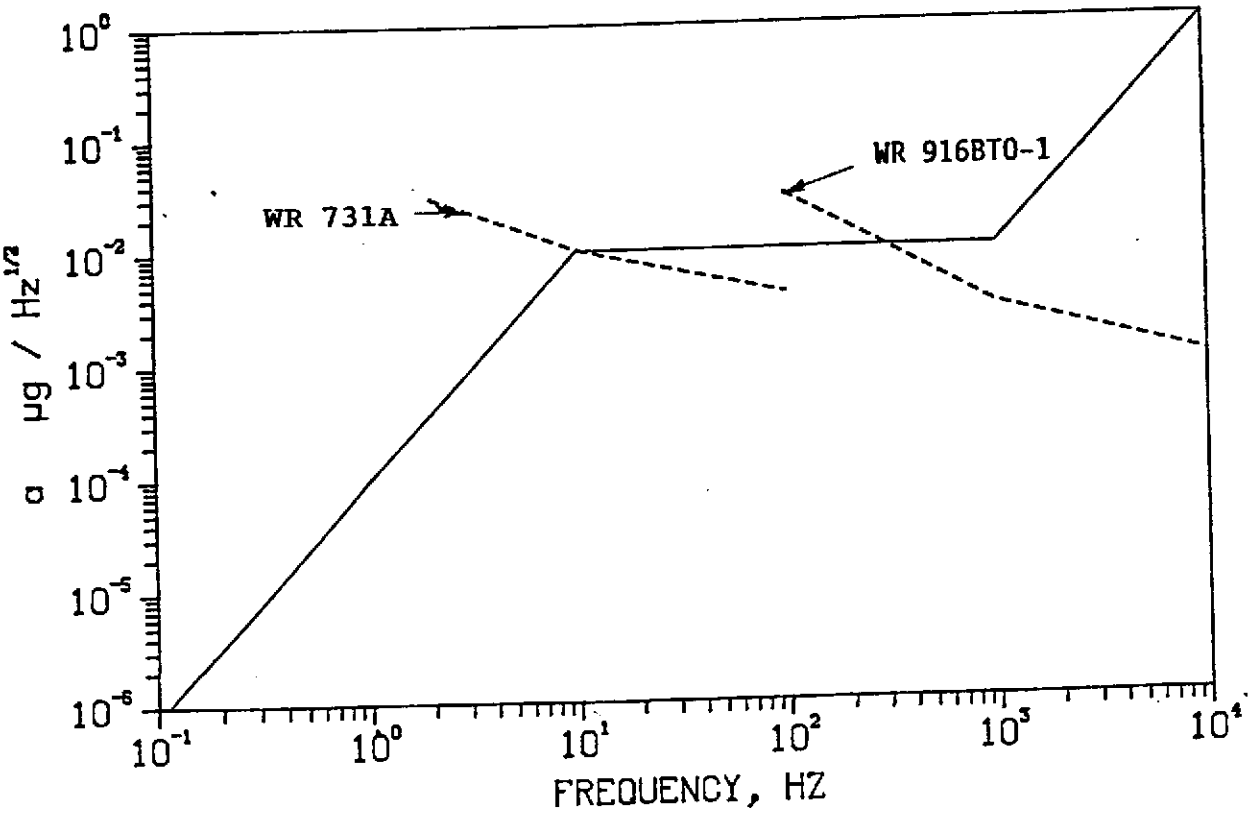
11. Miguel C. Junger and David Feit, Sound, Structures and their Interaction, The MIT Press, Cambridge, MA 1986, Ch 7.

12. ibid, Eq 7.80c with $n \nu 0$.



(a) Displacement



(b) Acceleration

Fig. 1 - LIGO Displacement and (equivalent) acceleration specifications

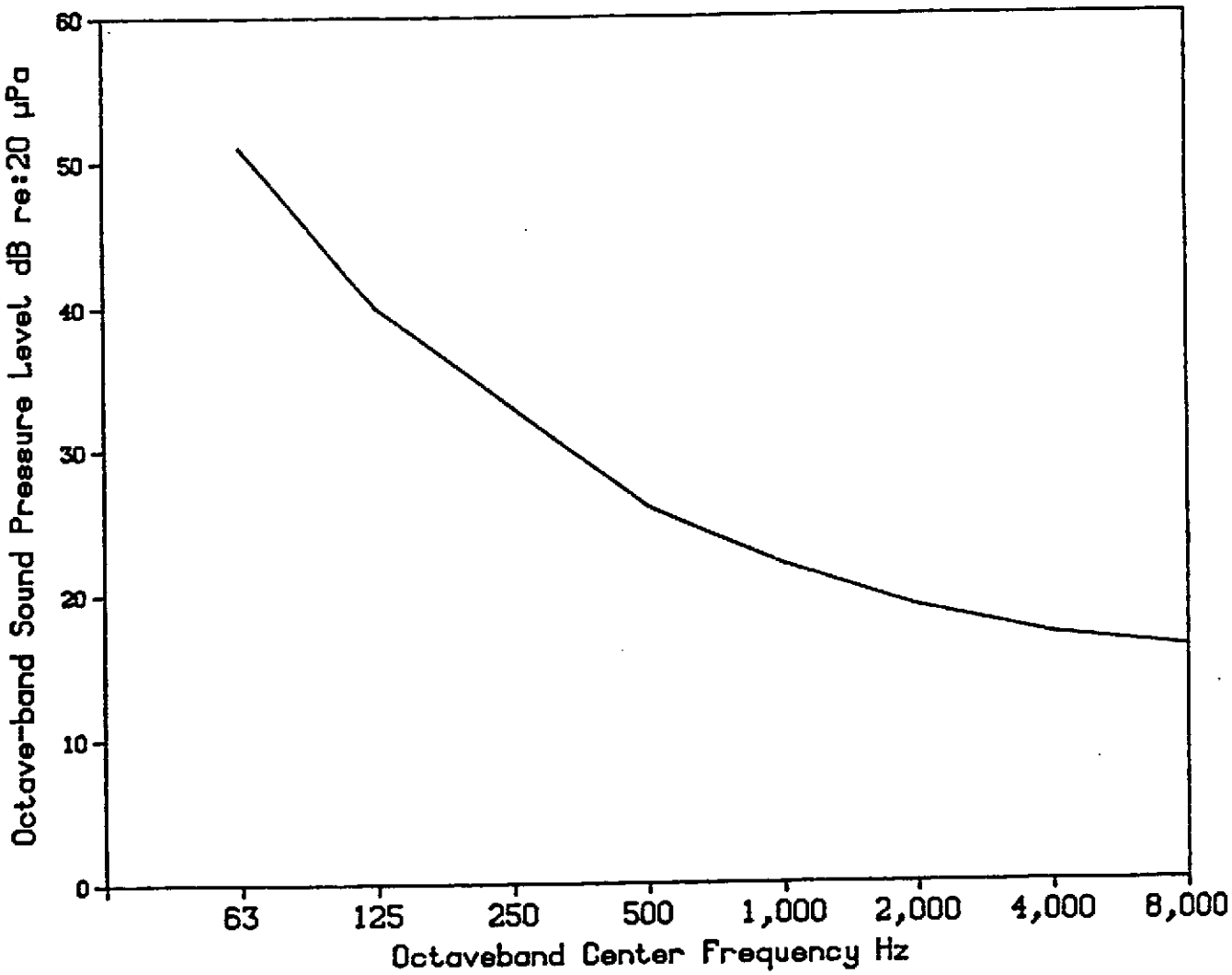


Fig. 2 Noise criterion-20 (NC-20) octave band sound pressure levels.

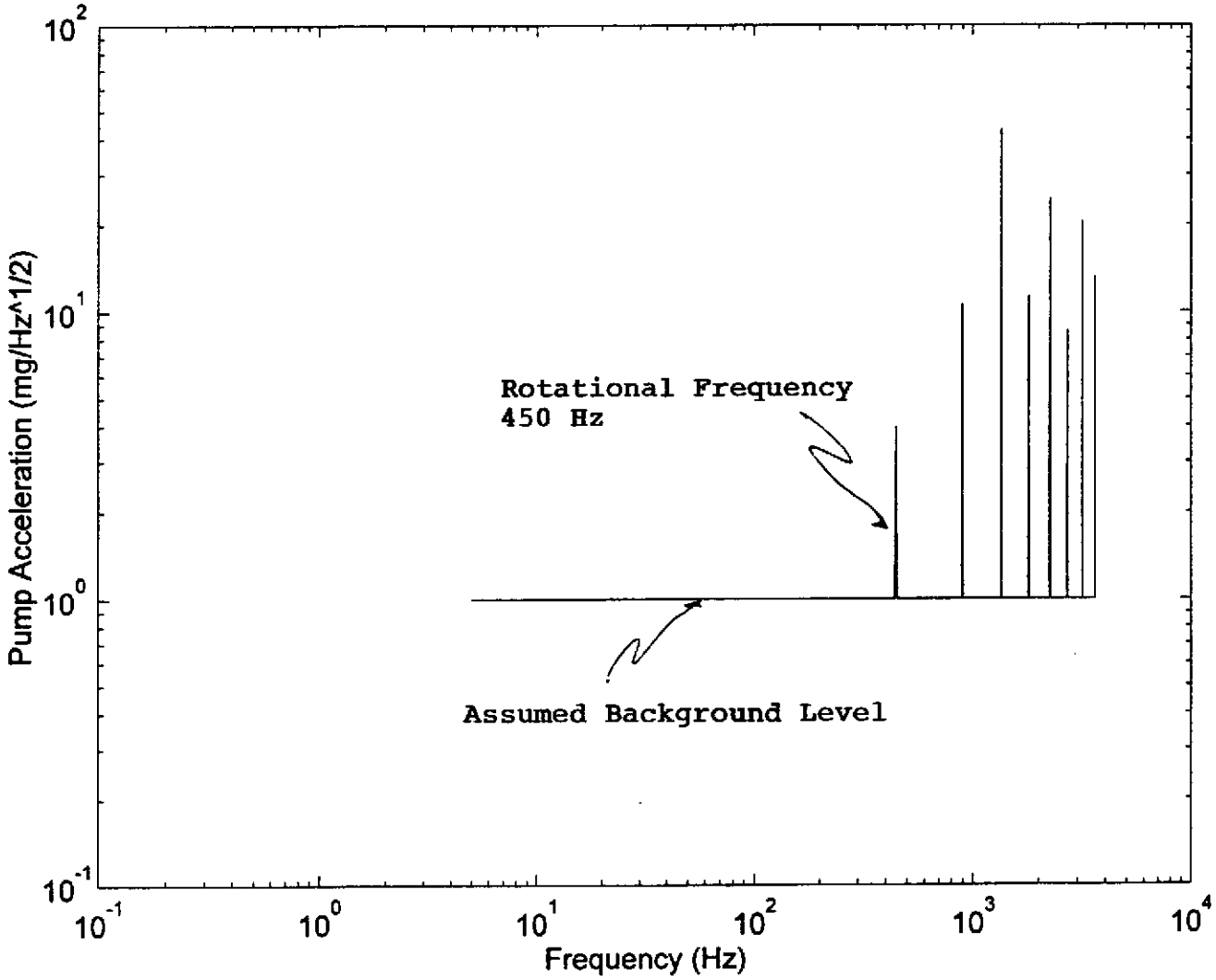


Fig. 3 Estimated source level of turbomolecular pump.

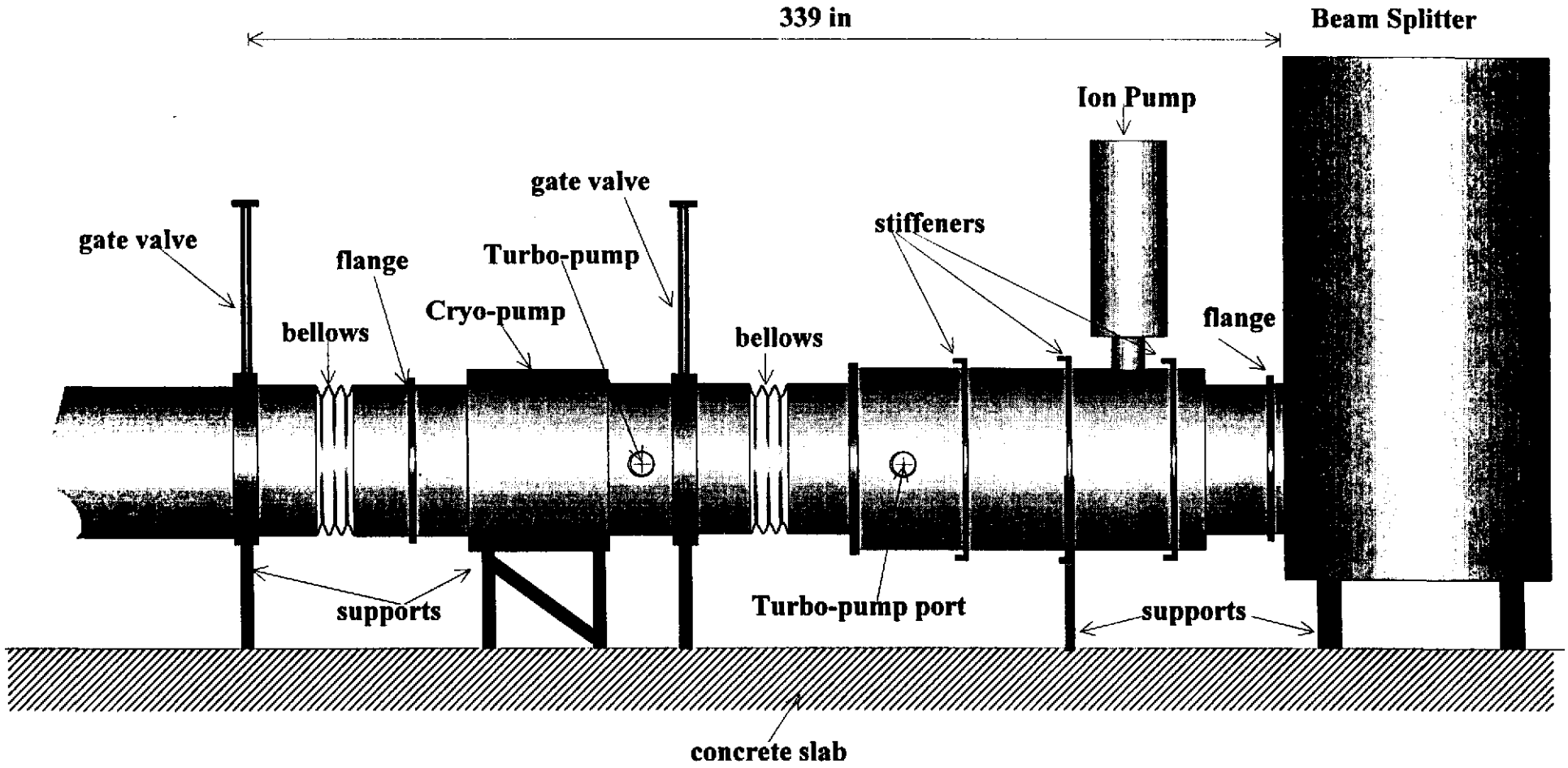


Fig. 4 Sketch of end station vacuum equipment.

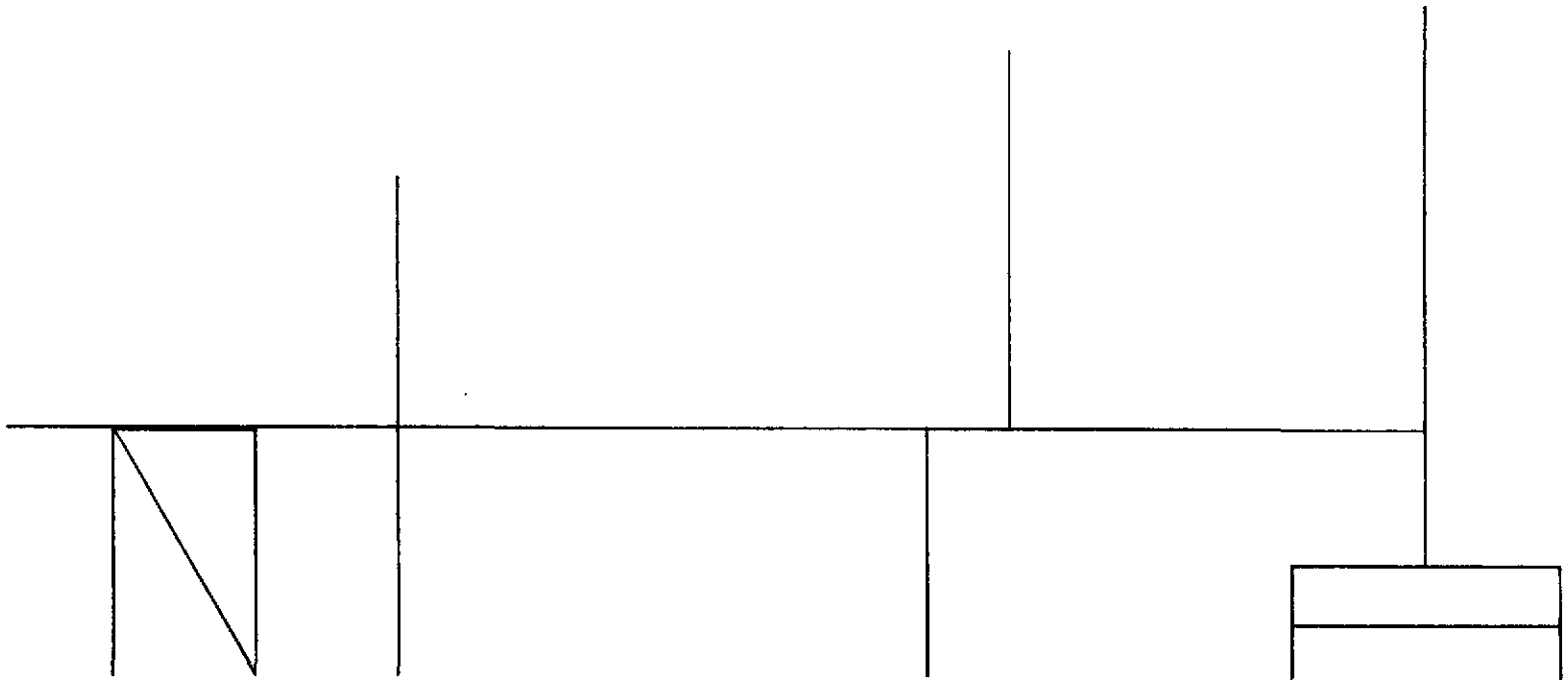


Fig. 5 Nastran plot of low frequency beam model.

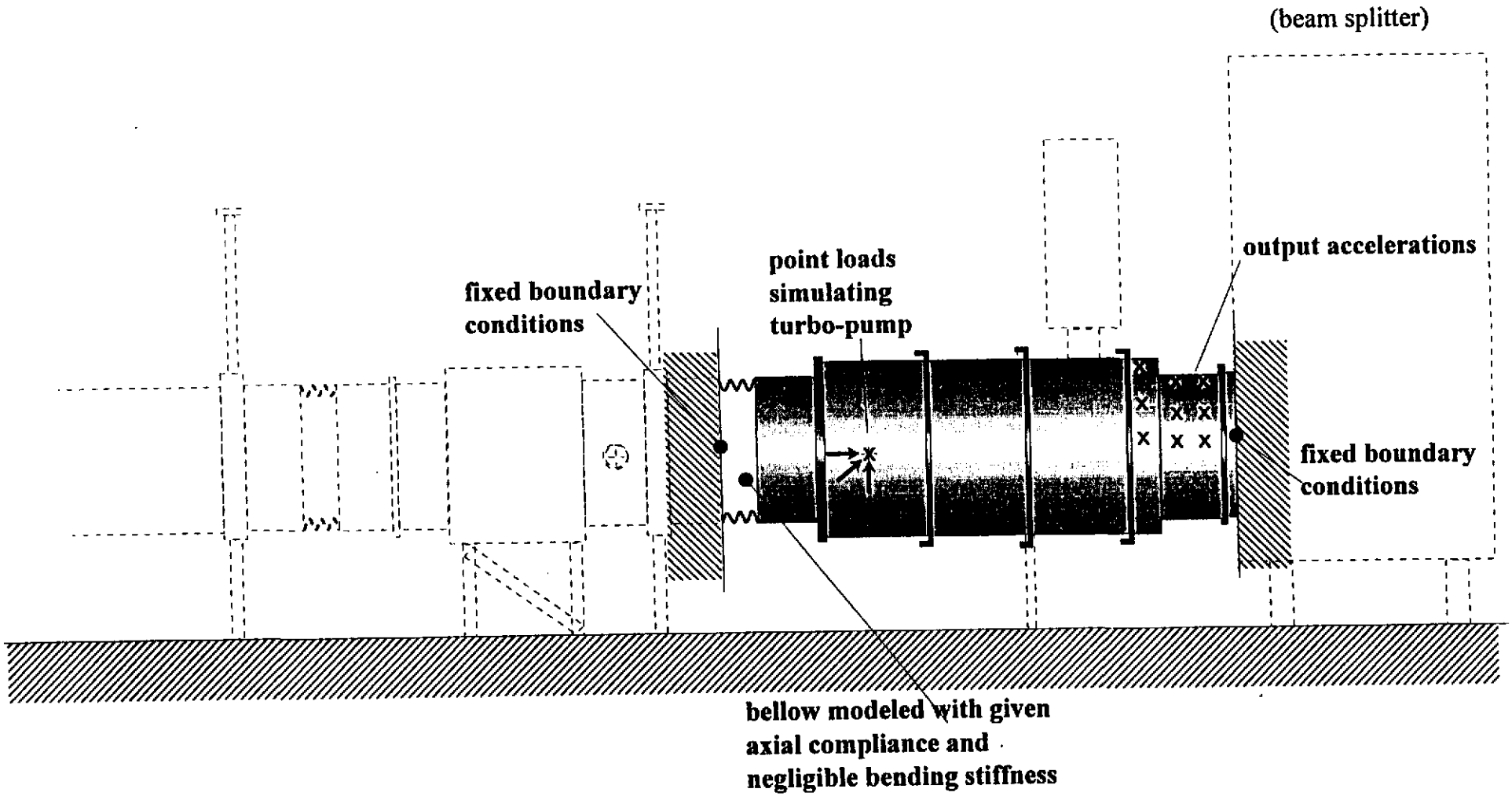


Fig. 6 Portion of end station included in midfrequency model.

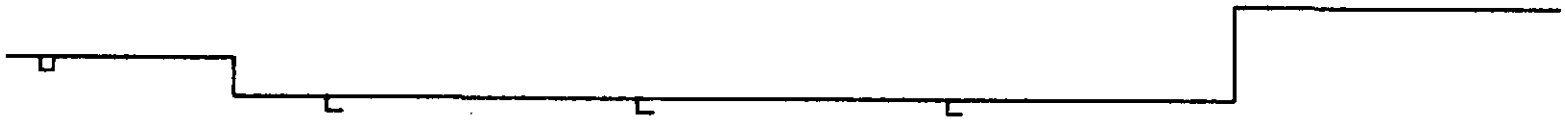


Fig. 7 Nastran plot of midfrquency axisymmetric model.

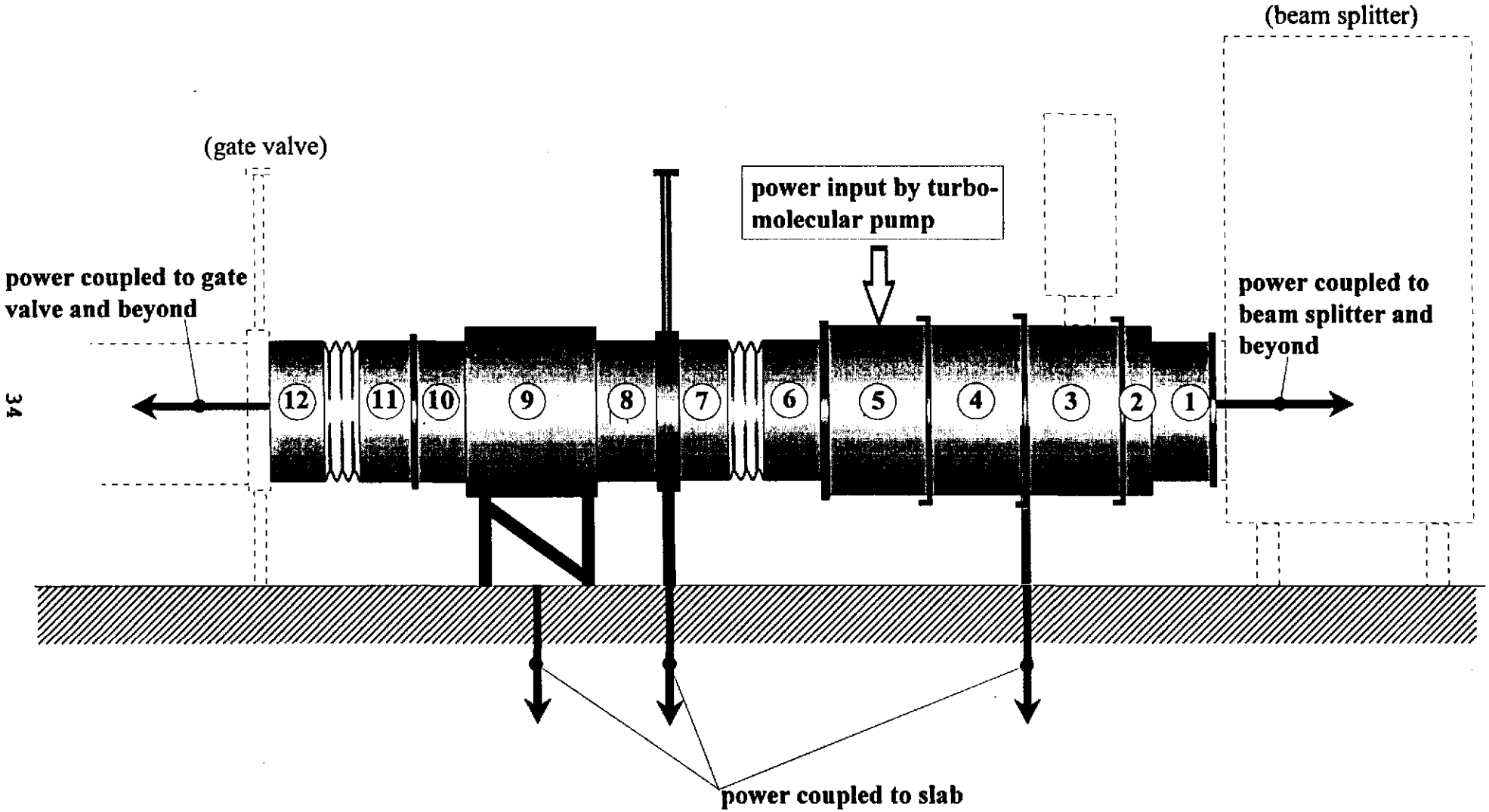
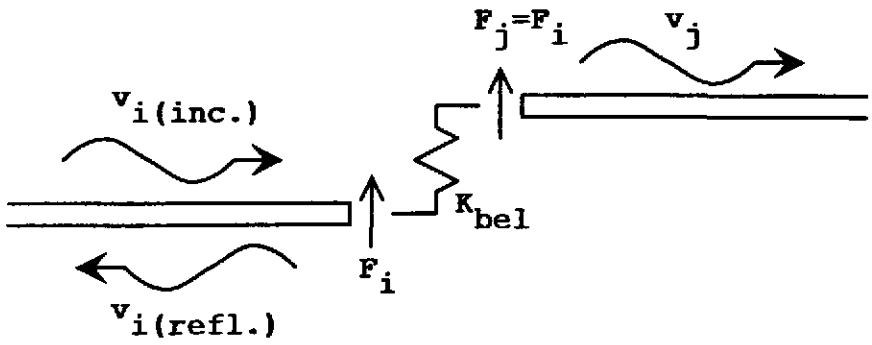
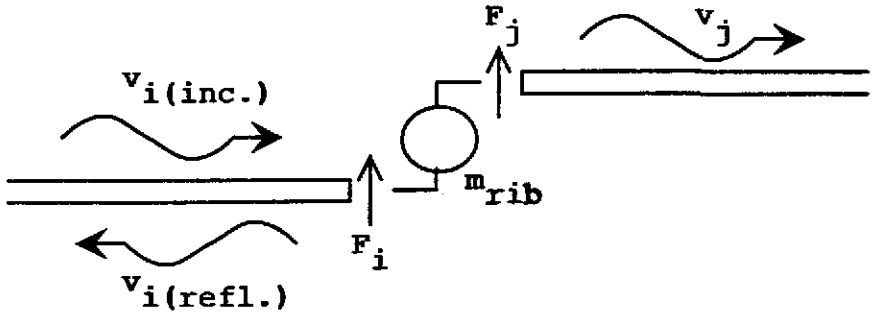


Fig. 8 SEA subsystem representation of end section structure.

a Subsystem Coupling Through Bellows



b Subsystem Coupling Across a Rib or Radius Change Flange



c Subsystem Coupling Through a Support to The Floor Slab

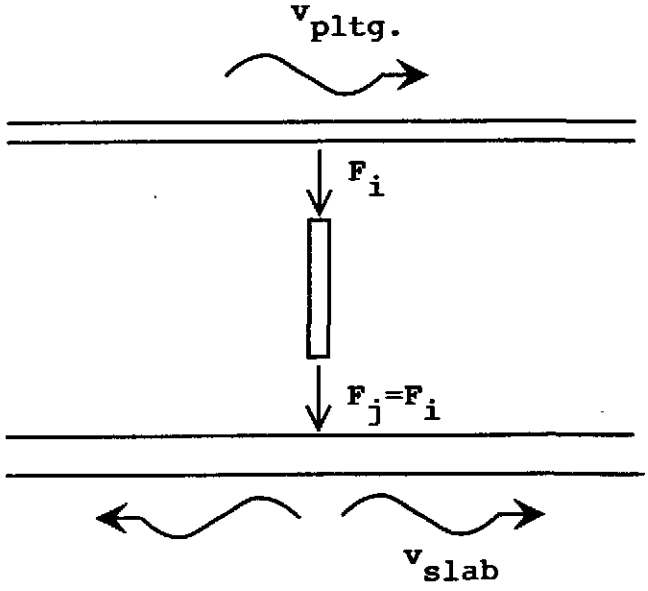


Fig. 9 Models for computing subsystem coupling loss factors.

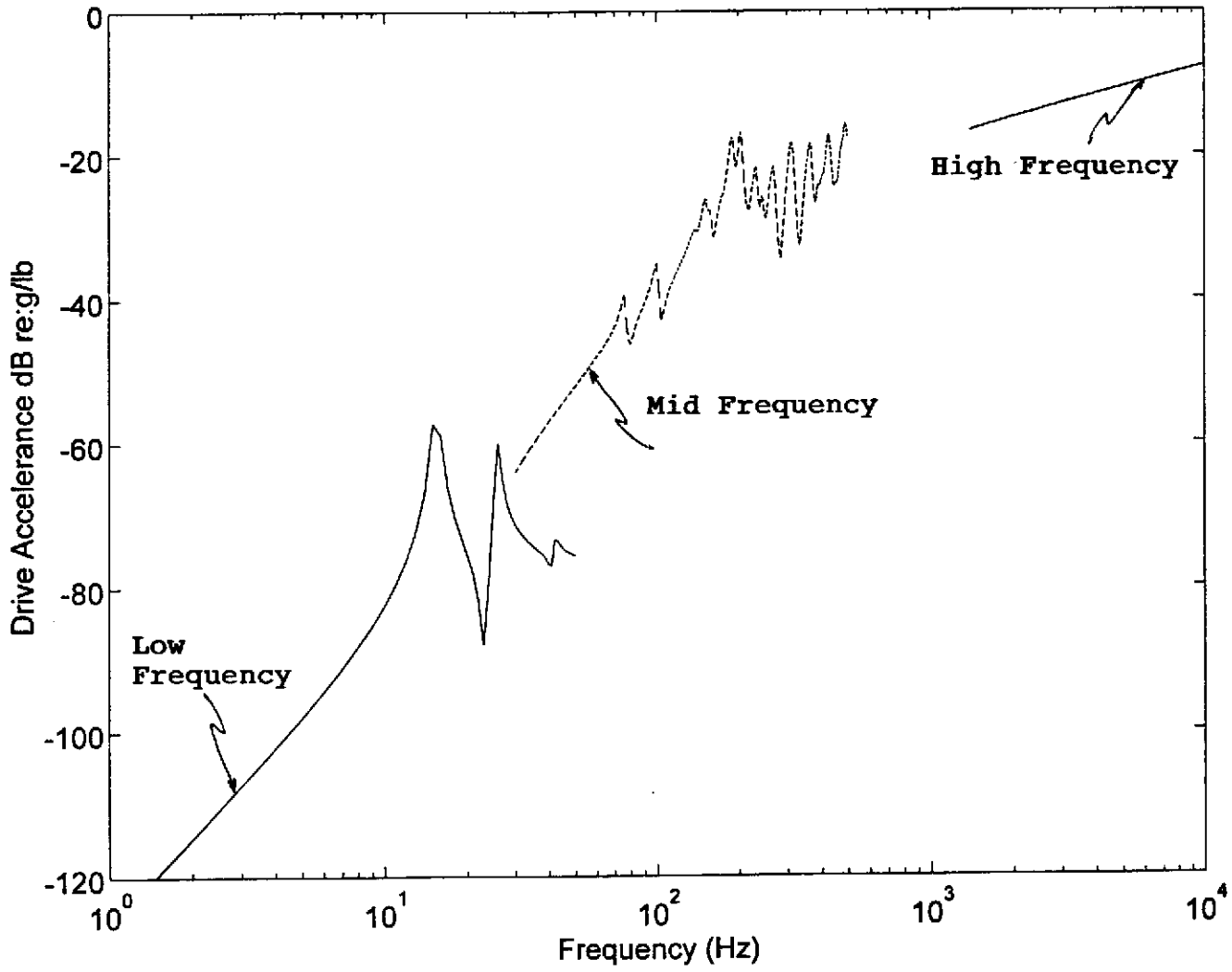


Fig. 10 Drive point accelerance at turbomolecular pump (radial direction

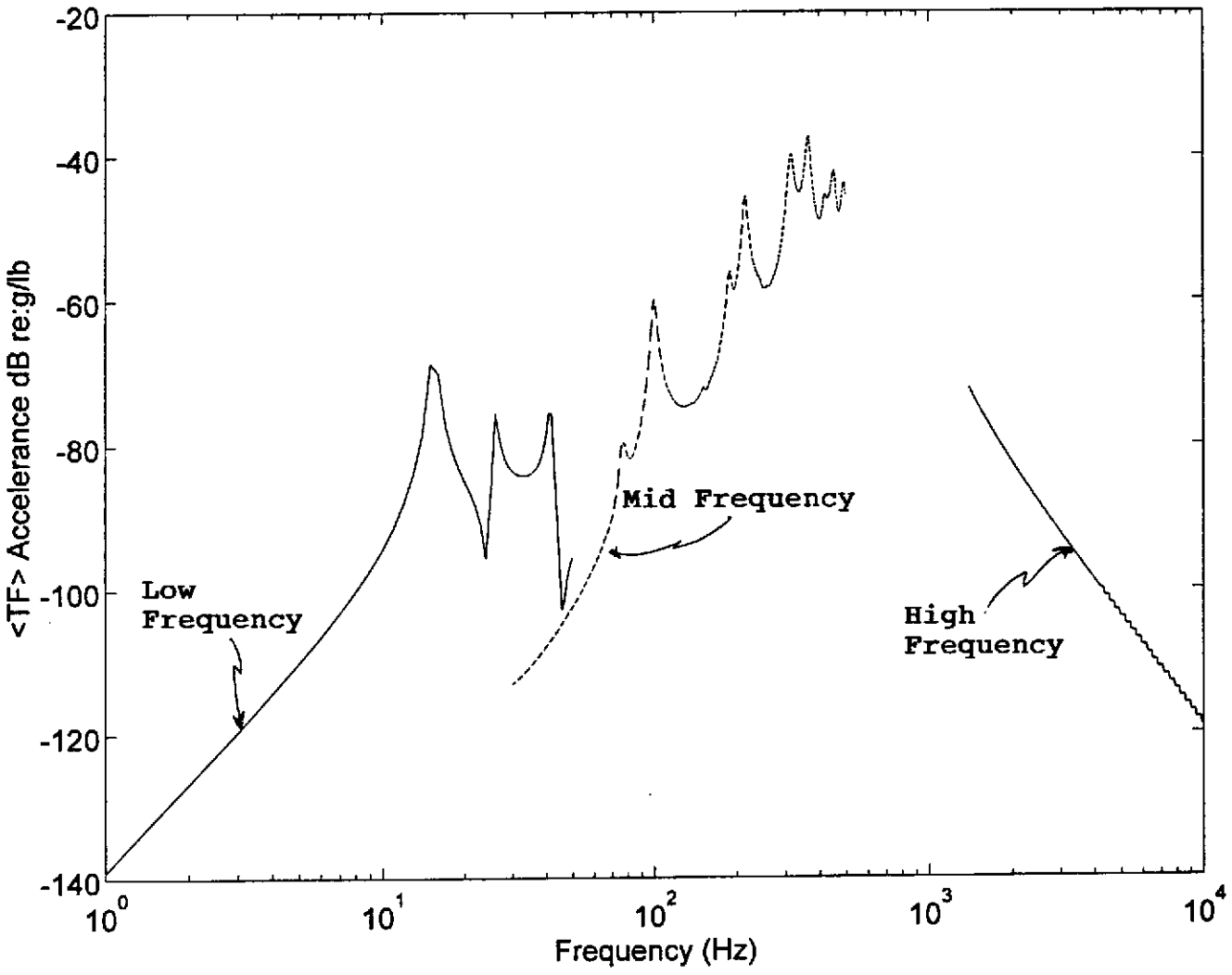


Fig. 11 Transfer accelerance from turbo pump to beam splitter.

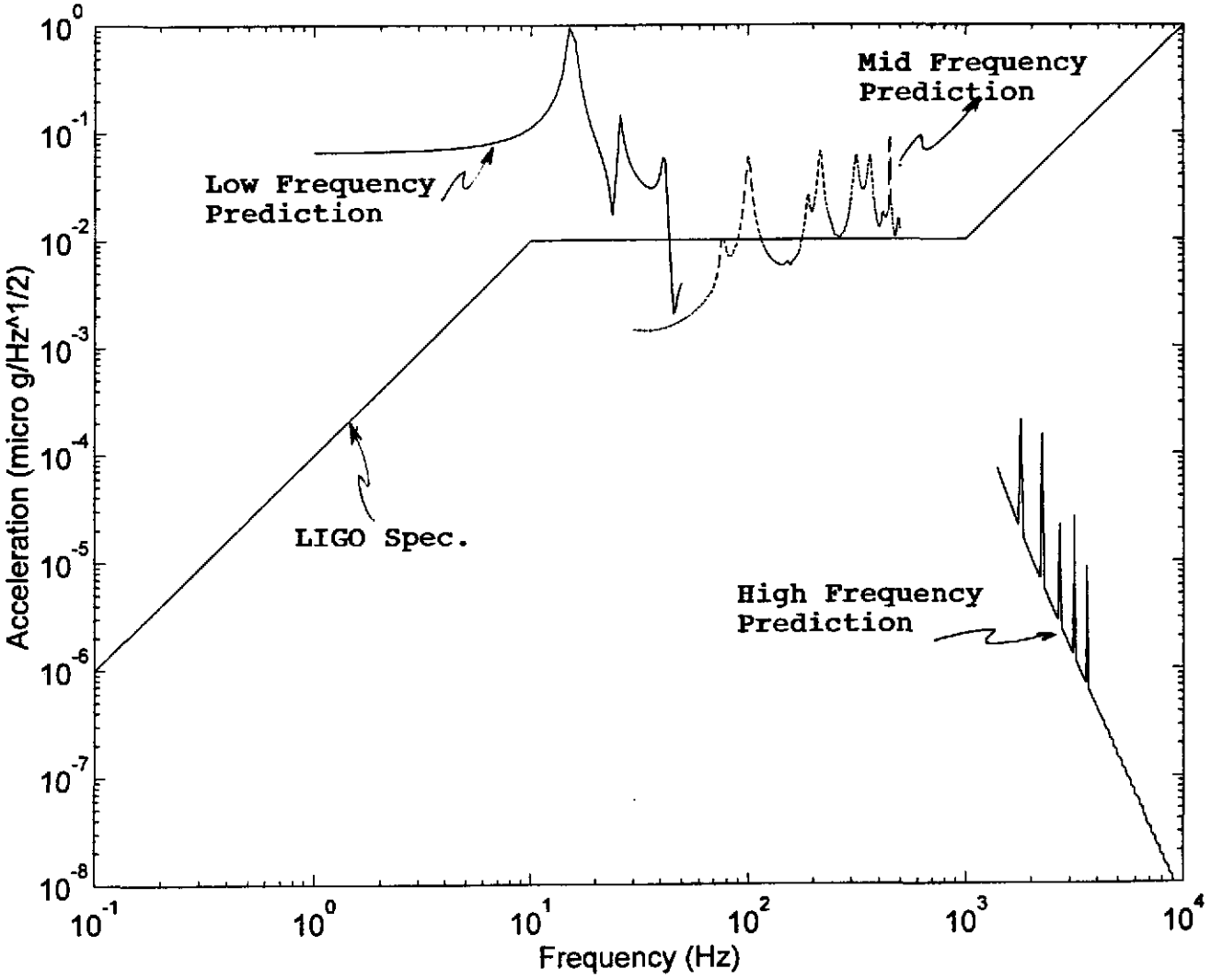


Fig. 12 Predicted acceleration levels at beam splitter compared to LIGO spec.

OCTAVE BAND FREQ, Hz:	63	125	250	500	1k	2k	4k	8k
SOURCES IN VSER								
Lw of Edwards QP-80 Backing Pum	82	66	63	79	79	79	81	73
Lw of Large Ion Pump Controller	60	62	64	65	66	66	65	60
Combined Lp on Surface of VSER in common with LVEA	59.1	38.8	26.7	34.3	30.6	30.2	30.8	18.7
SOURCES IN LVEA								
Lw of Turbomolecular Pump	65	60	55	60	53	45	46	40
Lw of Cryopump	59	48	41	34	30	27	25	24
SOUND PRESSURE LEVELS								
Lp @ BEAM SPLITTER CHAMBER DUE TO ALL SOURCES	61.5	52.9	47.9	52.9	45.8	38.5	39.5	33.0
Lp Criterion, NC-20:	51	40	33	26	22	19	17	16
EXCEEDANCE	11	13	15	27	24	19	22	17
Octave Band Freq.,Hz	63	125	250	500	1k	2k	4k	8k

Lw = Sound Power Level in dB re 10^-12 watt

Lp = Sound Pressure Level in dB re 20 microPascal

Fig. 13 Predicted noise level in end station.

DESIGN GOALS /REQUIREMENTS PROCEDURE

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

QUALITY ASSURANCE: Allan L Bradford

TECHNICAL DIRECTOR: D. A. M. Williams

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
Ø	D. M. Williams	R&B 5/1/96	ISSUED PER DEO 0152 FOR FDR

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number A V049-A-095	Rev. 0
	D. M. W 5-1-96	R&B 5/1/96		

1.0 PURPOSE

The purpose of this procedure is to define instructions for preparing the **Design Goals/Requirements *Form*** for the LIGO project.

2.0 GENERAL

As part of the LIGO project management plan, PSI has committed to generate design criteria for for each subsystem and major component. The design criteria is to be listed on the **Design Goals/ Requirements** form. The **Design Goals/ Requirements** form is to be completed as an initial activity and serves as a baseline document against which the design is developed. The purpose of the **Design Goals/ Requirements** form is to assure that the resulting design is compliant with all of the requirements of the Contract, Statement of Work, Technical Specification , and good engineering/design practice.

A project **Design Goals/ Requirements** master file is maintained by the technical director. As with other documents the **Design Goals/ Requirements Form** should be dated and if changes are made they should be noted by the revision level.

3.0 RESPONSIBILITY

It is the responsibility of the cognizant engineer to prepare and issue the **Design Goals/ Requirements** form. The form is to be reviewed by the technical director prior to issue. Each element of the **Design Goals/ Requirements** form should be signed off when the requirement has been completed by incorporation into lower level project documents including calculations, specifications, drawings, manufacturing, test, and installation procedures. The **Design Goals/ Requirements form** is to be reviewed, updated and issued as part of each design review meeting minutes.

4.0 ATTACHMENTS

Attached is a list of components/subsystems for which a **Design Goals/ Requirements** form is issued.

LIGO Project Design Requirements/Goals

System	Component	number pages	Assignment
Vacuum Enclosure			
	BSC, HAM, Adapters & Spools	3	R. Ciatto
Pumping System			
	Vacuum Pump Carts	2	S. Motew
	Main Ion Pumps	1	F. Bark
	Annulus Ion Pumps	1	F. Bark
	80 K Cryopumps	3	D. Moore
Valve System			
	112 &122 cm Gate Valves	2	T. Starr
	6,10, 14 " Gate Valves	2	T. Starr
	Angle Valves	1	T. Starr
Control System			
	Vacuum gauging	2	F. Bark
Vent & Purge System			
	Portable Clean Rooms	1	T. Starr
	CI 100 air compressors	1	T. Starr
Bakeout System			
	Bakeout Blankets	1	Fadi Bark

Project Design Requirements/Goals

Project : Ligo Vacuum Equipment
Project No: V59049
Specification No: LIGO-E940002-V
Rev: 2
Date: August 31, 1995
System or Component **BSC, HAM, Adaptors & Spools**

Prepared By: R. D. Ciatto
Approved By: D. A. McWilliams

Date: 4/30/96
Last Review 11/22/95
File: LIGODR.WB1
Quantity: BSC: 15+ 1 prototype
HAM: 19
Adapters: numerous

Item	Spec Referenc	Description of Design Requirement	Action, Conclusion, or Assignment	Action By	Date Required	Status
	5.1	Compatible with 1x10-9 torr	Matl selection, processing, cleaning			
			leak rate <1x10-9 torr-l/s,virtual leaks,			
			double O-ring, permeation, baking			
	5.1.1	Materials/304L or 316L	Use 304L for low cost			
			Dual rating 304/304L required for shells	D.Curtis		Spec complete 11/22/95
			Dual rating 304/304L OK for Heads	D.Curtis		Spec complete 11/22/95
			304L for flanges	D.Curtis		Spec complete 11/22/95
	5.1.2	Cleaning	Reference cleaning procedure	T. Starr	4/15/96	
	5.1.3	Welding	Weld procedure	P Ferland		Spec complete 3/14/96
		TIG per ASME &UHV practice	Develop Plasma Weld Procedure	P Ferland		Spec complete 3/14/96
		internal welds continuous		P Ferland		Spec complete 3/14/96
		external welds intermittant	skip weld	P Ferland		Spec complete 3/14/96
		heat affected zone contamination	argon purge	P Ferland		Spec complete 3/14/96
	5.1.4	Alignment				
		Align to optical axis	Installation procedure	R. Ciatto	4/15/96	
		Tranverse +-2mm	oversize 60 "nozzles to maintain clear			complete
			aperture			
			Individualy adjustable jacks at each leg	S. Dangel	4/25/96	Complete
		axial +- 25 mm				
		tolerances				
		+/-3mm, +/-1deg, +/- 3mm/3m	Fabrication procedure	D. Curtis		Spec complete 3/19/96
	5.1.5	Mechanical Loads				
		HVAC	Covered by Bakeout case	R.Ciatto		complete
		Atmospheric pressure	Design pressure = 14,7 psi	R.Ciatto		complete
		Vacuum Cycling	Consider all external load cases	R.Ciatto		complete
		Bakeout	Design temp = 190 C	R.Ciatto		complete
		HVAC failure	Covered by Bakeout case	R.Ciatto		complete
	5.1.6	Design				
		ASME VIII, Div1	Design Calculations	R.Ciatto		complete
		interchangeable parts	Fabrication procedure	D.Curtis		complete
		clearances for flanges	Retractable bellows	D. Curtis		complete

		access for leak checking	Design task	D. Curtis		complete
		lifting lugs >50lbs	Design Task	D. Curtis		complete
		ground connection	I/E to determine requirements	F.Bark		complete
		Reinforcement calcs	Use "Compress" program	R.Ciatto		complete
		loads per applicable codes &standards	Yes	R.Ciatto		complete
		free standing for leak checking	Yes	R.Ciatto		complete
		Earthquake per ANSI A58.1	Design Calculations	R.Ciatto		complete
	5.1.7.1	Configuration per Figure 8	Detail on Assembly Drawing	D. Curtis		complete
	5.1.7.2	Configuration per Figure 9	Detail on Assembly Drawing	D. Curtis		complete
		HAM ports				
	5.1.8	Brackets per Figure 10	Detail on Assembly Drawing	D. Curtis		complete
	5.1.9	Flanges and Ports				
		Dual O-ring,non lubed Viton	determine O-ring parameters	S. Motew		complete
		O-Ring retention Groove	Dove tail on ID	S. Motew		complete
		Flange centering pins	Request spec relief			
		Port Design				
		Max aperture,min length	Use 1/8 rollups where possible,	D. Curtis		complete
			1/4 wall on cover ports for reinforcement	D. Curtis		complete
	5.1.10	Access Connectors	Not Applicable			
	5.1.11	Optical Baffles	Not Applicable			
	5.1.12	Annular Spaces .3L/s	Change to .2 L/S per V049-1-012	R.Than		approved by TIM 18
	5.1.13	Fasteners				
		non lubed or plated except floor anchor	Spec plating	R.Ciatto		complete
		plate nuts preferred	Use only on CF flanges up to 8"	K. Rintala		complete
	5.1.14	Component Leak Rate				complete
		<1x10-9 torr-L/s	weld procedure, flange design	R.Ciatto		complete
		ASTM E498	Spec RGA with proper sensitivity	S. Chevaroli		complete
			Investigate He alternates for annulus test	R.Than		Verify on BSC prototype
	5.1.15	Workmanship				
		weld spatter	Full penetration weld from inside/weld	D. Curtis		complete
			detail on drawing			
		cutoff spatter	Full penetration weld from inside/weld	D. Curtis		complete
			detail on drawing			
		free iron	Reference cleaning procedure/Metalurgist	B. Newmark		
			to advise sequence			
		weld oxidation	Reference cleaning procedure/ purging,	T. Starr		
			acid cleaning			
		defects	Develop repair procedure	A. Bradbrook		complete
		no grinding or abrasion	weld procedure/ prohibit grinding,	A. Bradbrook		complete
		finished welds	controlled welding technique			complete
		vacuum surfaces	per fabrication procedure			complete

	Other Design					
	Requirements					
1	1	Cost Effective Design	----------	-----	-----	-----
		1.1 Minimize material costs				
		1.1.1 Minimize material thickness within	Fiinite element analysis	R. Ciatto		complete
		constraints of code and deflection	Buckling analysis			
		requirements	Use dual rated 304/304L in high stress			complete
			areas			
		1.1.2 Minimize special material finish	specify hot rolled,annealed, and pickeled	D. Curtis		complete
		or handling requirements				
2	2	Maintain a leak tight pressure boundary	Design bolted flanges to maintain seal	R. Ciatto		complete
3	3	External Design Press & Temp	Design for vacuum &max operating	R. Ciatto		complete
		compatible with 150 C vacuum bakeout	temp +tol+ SF	R. Ciatto		complete
			150C+20C +20C= 190C			
4	4	Internal Design Press &Temp	Determine Max allowable pressure using	R. Ciatto		complete
		compatible with clean air purge	RT allowable stresses.			
	5	Unit must be shipped in horizontal	shipping supports lugs required	S. Dangel		
		position	compatible with flat bed truck shipment			
	6	Class 100 interior	Shop cleaning procedure	T. Starr	4/15/96	complete
			packaging procedure	D. Curtis	4/25/96	complete
			ship under vacuum. Design shipping	R. Ciatto	4/25/96	complete
			covers			
			Installation Procedure	D Evers	4/25/96	complete

Project Design Requirements/Goals

Date: 5/1/96

Project : Ligo Vacuum Equipment
Project No: V59049
Specification No: LIGO-E940002-02-V
Rev: 2
Date: August 31, 1995
System or Compone VACUUM PUMP CARTS

Prepared by: Jim 5/1/96
Approved by: D. A. Mueller 5-1-96

File: LIGODR1.WB1

Quantity:

Item	Spec Ref	Description of Design Requirement	Action, Conclusion, or Assignment	Action By	Date Required	Status
1		Cost Effective Design	----------	-----	-----	-----
	4.2	PUMP DOWN TIME:ATMOS. TO 1E-6 TORR	PSI SPECS. V049-2-001 R3,V049-2-002 R4			
		FOR ISOLATABLE SECTION=24 HRS.				
		NOISE/VIBRATION EXEMPT FIRST 4 HRS.				
		TURBO PUMPS ALWAYS NOISE EXEMPT.				
		2 PUMP CARTS ON VERTEX /DIAGONAL				
		1 PUMP CART ON OTHER SECTONS				
	4.6.4	ELEC. EQUIP. MUST MEET COMM. EMI STDS.	PSI SPEC V049-2-033 R2, 5.2.1.2			
	4.6.5	EQUIP. SUITABLE FOR CL.50000 CLEAN RM.	PSI SPEC V049-2-033 R2, 5.1.7			
			V049-2-001 R3,4.1.2;V049-2-002 R4,4.1.2			
	4.8	DESIGN LIFE: 20 YEARS	PSI SPEC V049-2-033 R2, 5.1.8			
	5.2	PUMPDOWNS				
		760 TORR-1 TORR,4 HRS.:ROOTS PUMP.	VO49-2-001 R3, 3.3			
		1 TORR-<1E-6 TORR,24 HRS.:TURBO PUMP	VO49-2-002 R4, 3.0			
		LOW NOISE /VIBRATION REQ.	VO49-2-002 R4, 4.0.2			
	5.2.1	ROOTS EXEMPT FROM NOISE/VIBRATION.				
		TURBO MUST MEET NOISE/VIBRATION PER 4.6.	PSI SPEC V049-2-033 R2, 5.1.5			
		ROOTS/TURBO SHALL NOT CONTAM. CHAMBERS.	V049-2-001 R3,4.1.7;V049-2-002 R4,4.1.7			

Project Design Requirements/Goals

Project : Ligo Vacuum Equipment
Project No: V59049
Specification No: LIGO-E940002-02-V
Rev: 2
Date: August 31, 1995
System or Compone VACUUM PUMP CARTS

Prepared by: SM 5/1/96
Approved by: D Commerford

Date: 5/1/96

File: LIGODR1.WB1

Quantity:

Item	Spec Ref	Description of Design Requirement	Action, Conclusion, or Assignment	Action By	Date Required	Status
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	5.2.1.1	4 ROOTS+BACKING PUMP CARTS REQ.	PSI SPEC. V049-2-001 R3,PARA :			
		500 CFM AT 1 TORR	3.3			
		1000 CFM AT 0.1 TORR	3.3			
		NO OIL IN PUMPING PATH.	4.1.7			
		INTERLOCKED TO PREVENT VENTING.	4.2.2.2			
		2000 M^3 WITHOUT OVERHEATING.	3.1			
		PROVISION FOR CONN. TO CONTROL SYS.	4.2.2.1			
		PROVISION FOR CONN. TO EXHAUST SYS.	4.1.6			
		V.E. GAGE ON ROOTS & BACK.PUMP INLET.	4.2.1.1			
		AUX. VALVED LEAK DETECTOR PORTS.	4.2.1.2			
		BLANKOFF FLANGES ON UNUSED PORTS	4.2.1.3			
	5.2.1.2	10 TURBO CARTS REQ.	SPEC.V049-2-002 R4, PARA :			
		WIDE RANGE MAG. LEV. TURBOMOLECULAR	4.1.1			
		BACKED BY OIL FREE DIAPH.,PISTON,SCROLL.	4.1.1			
		1400.L/SEC N2 AT 1E-3 TORR.	3.0			
		THRUPUT: 5 TORR-L / S AT 1 TORR BACK.PRES.	3.0			
		2000 M^3 WITHOUT OVERHEATING.	3.0			
		INTERLOCKED TO PREVENT VENTING / CONTAM.	4.1.3			
		PROVISION FOR CONN. TO CONTROL SYS.	4.2.2.1			
		PROVISION FOR CONN. TO EXHAUST SYS.	4.1.6			
		V.E. GAGE ON ROOTS & BACK.PUMP INLET.	4.2.1.1			
		AUX. VALVED PORTS FOR L. DETECT. / AUX .TURBO	4.2.1.2			
		BLANKOFF FLANGES ON UNUSED PORTS	4.2.1.3			

Project Design Requirements/Goals

Date: 5/1/96

Project : Ligo Vacuum Equipment
Project No: V59049
Specification No: LIGO-E940002-02-V
Rev: 2
Date: August 31, 1995
System or Compone VACUUM PUMP CARTS

Prepared by: AM 5/1/96
Approved by: D. C. McWilliams

File: LIGODR1.WB1

Quantity:

Item	Spec Ref	Description of Design Requirement	Action, Conclusion, or Assignment	Action By	Date Required	Status
			---	---	---	---
	5.2.4	10 AUX. TURBO CARTS REQ.	PSI SPEC V049-2-003 R3,PARA :			
		OIL FREE BACKING PUMPS	4.1.6			
		INTERLOCKED TO PREVENT VENTING.	4.2.2.2			
		PROVISION FOR CONN. TO CONTROL SYS.	4.2.2.1			

Project Design Requirements/Goals

Project:	LIGO Vacuum Equipment		**Date:**	1/22/96	
Project No.:	V59049		**File:**	LIGODR.WB1	
Specification No.:	LIGO-E940002-V		**Quantity:**	18	
Rev:	2				
Date:	8/31/95		**Prepared by:**	F. Bartl	
System or Component:	Main Ion Pumps		**Aproved by:**	D. Shoemaker	

Item	Spec. Reference	Description. of Design Req'ts.	Action, Conclusion, or Assignment	Action By	Date Req'd	Status
		Cost Effective Design	---	---	---	---
1	E940002V/5.2.2	N2 pump speed.	V59049-2-004 section 3.1.1			
2	E940002V/5.2.2	Minimum pump life.	V59049-2-004 section 3.1.3			
3	E940002V/5.2.2	Pump type.	V59049-2-004 section 3.1.3			
4	E940002V/5.2.2	Multiple Electrical Feedthrus.	V59049-2-004 section 3.1.4			
5	E940002V/5.2.2	Maximum starting pressure 1x10E-5 torr.	V59049-2-004 section 3.1.4			
6	E940002V/5.2.2	Rack mountable power supply.	V59049-2-004 section 3.1.1			
7	E940002V/5.2.2	Power supply remote capabality	V59049-2-004 section 3.1.2			
8	E940002V/5.2.2	Documentation and Warranty	V59049-2-004			
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Project Design Requirements/Goals

Project:	LIGO Vacuum Equipment		**Date:**	1/22/96	
Project No.:	V59049		**File:**	LIGODR.WB1	
Specification No.:	LIGO-E940002-V		**Quantity:**	43/32	
Rev:	2				
Date:	8/31/95		**Prepared by:**	F. Bartl	
System or Component:	Annulus Ion Pumps		**Aproved by:**	Daniel Sellers	

Item	Spec. Reference	Description. of Design Req'ts.	Action, Conclusion, or Assignment	Action By	Date Req'd	Status
		Cost Effective Design	---	---	---	---
1	E940002V/5.2.4	Pump type..	V59049-2-004 section 3.2.1 and 3.3.1			
2	E940002V/5.2.4	Minimum pump life.	V59049-2-004 section 3.1.3			
3	E940002V/5.2.4	Minimum size.	V59049-2-004 section 3.3.2			
4	E940002V/5.2.4	Maximum starting pressure 1x10E-5 torr.	V59049-2-004 section 3.1.4			
5	E940002V/5.2.4	Rack mountable power supply.	V59049-2-004 section 3.1.1			
6	E940002V/5.2.4	Power supply remote capabality	V59049-2-004 section 3.2.2			
7	E940002V/5.2.4	Documentation and Warranty	V59049-2-004			
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Project Design Requirements/Goals

Prepared By: David Moore Date: 1/9/96

Project : Ligo Vacuum Equipment

Project No: V59049 Approved By: D A McWilliams

Specification No: LIGO-E940002-V File: 80Kpmp .wb1

Rev: 3

Date: November 21, 1995

System or Component **80K Pump** Quantity: 12

Item	Spec Ref.	*Description of* Design Requirement	Action, Conclusion, or Assignment	Action By	Date Req'd	Status
1		Cost Effective Design	----------	-----	-----	-----
2	5.1	Compatible with 1x10-9 torr	Matl selection, processing, cleaning	D. Moore		
			leak rate <1x10-9 torr-l/s,virtual leaks,			
			double O-ring, permeation, baking			
3	5.1.1	Materials/304L or 316L	Use 304L for low cost, mill test reports	D. Moore		
			(chamber, tube, & flange)			
4	5.1.2	Cleaning	Reference cleaning procedure	D. Moore		
5	5.1.3	Welding	Weld procedure	P. Ferland		
		TIG per ASME &UHV practice				
		internal welds continuous				
		external welds intermittant	skip weld			
		heat affected zone contamination	argon purge			
6	5.1.4	Alignment		T.B.D.		
		Align to optical axis				
		Tranverse +-2mm				
		axial +- 25 mm				
		tolerances				
		+/-3mm, +/-1deg, +/- 3mm/3m				
7	5.1.5	Mechanical Loads		R. Ciatto		
		HVAC				
		Atmospheric pressure				
		Vacuum Cycling				
		Bakeout				
		HVAC failure				
8	5.1.6	Design				
		ASME VIII, Div1	Design Cond: -320F, 40 psid;	R. Ciatto		
			400F, 25 psid; 70F, 14.7 psid			
		interchangeable parts		D. Moore		
		clearances for flanges		D. Moore		
		access for leak checking		D. Moore		
		lifting lugs >50lbs		D. Moore		

		ground connection		D. Moore		
		Reinforcement calcs		R. Ciatto		
		loads per applicable codes &standards		R. Ciatto		
		free standing for leak checking		R. Ciatto		
		Earthquake per ANSI A58.1		R. Ciatto		
9		Deleted				
10		Deleted				
11	5.1.9	Flanges and Ports		R. Curtis		
		Dual O-ring,non lubed Viton				
		O-Ring retention Groove	dove tail on ID			
		Flange centering pins				
		Port Design				
		Max aperture,min length	Ref: Calculations and sketch			
12	5.1.10	Access Connectors	Not Applicable			
13	5.1.11	Optical Baffles	Not Applicable			
14	5.1.12	Annular Spaces .3L/s	Annulus calculations	R.Than		
15	5.1.13	Fasteners				
		non lubed or plated except floor anchors	Spec plating	R. Ciatto		
		plate nuts preferred				
16	5.1.14	Component Leak Rate				
		<1x10-9 torr-L/s	weld procedure, flange design	P. Ferland		
		ASTM E498	Spec RGA with proper sensitivity	R.Than		
17	5.1.15	Workmanship	Fabrication spec.	P. Ferland		
		weld spatter	Fabrication spec.			
		cutoff spatter	Fabrication spec.			
		free iron	Fabrication spec.			
		weld oxidation	Fabrication spec.			
		defects	Fabrication spec.			
		no grinding or abrasion	Fabrication spec.			
		finished welds	Fabrication spec.			
		vacuum surfaces	Fabrication spec.			
18	5.2.3	Removeable beam tube section at one		R. Curtis		
		end, min. length = 60 cm.				
19	5.2.3	Reduce vaporization in the	Reduce supply line size if possible.	D. Moore		
		supply line	Test program.			
20	4.6.2	Keep noise generation low (secondary)	Minimize heat leak. Avoid slug flow.	D. Moore		
21	4.6.3	Reduce vibration transmitted into beam tub	Bellows, elastomeric material			
			at support hanger	D. Moore		
	Other Req'ments					
22		Maintain a leak tight pressure boundary	Design bolted flanges to maintain seal	R. Ciatto		

23		External Design Press & Temp	Design for vacuum &max operating	R. Ciatto		
		compatible with 150 C vacuum bakeout	temp +tol+ SF			
			150C+20C +20C= 190C			
		Internal Design Press &Temp	Determine Max allowable pressure using			
		compatible with clean air purge	RT allowable stresses. Ref: structural pkg			
24		Prevent water backstreaming and	Heat exchanger at discharge of vent lin	D. Moore		
		forming ice				
25		Minimize heat leak to minimize dewar size	Use low e liner, and radiation shield(s)	D. Moore		
			around pump			
26		Protect vacuum equip. in the event	Rupture disc on vacuum chamber	D. Moore		
		of LN2 pipe break				
27		Evacuation of LN2 reservoir , leak checking	Reservoir to be designed for full vacuum	R. Ciatto		

Project Design Requirements/Goals

Date: 11/30/95

Project : Ligo Vacuum Equipment
Project No: V59049
Specification No: LIGO-E940002-V
Rev: 2
Date: August 31, 1995
System or Component: Large Gate Valves

Prepared By: Thomas M. Stein 11-30-95

Approved By: D. A. McWilliams 12-5-95

File: ligodr.wb1

Note: The vendor (GNB) has committed to meeting all specification requirements.

Quantity: 32

Item	Spec Ref.	Description of Design Requirement	Action, Conclusion, or Assignment	Action By	Date Req'd	Status
1		Cost Effective Design	----------	-----	-----	-----
2	3.1	112 cm Clear aperture at cryopumps	Spec V049-2-005, 4.1.15			
3	3.5	Weld stubs for LA mid joints.	Spec 005, 4.1.11			
4	4.1	Leaks greater than 1 x 10-9 repaired	Spec 005, 4.1.3. Total valve leak less than 10-10			
5	4.2.3	Pumpdown time, ultimate pressures	Spec 005, 4.1.17. Final cleaning and assembly in cleanroom. Internals electropolished. 4.1.1. Metal bellows stem seals 4.1.4. Double gate and bonnet seals 4.1.16. Flange seal faces 32 finish with circ. lay			
6	4.4	Controls for safe and reliable operation	Spec 005, 4.2.1. Limit switches provided Spec 005, 4.2.2. Detailed controls requirements			
7	4.5	Bakeout to 150 C	Valves are operable (except as limited by the Viton o-rings) to 1000 F.			
8	4.6.1	Shock limited to 0.01 g p-p within 1 m of any HAM or BSC chamber	Spec 005, 4.1.9. Limit put on valves themselves. GNB has design and experience. DC electric motors used for fine control. Valves away from chambers allowed to be pneumatic.			
9	4.6.4	Limit for EMI (commercial stds)	Spec 033, 5.2.1.2			
10	4.6.5	External particulates	Spec 033, 5.1.7			
11	4.8	20 Year design life	Spec 033, 5.1.8			
12	4.9	Environmental exposure	Spec 033, 5.1.9			
13	5.1.1	Type 304L or 316L material, prebaked	Spec 005, 4.1.1. 304L will be used.			
14	5.1.1	Viton for seals	Spec 033, 6.3. Special grade of Viton specified			
15	5.1.2	Cleaning to approved procedures	Spec 005, 4.1.17. Final cleaning and assembly in cleanroom. Internals electropolished. Spec 005, 7.0. Black light and RGA inspections GNB has special procedures for equip. protection			
16	5.1.3	Welding requirements	Spec 033, 8.0. GNB also has UHV experience			
17	5.1.5	Mechanical loads	Spec 005, 4.1.14. Conservative design loads defined. PSI will also design and fab a support.			

System or Component: Large Gate Valves

Item	Spec Ref.	Description of Design Requirement	Action, Conclusion, or Assignment	Action By	Date Req'd	Status
18	5.1.6	Design to standards	Spec 033, 5.1.2			
19	5.1.6	Interchangeable separable parts	Spec 033, 5.1.10			
20	5.1.6	Lifting lugs	Spec 033, 5.1.12			
21	5.1.15	Workmanship, finish, and appearance	Spec 033, 8.5			
22	5.3.1	Non-contam. & non-migratory lub.	Spec 005, 4.1.2. Dry film lub will be used			
23	5.3.1	Double Viton gate seals	Spec 005, 4.1.4			
24	5.3.1	Gate seals less than 1 x 10-9 leakage	Spec 005, 4.1.4			
25	5.3.1	Valves of same size and type identical	Spec 005, 4.1.5. Order not split between vendors.			
26	5.3.1	10,000 Cycle rating	Spec 005, 4.1.5			
27	5.3.1	Protection from inadvertent operation	Spec 005, 4.1.10. Padlockable (no damage if inadvertent actuation is attempted).			
28	6.1.2.3	Valve leak tests	Spec 005, 6.1. Added requirement to use oil-free pump and detector.			
29	6.1.2.3	Demonstration of operation	Spec 005, 6.3. 20 Cycles required.			

Project Design Requirements/Goals

Project : Ligo Vacuum Equipment
Project No: V59049
Specification No: LIGO-E940002-V
Rev: 2
Date: August 31, 1995
System or Component: 6", 10" & 14" Gate Valves

Prepared By: Thomas M. Stan
Approved By: D. A McWilliams

Note: The vendor has committed to meeting all specification requirements.

Date: 12/8/95
File: ligodr.wb1
Quantity: 7/25/18

Item	Spec Ref.	Description of Design Requirement	Action, Conclusion, or Assignment	Action By	Date Req'd	Status
1		Cost Effective Design	---	---	---	---
2	4.1	Leaks greater than 1 x 10-9 repaired	Spec 006, 4.3. Total valve leak less than 10-10			
3	4.2,3	Pumpdown time, ultimate pressures	Spec 006, 4.13. Final cleaning and assembly in cleanroom. 4.1. Metal bellows stem seals			
4	4.4	Controls for safe and reliable operation	Spec 006, 4.12. Limit switches provided for 6" and 10" valves.			
5	4.5	Bakeout to 150 C +/- 20 C	Spec 006, 4.11.			
6	4.6.1	Shock limited to 0.01 g p-p within 1 m of any HAM or BSC chamber	Spec 006, 4.10. Limit put on valves themselves. (Valves are manual.)			
7	4.6.5	External particulates	Spec 033, 5.1.7			
8	4.8	20 Year design life	Spec 033, 5.1.8			
9	4.9	Environmental exposure	Spec 033, 5.1.9			
10	5.1.1	Type 304L or 316L material, prebaked	Spec 006, 4.1			
11	5.1.1	Viton for seals	Spec 033, 6.3. Special grade of Viton specified			
12	5.1.2	Cleaning to approved procedures	Spec 006, 4.13. Final cleaning and assembly in cleanroom. Spec 006, 7.0. Black light and RGA inspections			
13	5.1.3	Welding requirements	Spec 033, 8.0.			
14	5.1.5	Mechanical loads	Spec 006, RFQ: Option quoted to strengthen 14" valves for 1500 lb ion pump mounting.			
15	5.1.6	Design to standards	Spec 033, 5.1.2			
16	5.1.6	Interchangeable separable parts	Spec 033, 5.1.10			
17	5.1.6	Lifting lugs	Spec 033, 5.1.12			
18	5.1.15	Workmanship, finish, and appearance	Spec 033, 8.5			
19	5.3.1	Non-contam. & non-migratory lub.	Spec 006, 4.2.			
20	5.3.1	Gate seals less than 1 x 10-9 leakage	Spec 006, 4.4			
21	5.3.1	Valves of same size and type identical	Spec 006, 4.6. Order not split between vendors.			
22	5.3.1	10,000 Cycle rating	Spec 006, 4.6			
23	5.3.1	Protection from inadvertent operation	Spec 006, 4.8. Padlockable			
24	6.1.2.3	Valve leak tests	Spec 006, 6.1. Added requirement to use oil-free pump and detector.			
25	6.1.2.3	Demonstration of operation	Spec 006, 5.0. Functional test report req'd			

Project Design Requirements/Goals

Project : Ligo Vacuum Equipment
Project No: V59049
Specification No: LIGO-E940002-V
Rev: 2
Date: August 31, 1995
System or Component: Angle Valves

Prepared By: Thomas M. Stern (signature)
Approved By: D. A. McWilliams (signature)

Date: 3/29/96
File: ligodr.wb1
Quantity: 310

Item	Spec Ref.	Description of Design Requirement	Action, Conclusion, or Assignment	Action By	Date Req'd	Status
1		Cost Effective Design	-------------	-----	-----	-----
2	4.1	Leaks greater than 1 x 10-9 repaired	Spec 059, 3.4. Total valve leak less than 10-9			
3	4.2,3	Pumpdown time, ultimate pressures	Spec 059, 3.3. Metal bellows stem seals Spec 059, 3.2. CF flanges			
4	5.1.1	Type 304L or 316L material	Spec 059, 3.1			
5	5.1.1	Prebaked Viton for seals	Spec 033, 6.3. Special grade of Viton specified			
6	5.1.2	Cleaning to approved procedures	Spec 059, 6.0. Black light inspection			
7	5.1.6	Interchangeable separable parts	Catalog items			
8	5.3.1	Non-contam. & non-migratory lub.	Spec 059, 3.6. Non-lubricated int. mechanisms			
9	5.3.1	Gate seals less than 1 x 10-9 leakage	Spec 059, 3.4. Total valve leak less than 10-9			
10	5.3.1	Valves of same size and type identical	Order not split between vendors.			
11	5.3.2	Bakeout to 150 C +/- 20 C	Spec 059, 3.8.			
12	5.3.2	10,000 Cycle rating fo metal-sealed vlvs				
13	6.1.2.3	Valve leak tests	Spec 059, 5.0.			

Project Design Requirements/Goals

Project:	LIGO Vacuum Equipment		**Date:**	4/20/96
Project No.:	V59049		**File:**	LIGODR.WB1
Specification No.:	LIGO-E940002-V		**Quantity:**	24WA/13LA/4 PSI
Rev:	2			
Date:	8/31/95		**Prepared by:**	F. Bartl
System or Component:	Pirani Gauges		**Aproved by:**	D. M. Williams

Item	Spec. Reference	Description. of Design Req'ts.	Action, Conclusion, or Assignment	Action By	Date Req'd	Status
		Cost Effective Design	---	---	---	---
1	E940002V/5.6.1.1	Bakable to 250 deg C	V59049-2-007 section 4.1.2			
2	E940002V/5.6	0-10V output	V59049-2-007 section 4.2.2			
3	E940002V/5.6	24VDC supply	V59049-2-007 section 4.2.2			
4	E940002V/5.6.1.1	CF Flanges	V59049-2-007 section 4.1.1			
5	E940002V/5.6.1.1	Range: ATM to 1x10E-3	V59049-2-007 section 3.2			
6	E940002V/5.6.1	Smart Electronics/Removable	V59049-2-007 section 3.1.2			
7	E940002V/5.6.1.1	Controller setpoint	V59049-2-007 section 4.2.2			
8	E940002V/5.6.1	Locking connector/feedthru	V59049-2-007 section 4.2.1			
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16						

Project Design Requirements/Goals

Project:	LIGO Vacuum Equipment		**Date:**	4/20/96
Project No.:	V59049		**File:**	LIGODR.WB1
Specification No.:	LIGO-E940002-V		**Quantity:**	24WA/13LA/4 PSI
Rev:	2			
Date:	8/31/95		**Prepared by:**	F. Bartl
System or Component:	Cold Cathod Gauges		**Aproved by:**	D. Williams

Item	Spec. Reference	Description. of Design Req'ts.	Action, Conclusion, or Assignment	Action By	Date Req'd	Status
		Cost Effective Design	---	---	---	---
1	E940002V/5.6.1.2	Bakable to 250 deg C	V59049-2-007 section 4.1.2			
2	E940002V/5.6	0-10V output	V59049-2-007 section 4.2.2			
3	E940002V/5.6	24VDC supply	V59049-2-007 section 4.2.2			
4	E940002V/5.6.1.2	CF Flanges	V59049-2-007 section 4.1.1			
5	E940002V/5.6.1.2	Range: 1x10E-2 to 1x10E-9	V59049-2-007 section 3.3			
6	E940002V/5.6.1	Smart Electronics/Removable	V59049-2-007 section 3.1.2			
7	E940002V/5.6.1.2	Controller setpoint	V59049-2-007 section 4.2.2			
8	E940002V/5.6.1	Locking connector/feedthru	V59049-2-007 section 4.2.1			
9	E940002V/5.6.	Max. Oper. Press. 1x10E-2	V59049-2-007 section 3.3			
10						
11						
12						
13						
14						
15						
16						

Project Design Requirements/Goals

Project : Ligo Vacuum Equipment
Project No: V59049
Specification No: LIGO-E940002-V
Rev: 2
Date: August 31, 1995
System or Component: Portable Clean Rooms

Prepared By: [signature]
Approved By: D. A. McWilliams [signature]

Date: 3/25/96
File: ligodr.wb1
Quantity: 14

Item	Spec Ref.	Description of Design Requirement	Action, Conclusion, or Assignment	Action By	Date Req'd	Status
1	5.4	Class 100 Equivalent	Spec 010, 3.0.			
2	5.4	Federal Std. 209 Design	Spec 010, 4.1.1.			
3	5.4	Airflow to optimize particulate removal	Spec 010, 4.1.2.			
4		Extended filter life	Prefilters on blowers			
5		Easy handling	Separable ceiling units with lifting lugs			
6		Portability	Casters			
7		Flexibility	Joinable to make larger working spaces Wall seals for various size tubes Blank cover for BSC dome opening Additional active unit for BSC dome opening Adjustable legs on BSC clean rooms Separate controls for fans and lights Convenience outlet			

Project Design Requirements/Goals

Project : Ligo Vacuum Equipment
Project No: V59049
Specification No: LIGO-E940002-V
Rev: 2
Date: August 31, 1995
System or Component: Clean Air Supply Systems

Prepared By: Thomas M. Stan
Approved By: D M Williams

Date: 3/22/96
File: ligodr.wb1
Quantity: 6/2

Item	Spec Ref.	Description of Design Requirement	Action, Conclusion, or Assignment	Action By	Date Req'd	Status
1		Cost Effective Design	----------	-----	----	-----
2	4.4	Controls for safe and reliable operation	Vent control valves provided for controlled system venting.			
3	4.6.3	Vibration	Spec 011, 4.1.3. Spec doesn't apply, but reasonable measures required.			
4	4.8	20 Year design life	Spec 033, 5.1.8			
5	4.9	Environmental exposure	Spec 033, 5.1.9			
6	5.1.1	Type 304L or 316L material	Spec 011, 4.1.4. Filters and downstream material SS.			
7	5.1.2	Cleaning to approved procedures	Spec 011, 4.1.8 Cleaning of piping by PSI as part of installation.			
8	5.1.6	Interchangeable separable parts	Spec 033, 5.1.10			
9	5.1.6	Lifting lugs	Spec 033, 5.1.12			
10	5.1.15	Workmanship, finish, and appearance	Spec 033, 8.5			
11	5.4	Air quality	Spec 011, 3.0. Class 100, -60 C dp, 30 psig. Spec 011, 4.1.8			
12	5.4	Valved and pressure limited	PSI P&ID's call for regulators, valves and controls Spec 011, 3.0			
13	5.4	No hydrocarbons introduced	Spec 011, 3.0. Non-lubricated compressors. Spec 011, 3.0. Carbon filters. Spec 011, 4.1.9			
14	5.4	Allow for air shower manifolds	PSI P&ID's call for connections to each chamber.			
15	6.1.3.4	Test for cleanliness	To be developed as part of commissioning.			

Project Design Requirements/Goals

Project:	LIGO Vacuum Equipment		**Date:**	2/26/96	
Project No.:	V59049		**File:**	LIGODR.WB1	
Specification No.:	LIGO-E940002-V		**Quantity:**		
Rev:	2				
Date:	8/31/95		**Prepared by:**	F. Bartl	
System or Component:	Bakeout System		**Aproved by:**	D. Williams	

Item	Spec. Reference	Description. of Design Req'ts.	Action, Conclusion, or Assignment	Action By	Date Req'd	Status
		Cost Effective Design	---	---	---	---
1	E940002V/5.5	Bakeout Temp. 150^{0}C	V59049-2-009, 3.0			
2	E940002V/5.5	2" Insulation Thickness	V59049-2-009, 4.1.3			
3	E940002V/5.5	K=.043 W/M-K	V59049-2-009, 3.0			
4	E940002V/5.5	$\Delta \pm 20^0$C	V59049-2-009, 3.0			
5	E940002V/5.5	180 KW Limitation	V59049-2-009, 4.2.3.3			
6	E940002V/5.5	2 TC's Per Blanket & Plug	V59049-2-009, 4.2.1.1			
7	E940002V/5.5	Power Plug Per Blanket	V59049-2-009, 4.2.3.2			
8	E940002V/5.5	250^{0}C for Gauges Bakeout	NA for Prototype			
9	E940002V/5.5	200^{0}C in 48 hrs Capability	V59049-2-009, 3.0			
10	E940002V/5.5	Class 50,000 Cleanroom	V59049-2-009, 4.1.2			
11	E940002V/5.5	25 KW Max For BSC	V59049-2-009, 4.2.3.3			
12	E940002V/5.5	Type "J" TC's #20	V59049-2-009, 4.2.1.1			
13		Tagging	V59049-2-009, 4.1.7			
14		Documentation	V59049-2-009, 5.0			
15		Warranty	V59049-2-009, 8.0			
16			& V59049-2-034, Article 40			

SPECIFICATION FOR

ROUGHING PUMP CARTS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE: Alan L Budlong

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Rudolf Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
3	SM 3/20/96	D. McW 3-20-96	REVISED PER DEO 0100
2	SM 12/26/95	D. McW 12-26-95	REVISED FOR PURCHASE DEO 0034
1	SM 11/9/95	D. McW 11-10-95	REVISED PER CLIENT COMMENTS DEO 0015
0	SM 10/16/95	D. McW 10-28-95	REVISED AND ISSUED FOR QUOTATION & APPROVAL/ DEO 0009
P1	T.M.C. 9-26-95		REVISED FOR UPDATED PRELIMINARY DESIGN

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED DMoore	DATE 6/14/95	APPROVED BES	DATE 9/26/95	Number V049-2-001 A	Rev. 3

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1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, and shipment of roughing pump carts. Separate carts shall be provided for the roots-type pump and for the backing pump.

All attachments are part of this specification.

The specified equipment is intended for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF contract, includes two installations at widely separated sites: near Hanford, WA and Livingston, LA. Each installation contains laser interferometers in an L shape with 4 km long arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery (for pairs of carts) shall be as follows:

	Quantity	Date
Washington Site:	2	8/1/96
Louisiana Site:	2	8/10/97
Total Required	4	

2.3 Acceptances at the sites (the start of Vendor's warranty periods) are expected to occur on a staggered basis, with final acceptance to occur no later than 6 months after delivery.

3.0 EQUIPMENT REQUIREMENTS

3.1 Each pump cart (set) shall be capable of roughing down a volume of 2,000 cubic meters from 760 torr to 1 torr without overheating.

3.2 Deleted.

3.3 The minimum required pumping speed at the pump inlet at 1 torr is 500 cfm; at 0.1 torr the minimum required pumping speed is 1000 cfm. The pump set shall be capable of roughing a volume of 200 cubic meters from atmosphere to 1 torr in 4 hours or less.

3.4 Vendor to specify system performance when cart is separated (see paragraph 4.1.1).

4.0 DESIGN REQUIREMENTS

The pumpcarts will be required to operate under two distinct operating conditions: Beam Tube evacuation and Vacuum Equipment evacuation.

1. Beam Tube Pumping

   The main roughing pumps will be used to evacuate the 2000 m^3 beam tubes. For this case the roughing pump carts will be separated by approximately 10'. It is the intent of this specification to allow this cart configuration to be the suppliers standard design.

   The beam tube evacuation will occur during initial stages of construction prior to completion of the Vacuum Equipment Building. During this phase, a temporary structure will house the pumping cart system. The pumping carts will be located on the Beam Tube Anchor Foundation (see Attachment D).

2. Vacuum Equipment Pumping

   For evacuating Vacuum Equipment during installation and maintenance, the pumping carts will be separated into two sections. The first stage blower will be close coupled to the Vacuum Equipment in the Vacuum Equipment room. The first stage pumps will discharge into a vacuum header connected to the second stage blower and backing pumps which will be located in a separate Mechanical Equipment Room (to minimize noise and eliminate the requirement for supplying large quantities of cooling water into the Vacuum Equipment Room). The vacuum equipment support structure for the final configuration of the first stage blower will be provided by PSI.

4.1 Mechanical Requirements

4.1.1 Each cart set shall consist of a roots-type blower cart backed by one or more mechanical pumps on a separate cart, and accessories described below and on the attached P&ID Bypass valves shall be provided if required by the vendors design. Initial operation will have the blower and backing pump separated via the 10′ of flex hose between blower discharge and the backing pump. Future operation will have the carts separated via 10′ of flex hose and a vacuum header.

4.1.2 Each cart shall be a complete system mounted on a frame suitable for operation in a Federal Standard 209 Class 50,000 environment (cleanroom). Vibration isolation supports shall be included. Castors or pallet jack access must be provided for each cart.

4.1.3 The design of the carts shall preclude contamination of the vacuum chambers during the life of the equipment, even in the event of equipment failure or operator error.

4.1.4 The process inlet to the cart shall be supplied by others. Seals shall be non-lubricated baked Viton O-rings.

4.1.5 The process outlet from the roots-type pump cart shall incorporate a 10‘ long flex line for connection to the backing pump or in the future a vacuum header. This connection shall, depending on the required tube size, be an ISO Quick Flange or Large Flange with double claw clamps. Seals shall be non-lubricated baked Viton O-rings.

4.1.6 Provision for sealed connection to a ducted facility exhaust system shall be provided on the backing pump outlet.

4.1.7 There shall be no oil in the pumping path.

4.1.8 Any required utility connections (such as for cooling water) shall be manifolded to a single connection point and terminated appropriately (such as with an isolation valve and a 1/2" quick disconnect fitting). Filtered cooling water will be provided as follows:

Supply Temperature:	20 - 25C
Supply Pressure:	3. - 5. bara
Return Temperature:	25 - 30C
Return Pressure:	2. - 4. bara

Cooling water hose kits shall be provided to interconnect the blower cart and the backing pump. The hoses shall be 15′ long.

4.1.9 The roots pump cart inlet nozzle shall be located at as low an elevation as possible. A blind flange with a gauge connection and suitable volume for shop speed testing shall be provided.

4.1.10 The acoustic noise and vibration requirement detailed in Section 5.1 of Attachment A do not apply to the roughing pump carts.

4.2 Electrical Requirements

4.2.1 Instrumentation Requirements

4.2.1.1 There shall be Pirani vacuum gauges located at each pump inlet (both the roots pump and the backing pump). Bakeable vacuum gauges are required only for the inlet (chamber side) of the roots blower. A local vacuum gauge readout controller shall be provided. The vacuum gauges will remain with the roots blower when the backing pump is remotely located.

4.2.1.2 There shall be auxiliary valved (manual valves) ports to allow connection of a leak detector.

4.2.1.3 All unused ports shall be fitted with blankoff flanges.

4.2.1.4 A purge gas flow switch (or pressure switch) shall be provided to shutdown the cart when there is insufficient purge gas flow (or pressure). An adjustable 10-60 second delay timer shall be included in the shutdown logic to prevent spurious shutdowns.

4.2.2 Controls Requirements

4.2.2.1 Controls for local operation shall be provided. The Buyer will interconnect the cart wiring when they are installed in the split location for Vacuum Equipment pumping (terminals to be provided by the vendor). In addition, provide terminal strips in a junction box to interface with the future LIGO control system. The following signals shall be provided:

Description	Signal Type
Pump Running (Each Pump)	Dry Contacts
Auto. Valve Open	Dry Contacts
Roots Pump Inlet Vacuum	0 - 10 VDC
Backing Pump Vacuum	0 - 10 VDC
Purge Gas Shutdown	Dry Contacts

4.2.2.2 The pump carts shall be self-contained so that, under power failure or pump failure, interlocks shall prevent pumped chambers from being vented or from being exposed to a non-operating pump.

4.2.2.3 A manual gate valve on the chamber nozzle will be provided by others. A fail closed pneumatically actuated 6" UHV gate valve (with pilot solenoid and open and closed limit switches) shall be provided on the inlet of the roots pump cart. The controls necessary to close this valve on pump failure shall be incorporated into the cart controls.

4.2.2.4

4.2.2.5 Pumps shall be stopped and started by pushbutton switches located on the blower cart. The backing cart shall be capable of being started and stopped by a signal from the blower cart.

4.2.2.6 Vendor must list in his quotation all safety devices (such as flow switches, pressure switches, temperature switches, safety relief valves, etc.) supplied with the systems.

4.2.2.7 Vendor must provide in his quotation a brief description of all operational sequences such as startup, normal quotation, normal shutdown, safety shutdowns, etc.

4.2.3 Power Requirements

4.2.3.1 Power connection to the cart shall be by an appropriate 20' long cord with twist-lock, NEMA type plug configuration (a single connection for the cart including controllers when configured as one assembly). Required controllers and overload protection shall be provided on the cart. Vendor must provide specifications for the power and control cables needed to connect the separated cart components. The field wiring cables will be provided by the Buyer when the blower is remotely located. Vendor will provide the cables needed when the carts are located together.

4.2.4 Purge Gas

Clean, dry, air will be supplied at 80 psig for use as seal purge gas for the vacuum pumps requiring this utility.

5.0 REQUIRED DOCUMENTATION

Documentation requirements listed in Attachment B and attached Q.A. requirements form, Attachment A shall be provided according to the Buyer's schedule.

6.0 SHOP TESTING

In addition to the Vendor's standard tests, each electrically powered vacuum pump cart shall be tested for speed, ultimate pressure, leakage and operation of protective features. All safety interlocks shall be tested for proper operation by simulating the faulted condition.

7.0 INSPECTION

All testing and inspections called for in Attachment B (Specification V049-2-033 General Equipment Requirements) shall be performed by the Vendor. Additional quality assurance requriements are listed in Attachment A, Quality Assurance Requirements Summary.

8.0 WARRANTY

Refer to Specification V049-2-034, Equipment Purchase Commercial Requirements for Warranty Requirements

ATTACHMENT "A"
LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: ROUGHING PUMP CART	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO: V049-2-001

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE	2 Wks.		X	2	X		
VENDOR Q.A. PLAN	2		X	2	X		
PREP FOR SHIPMENT PROCEDURE	2		X	2	X		
ASSEMBLY DRAWINGS	6		X	2	X		
DESIGN REVIEW	4	X			X		
IN-PROCESS INSPECTIONS		X		2	X	Prior to release for fabrication.	
OPERATION & MAINTENANCE MANUALS	TBD			5	X		
SHOP TEST PLAN	8		X	2	X	Prior to release for fabrication.	
SHOP TEST (WITH REPORT)		X		2	X	Prior to release for shipment.	

SPECIFICATION FOR

MAIN TURBOMOLECULAR CARTS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE: Alan H Bradbrook

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Richard Bayley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
4	DM 3/20/96	D. McW	REVISED PER DEO 0100
3	DM 12/26/95	D. McW 1-2-96	REVISED FOR PURCHASE DEO0034
2	DM 11/9/95		REVISED PER CLIENT COMMENTS DEO0015
1	DM 11/2/95		REVISED ATTACHMENT C P&ID V049-0-041 TO P2
0	DM 10/16/95	D. McW 10-20-95	REVISED & ISSUED FOR QUOTATION & APPROVAL/DEO 0004
P1	TM 9-26-95		REVISED FOR UPDATED PRELIMINARY DESIGN

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED: DMoore	DATE: 6/14/95	APPROVED: KEB	DATE: 9/26/95	Number: V049-2-002 A	Rev. 4

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1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, and shipment of the main turbomolecular pump carts (and backing pump carts).

All attachments are part of this specification.

The specified equipment is intended for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF contract, includes two installations at widely separated sites: near Hanford, WA and Livingston, LA. Each installation contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery (for pairs of carts) shall be as follows:

	Quantity	Date
PSI (Westboro, MA)	2	4/1/96
Washington Site	4	8/1/96
Louisiana Site	4	8/10/97
Total Required	10	

2.3 Acceptances at the sites (the start of Vendor's warranty periods) are expected to occur on a staggered basis, within 6 months of delivery.

3.0 EQUIPMENT REQUIREMENTS

The main turbomolecular pump carts are to be used to pump down large volumes from 1 torr to 1 x 10^{-6} torr. The minimum speed at the inlet port shall be 1,400 l/s for nitrogen at 1 x 10^{-3} torr. The pump set shall be capable of a throughput of at least 5 torr-liters per second at a backing pressure of 1 torr. The pump set shall be capable of pumping a volume of at least 2,000 cubic meters (from 1 torr to 1 x 10^{-6} torr) without overheating.

The backing pump will be used to rough pump volumes up to 70 m^3 from atmosphere. The cart shall be equipped with a bypass line and manual valving to allow the turbo pump to be bypassed during early stages of pumpdown.

3.1 Vendor to specify system performance (speed vs. pressure curve) when the cart is separated (see paragraph 4.1.1).

4.0 DESIGN REQUIREMENTS

The main turbo pump carts will be required to operate under two distinct operating conditions: Beam Tube Evacuation and Vacuum Equipment Evacuation.

1. Beam Tube Pumping

   The main turbomolecular pumps will be used initially to evacuate the 2000 m^3 Beam Tube. For this case all of the vacuum pump components will be mounted on a single cart (or two frames bolted together). It is the intent of this specification to allow this cart configuration to be the suppliers standard design.

   The Beam Tube evacuation will occur prior to completion of the Vacuum Equipment Building. During this phase, a temporary structure will house the pumping cart. The pumping cart will be located on the Beam Tube Anchor Foundation (see Attachment D).

2. Vacuum Equipment Pumping

   For evacuating the Vacuum Equipment during installation and maintenance, the pumping carts will be separated into two sections (by the buyer). The turbo molecular pump will be close coupled to the Vacuum Equipment in the Vacuum Equipment Room. It will discharge into a vacuum header connected to dry backing pump which will be located in a separate Mechanical Equipment Room (to minimize noise and vibration).

   The turbomolecular cart will be modified by PSI to reduce vibration transmission into the vacuum vessels and into the floor.

4.1 Mechanical Requirements

4.1.1 Each turbomolecular pump set shall consist of a "wide range" magnetically levitated turbomolecular pump backed by an oil-free pump (diaphragm, piston or scroll pump) on separate carts. Also included on the carts are the accessories described below and on the attached P&ID. Initial operation will require the turbo cart to be mounted on top of the backing cart. Future operation will have the turbopump and backing pumps separated via the following vacuum header: 240' of 4" diameter pipe, (6) 90 degree elbows, (1) 45 degree elbow, (1) tee (branch), 10' of 1 1/2" flex hose between turbopump discharge and header.

4.1.2 Each cart shall be a complete system mounted on a frame suitable for operation in a Federal Standard 209 Class 50,000 environment (cleanroom). Vibration isolation supports shall be included.

4.1.3 The design of the carts shall preclude contamination of the vacuum chambers during the life of the equipment, even in the event of equipment failure or operator error.

4.1.4 The inlet connection to the turbomolecular pump will be a 12" O.D. conflat. Turbomolecular pumps shall be supplied with protective inlet screens.

4.1.5 The process outlet from the turbo pump cart shall incorporate a 10' long flex line for connection to a vacuum header. This connection shall, depending on the required tube size, be an ISO Quick Flange or Large Flange with double claw clamps. Seals shall be non-lubricated baked Viton O-rings.

4.1.6 Provision for sealed connection from the backing pump outlet to a ducted facility exhaust system shall be provided.

4.1.7 There shall be no oil in the pumping path.

4.1.8 Any required utility connections (such as for cooling water) shall be manifolded to a single connection point and terminated appropriately (such as with an isolation valve and a 1/2" quick disconnect fitting). Filtered cooling water will be provided as follows:

Supply Temperature:	20 - 25C
Supply Pressure:	3. - 5. bara
Return Temperature:	25 - 30C
Return Pressure:	2. - 4. bara

4.1.9 The turbo pump shall be portable and connected to the pumpcart by 10ft. long flex line for vacuum, power, and cooling water. For pumping of the Beam Tube the TMP will be mounted horizontally and hard piped to an isolation valve mounted on top of the Beam Tube. A blind flange with a gauge connection and suitable volume for shop speed testing shall be provided.

4.1.10 Insulated heating jackets with temperature controllers for the turbo pumps and inlet piping (flex) up to the turbo inlet flanges will be provided by the buyer. The heaters shall be capable of temperature control up to 120 C.

4.2 Electrical Instrumentation Requirements

4.2.1 Instrumentation Requirements

4.2.1.1 There shall be vacuum gauges located at each pump inlet (both the turbomolecular pump and the backing pump). The inlet to the turbomolecular pump shall have both a Pirani gauge and a cold cathode gauge, and the inlet to the backing pump shall have a Pirani gauge. All vacuum gauges remain with the turbomolecular pump when the backing pump is remotely located. Bakeable (to 250C) vacuum gauges are required only for the inlet (chamber side) of the turbopump. A local vacuum gauge controller shall be provided with each cart.

4.2.1.2 There shall be auxiliary valved (manual valves) ports to allow connection of a leak detector.

4.2.1.3 All unused ports shall be fitted with blankoff flanges.

4.2.1.4 A purge gas flowswitch (or pressure switch) shall be provided to shutdown the cart when there is insufficient purge gas flow (or pressure). An adjustable 10-60 second delay timer shall be included in the shutdown to prevent spurious shutdowns.

4.2.2 Controls Requirements

4.2.2.1 Controls for local operation shall be provided. The buyer will interconnect the cart wiring when they are installed in the split location for vacuum equipment pumping (terminals to be provided by the vendor). In addition, provide terminal strips in a junction box to interface with the future LIGO control system. The following signals shall be provided:

Description	Signal Type
Pump Running (Each Pump)	Dry Contacts
Auto. Valve Open & Closed	Dry Contacts
Turbo Pump Inlet Vacuum (2)	0 - 10 VDC (2)
Backing Pump Vacuum	0 - 10 VDC
Purge Gas Shutdown	Dry Contacts

4.2.2.2 The pump carts shall be self-contained so that, under power failure or pump failure, interlocks shall prevent pumped chambers from being vented or from being exposed to a non-operating pump.

4.2.2.3 A manual gate valve on the chamber nozzle will be provided by others. A fail closed pneumatically actuated valve (with pilot solenoid and open and close limit switches) shall be provided on the outlet of the roots pump cart. The controls necessary to close this valve on pump failure shall be incorporated into the cart controls.

4.2.2.4

4.2.2.5 Pumps shall be stopped and started by pushbutton switches located on the turbo cart. The backing cart shall be capable of being started and stopped by a signal from the turbo cart. The control system must include a safety permissive that requires the turbomolecular pump foreline pressure to be < 2 torr before the turbo pump is allowed to start.

4.2.2.6 Vendor must list in his quotation all safety devices (such as flow switches, pressure switches, temperature switches, safety relief valves, etc.) supplied with the systems.

4.2.2.7 Vendor must provide in his quotation a brief description of all operational sequences such as startup, normal operation, normal shutdown, safety shutdowns, etc.

4.2.3 Power Requirements

4.2.4 Purge Gas

Clean, dry, air will be supplied at 15 psig for use as seal purge gas for the vacuum pumps requiring this utility.

4.2.3.1 Power connection to the cart shall be by an appropriate 20' long cord with twist-lock, NEMA type plug configuration (a single connection for the cart, including controllers when configured as one assembly and two cards and plugs when separated into two sections). Required controllers and overload protection shall be provided on the cart. Vendor must provide specifications for the power and control cables needed to connect the separated cart components. Field wiring cables will be provided by buyer when the turbopump is remotely located. Vendor will provide the cables needed when the turbopump is located on the cart.

5.0 REQUIRED DOCUMENTATION

Documentation requirements listed in Attachment B and the QA requirements form, Attachment A, shall be provided according to the Buyer's schedule.

6.0 SHOP TESTING

In addition to the Vendor's standard tests, each electrically powered vacuum pump cart shall be tested for speed, acoustic noise, ultimate pressure, leakage and operation of protective features. All safety interlocks shall be tested for proper operation by simulating the faulted condition.

7.0 INSPECTION

All testing and inspections called for in Attachment B (Specification V049-2-033, General Equipment Requirements) shall be performed by the Vendor. Additional quality assurance requirements are listed in Attachment A, Quality Assurance Requirements Summary.

8.0 WARRANTY

Refer to Specification V049-2-034, Equipment Purchase Commercial Requirements for Warranty Requirements.

ATTACHMENT "A"
LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: MAIN TURBOMOLECULAR PUMPS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-002

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE	2 Wks.		X	2	X		
VENDOR Q.A. PLAN	2		X	2	X		
CLEANING PROCEDURE	2		X	2	X		
PREP FOR SHIPMENT PROCEDURE	6		X	2	X		
ASSEMBLY DRAWINGS	4		X	2	X		
DESIGN REVIEW		X			X	Prior to release for fabrication.	
IN-PROCESS INSPECTIONS	TBD	X		2	X		
OPERATION & MAINTENANCE MANUALS	8			5	X		
SHOP TEST PLAN			X	2	X	Prior to release for fabrication.	
SHOP TEST (WITH REPORT)		X		2	X	Prior to release for shipment.	

SPECIFICATION FOR

AUXILIARY TURBOMOLECULAR PUMP CARTS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE: Alan L Burbank

TECHNICAL DIRECTOR: D. A. Mueller Adams

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
3	dm 3/20/96	D. Mlw 3-20-96	REVISED FOR PURCHASE OEO 0100
2	dm 12/26/95		REVISED FOR PURCHASE OEO 0034
1	dm 11/9/95		REVISED PER CUSTOMER COMMENTS OEO 0016
0	dm 10/16/95		REVISED & ISSUED FOR QUOTATION & APPROVAL/OEO 0004
P1	TMS 9-26-95		REVISED FOR UPDATE & PRELIMINARY DESIGN

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number V049-2-003 / Rev. 3
	DMoore	6/19/95	RCB	9/26/95	A

SPECIFICATION TABLE OF CONTENTS

Number

Rev.

SPECIFICATION

Number A V049-2-003 Rev. 3

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, and shipment of the auxiliary turbomolecular pump carts. The Vendor shall quote 1) complete packages and 2) individual components.

All attachments are part of this specification.

The specified equipment is intended for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF contract, includes two installations at widely separated sites: near Hanford, WA and Livingston, LA. Each installation contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

	Quantity	Date
PSI (Westboro, MA)	2	4/1/96
Washington Site:	2	8/1/96
Louisiana Site:	2	8/10/97
Washington Site:	3	9/1/97
Louisiana Site:	1	3/1/98
Total Required	10	

2.2 Acceptances at the sites (the start of Vendor's warranty periods) are expected to within 6 months of delivery.

3.0 EQUIPMENT REQUIREMENTS

The auxiliary turbomolecular pump carts are to be used to rough pump annular spaces between flange seals in various components. The minimum speed at the inlet port of the turbo pump shall be 50 l/s for nitrogen. (Once the annular space is roughed to, it will be maintained by an ion pump supplied by others.)

4.0 DESIGN REQUIREMENTS

4.1 Mechanical Requirements

4.1.1 Each turbomolecular pump set shall consist of a turbomolecular pump backed by an oil-free pump (diaphragm, piston or scroll pump). Also included on the carts are the accessories described below and on the attached P&ID. If a manual bypass around the TMP is necessary to permit operation from atmosphere pressure, it shall be provided by the vendor.

4.1.2 Each cart shall be a complete system mounted on a frame suitable for operation in a Federal Standard 209 Class 50,000 environment (cleanroom). Vibration isolation supports shall be included.

4.1.3 The design of the cart shall preclude contamination of the vacuum chambers during the life of the equipment, even in the event of equipment failure or operator error.

4.1.4 Deleted.

4.1.5

4.1.6 There shall be no oil in the pumping path.

4.1.7 Any required utility connections (such as for cooling water) shall be manifolded to a single connection point and terminated appropriately (such as with an isolation valve and a 1/2" quick disconnect fitting).

Filtered cooling water will be provided as follows:

Supply Temperature:	20 - 25C
Supply Pressure:	3. - 5. bara
Return Temperature:	5 - 30C
Return Pressure:	2. - 4. bara

4.1.8 The process inlet to the cart shall include a flex line or bellows for connection to the roughing ports (ISO Quick Flange or Large Flange with clam shell closure, depending on the required tube size to meet the required pumping speed). Seals shall be non-lubricated baked Viton O-rings. Other connection types shall be as indicated on the attached P&ID.

4.1.9 The Buyer will supply insulated heating jackets with temperature controllers for heating the turbo pumps.

4.2 Electrical Requirements

4.2.1 Instrumentation Requirements

4.2.1.1 There shall be vacuum gauges located at each pump inlet (both the turbomolecular pump and the backing pump). The inlet to the turbomolecular pump shall have both a Pirani gauge and a cold cathode gauge, and the inlet to the backing pump shall have a Pirani gauge. Bakeable vacuum gauges are required only for the inlet (chamber side) of the turbopump (to 250^{0}C). A local vacuum gauge readout controller shall be supplied with each cart.

4.2.1.2 There shall be auxiliary valved (manual valves) ports to allow connection of a leak detector to the inlet and oulet of the TMP.

4.2.1.3 All unused ports shall be fitted with blankoff flanges.

4.2.2 Controls Requirements

4.2.2.1 Controls for local operation shall be provided. In addition, provide terminal strips in a junction box to interface with the future LIGO control system. The following signals shall be provided:

Description	Signal Type
Pump Running (Each Pump)	Dry Contacts
Auto. Valve Open	Dry Contacts
Roots Pump Inlet Vacuum	0 - 10 VDC
Turbo Pump Inlet Vacuum (2)	0 - 10 VDC (2)

4.2.2.2 The pump cart shall be self-contained so that, under power failure or pump failure, interlocks shall prevent pumped volumes from being vented or from being exposed to a non-operating pump.

4.2.2.3 A manual gate valve on the chamber nozzle will be provided by others. A fail closed pneumatically actuated valve (with pilot solenoid) shall be provided on the inlet of the TMP. The controls necessary to close this valve on pump failure shall be incorporated into the cart controls. An automatic vent valve and associated controls shall be provided to properly vent the TMP during a shutdown.

4.2.2.4

4.2.2.5 Pumps shall be stopped and started by pushbutton switches located on the cart.

4.2.2.6 Vendor must list in his quotation all safety devices (such as flow switches, pressure switches, temperature switches, safety relief valves, etc.) supplied with the systems.

4.2.2.7 Vendor must provide in his quotation a brief description of all operational sequences such as startup, normal, operation, twist-lock, NEMA type plug configuration normal shutdown, safety shutdowns, etc.

4.2.3 Power Requirements

Power connection to the cart shall be by an appropriate 20' long cord with (a single connection for the cart, including controllers). Required controllers and overload protection shall be provided on the cart.

5.0 REQUIRED DOCUMENTATION

Documentation requirements listed in Attachment B and the Q.A. requirement form, Attachment A, shall be provided according to the Buyer's schedule.

6.0 SHOP TESTING

In addition to the Vendor's standard tests, each electrically powered vacuum pump cart shall be tested for speed, acoustic noise, ultimate pressure, leakage and operation of protective features. All safety interlocks shall be tested for proper operation by simulating the faulted condition.

7.0 INSPECTION

All testing and inspections called for in Attachment B (Specification V049-2-033, General Equipment Requirements) shall be performed by the Vendor. Additional quality assurance requirements are listed in Attachment A, Quality Assurance Requirements Summary.

8.0 WARRANTY

Refer to Specification V049-2-034, Equipment Purchase Commercial Requirements for Warranty Requirements.

ATTACHMENT "A"
LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: ION PUMPS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-003

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE	2 Wks.		X	2	X		
VENDOR Q.A. PLAN	2		X	2	X		
CLEANING PROCEDURE	2		X	2	X		
PREP FOR SHIPMENT PROCEDURE	6		X	2	X		
ASSEMBLY DRAWINGS	4		X	2	X		
DESIGN REVIEW		X			X	Prior to release for fabrication.	
IN-PROCESS INSPECTIONS	TBD	X		2	X		
OPERATION & MAINTENANCE MANUALS	8			5	X		
SHOP TEST PLAN			X	2	X	Prior to release for fabrication.	
SHOP TEST (WITH REPORT)	*	X		2	X	Prior to release for shipment.	

SPECIFICATION FOR

ION PUMPS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: D Moore

QUALITY ASSURANCE: Allan L Bradbrook

TECHNICAL DIRECTOR: D. C. McWilliams

PROJECT MANAGER: Rachel Bayley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
2	3-13-96	RES	RELEASED FOR PURCHASE PER DEO # 0092
1	2-14-96 ETC	REB	RELEASED FOR PURCHASE PER DEO 0063
0	SLC 11-16-95		RELEASED FOR APPROVAL & QUOTATION PER DEO 0018
P1	10-19-95	RES	Released per DEO 0005
P1	TMS 9-26-95		REVISED FOR UPDATED PRELIMINARY DESIGN

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION		
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number V049-2-004	Rev.
	D Moore	6/14/95	REB	9/26/95	A	2

SPECIFICATION TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of the ion pumps for the LIGO vacuum system. The ion pumps will be used to perform the following functions:

a) Maintain an ultra high vacuum in the equipment at the corner, mid and end stations of the LIGO interferometer (main ion pumps).

b) Maintain an ultra high vacuum in the annular spaces between dual-sealed flanges on the chambers (chamber annulus ion pumps).

c) Maintain an ultra high vacuum in the annular spaces between the double gate seals and dual seal flanges of the large gate valves which isolate sections of the interferometer from each other (valve annulus ion pumps).

All attachments are incorporated herein by reference and made a part of this specification.

The specified equipment is intended for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF grant, includes two sites (Hanford Reservation, near Richland, WA and Livingston, LA). Each site contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

Main Ion Pumps (2500 l/s)

Total Qty.	Description	PSI Part #	Lot *	Qty.	Delivery Date
18	2500 l/s Noble Diode Pump w/2 electrically isolated sections controlled by 2 individual feedthroughs	V0492004 P1	L1	1	7/1/96
			L2	12	5/1/97
			L3	5	11/1/97
18	2-3/4" CF Roughing Port	V0492004 P2	L1	1	7/1/96
			L2	12	5/1/97
			L3	5	11/1/97
18	8" CF Additional Port	V0492004 P3	L1	1	7/1/96
			L2	12	5/1/97
			L3	5	11/1/97
20	150' HV Cables	V0492004 P4	L0	2	5/1/96
			L2	10	5/1/97
			L3	8	11/1/97
16	250' HV Cables	V0492004 P5	L2	12	5/1/97
			L3	4	11/1/97
18	Multivac base unit w/Remote Interface/Setpoint Board	V0492004 P6	L0	2	5/1/96
			L4	16	5/1/97
36	Large HV Card w/programmable voltage	V0492004 P7	L0	4	5/1/96
			L4	32	5/1/97
13	Rack Adapter Kit	V0492004 P13	L0	1	5/1/96
			L4	12	5/1/97

CONTROLLERS CHAMBER AND BEAM MANIFOLD ANNULUS ION PUMPS AND 75 l/s ION PUMP

Total Qty.	Description	PSI Part #	Lot *	Qty.	Delivery Date
43	75 l/s Noble Diode Pump	V0492004 P8	L0	4	5/1/96
			L2	28	5/1/97
			L3	11	11/1/97
43	2-3/4" CF Roughing Port	V0492004 P2	L0	4	5/1/96
			L2	28	5/1/97
			L3	11	11/1/97
43	10' HV Cables	V0492004 P9	L0	4	5/1/96
			L2	28	5/1/97
			L3	11	11/1/97
43	Minivac Power Supply	V0492004 P10	L0	4	5/1/96
			L2	28	5/1/97
			L3	11	11/1/97

VALVE ANNULUS ION PUMPS AND CONTROLLERS 25 l/s ION PUMP

Total Qty	Description	PSI Part #	Lot	Qty	Delivery Date
32	25 l/s Noble Diode Pump	V0492004 P11	L2	20	5/1/97
			L3	12	11/1/97
32	2-3/4" CF Roughing Port	V0492004 P2	L2	20	5/1/97
			L3	12	11/1/97
32	10' HV Cables	V0492004 P9	L2	20	5/1/97
			L3	12	11/1/97
32	Minivac Power Supply	V0492004 P10	L2	20	5/1/97
			L3	12	11/1/97
1	AVS Speed Test	V0492004 P12	Per Spec		

*L0 = PSI Site; 5/1/96

L1 = PSI Site; 7/1/96

L2 = Washington Site; 5/1/97

L3 = Louisiana Site; 11/1/97

L4 = PSI Site; 5/1/97

Number

Rev.

Above is for pumps and cables. All main ion pump controllers will be shipped to PSI (Westboro, MA) on specified dates listed above except for Lot 1.

Lot 1 (Qty 1) and Lot 3 (Qty 1) will be shipped on 5/1/96. Remaining controllers from Lot 3 will be shipped as specified above.

2.2 Acceptances at the sites are expected to occur on a staggered basis, with final acceptance at Washington expected to occur about May 31, 1998, and about November 30, 1998 in Louisiana.

3.0 EQUIPMENT REQUIREMENTS

3.1 Main Ion Pumps

3.1.1 The main ion pumps shall have minimum nominal pumping speeds at the pump inlet of 2,500 liter/sec for nitrogen at 1×10^{-6} torr and 4,700 liters/sec for hydrogen at 1×10^{-9} torr. The minimum guaranteed pumping speeds for other gases at the partial pressures specified in Table 1 shall be stated. The pumping speed for nitrogen for total pressures ranging from 1×10^{-6} torr to 1×10^{-10} torr shall be stated.

Table 1

Species	Partial Pressure (Torr)	Min. Required Pumping Speed
H_2O	5×10^{-9}	2940 l/s
H_2	5×10^{-9}	4700 l/s
N_2	5×10^{-10}	2500 l/s
CO	5×10^{-10}	2350 l/s
CO_2	2×10^{-10}	2940 l/s
CH_4	2×10^{-10}	2150 l/s
He	5×10^{-10}	295 l/s
Ar	5×10^{-10}	590 l/s

3.1.2 A single large pump shall be provided.

3.1.3 Noble gas diode-type ion pumps with a minimum life of 40,000 hours or more at an operating pressure of 10^{-6} torr shall be used.

3.1.4 Main Ion Pumps (cell design and feedthroughs) shall be designed to allow starting at pressures of at least 1x 10^{-5} torr (two feedthroughs).

For this requirement, the vendor shall provide a design that electrically connects one half of the pump to one feedthru, while the remaining cells are connected to the other feedthru.

3.1.5 The vendor shall supply a controller for each main ion pump with sufficient current capability to start the pump at a pressure of at least $1x10^{-6}$ torr and run all cells of the pump under normal operation ($1x10^{-6}$ torr and lower).

3.1.6 Dual cabling shall be provided from controller to pump.

3.2 Chamber Annulus Pumps

3.2.1 Noble gas diode ion pumps, each with a capacity of 75 l/s of air at 1 x 10^{-6} torr, shall be provided for each chamber to maintain the annular vacuum for dual-sealed flanges.

3.2.2 The vendor shall supply a controller for each annulus ion pump with sufficient current capability to start the pump at a pressure of at least $5x10^{-6}$ torr.

3.3 Valve Annulus Ion Pumps

3.3.1 Noble gas diode ion pumps shall be provided for each large gate valve to maintain the annular vacuum at the valve flange dual seal annuli, as well as the dual gate seals when the valves are closed.

3.3.2 Each valve annulus ion pump shall have a capacity of 25 l/s of air at 1 x 10^{-6} torr..

3.3.3 The vendor shall supply a controller for each annulus ion pump with sufficient current capability to start the pump at a pressure of at least $5x10^{-6}$ torr.

4.0 DESIGN REQUIREMENTS

4.1 Mechanical Requirements

4.1.1 The main ion pump shall be a single pump. The pump will be supplied with a 14" O.D. tube on which a 16.5" Conflat Flange (CF) is mounted. The pipe or manifold on which the ion pump mounts will be the responsibility of the Buyer.

4.1.2 The chamber annulus ion pumps will be supplied with a 2.5" O.D. tube on whch a 4.5" CF is mounted.

4.1.3 The valve annulus ion pumps will be supplied with a 1.5" O.D. tube on which a 2 3/4" CF is mounted.

4.1.4 Electrical feedthroughs shall be protected from mechanical damage.

41.5. All annulus pumps shall have a minimum life of 40,000 hours or more at an operating pressure of 10^{-6}.

4.1.6 The vendor shall provide mounting or internal supports for the main pump (if necessary) to allow the pump to be mounted vertically from the CF. Lifting lugs shall be provided. See attached drawing.

4.1.7 All ion pump shalls be supplied with a 2 3/4" CF roughing port.

4.1.8 All main ion pumps shall be supplied with an additional 3" Conflat Flange (CF) and 8" CF blank.

4.2 Electrical Requirements

4.2.1 Instrumentation Requirements

4.2.1.1 The cables to interconnect the main ion pumps and controllers shall be provided. 20 cables will be 150' long. The remaining 16 will be 250' long.

4.1.1.2 The cables to interconnect the annulus ion pumps and controllers shall be provided. The cable length is approximately 10 feet for each pump.

4.2.1.3 Unused ports shall be fitted with blankoff flanges.

4.2.1.4 The vendor will submit full load power requirements for each controller.

4.2.2 Controls Requirements

4.2.2.1 The main ion pump controllers shall be rack mountable in standard 19 inch rack consoles (supplied by others). These consoles may be located up to 250 feet (cable length) away from the pumps. Rack mount hardware should be included with the power supplies.

4.2.2.2 All main ion pump controllers shall be supplied with (2) HV cards installed by the vendor that will provide a combined capacity of 800 MA.

4.2.2.3 All main ion pump controllers shall have remote capabilities that include the following:

Run Status	Dry Contact Output
Pump Fail	Dry Contact Output
Current Trip	Dry Contact Output
Standby Mode	Dry Contact Input
Start	Dry Contact Input
Stop	Dry Contact Input

0-10VDC analog output proportional to ion pump current.

0-10VDC analog output proportional to ion pump voltage.

4.2.2.4 All annulus pump controllers will have a single 0-10VDC analog output proportional to the ion pump current.

4.2.2.5 All annulus pump controllers are not required to be rack mountable and will be located within 10 feet of the pumps.

4.2.2.6 Vendor shall provide max. starting pressures for all controller/pump combinations.

5.0 REQUIRED DOCUMENTATION

Documentation requirements listed in Attachment B shall be provided according to the Buyer's schedule (schedule later).

6.0 SHOP TESTING

In addition to the Vendor's standard tests, the first lot (Lot #1) of pumps shall be tested for speed, ultimate pressure, leakage and normal operation, referencing Table #1 located in Section 3.1.1 of this specification. All safety interlocks shall be tested.

7.0 INSPECTION

The inspections called for in Attachment A & B shall be performed by the Vendor. Each pump shall be inspected for dimensional ionformance to approved assy. drwings.

8.0 WARRANTY

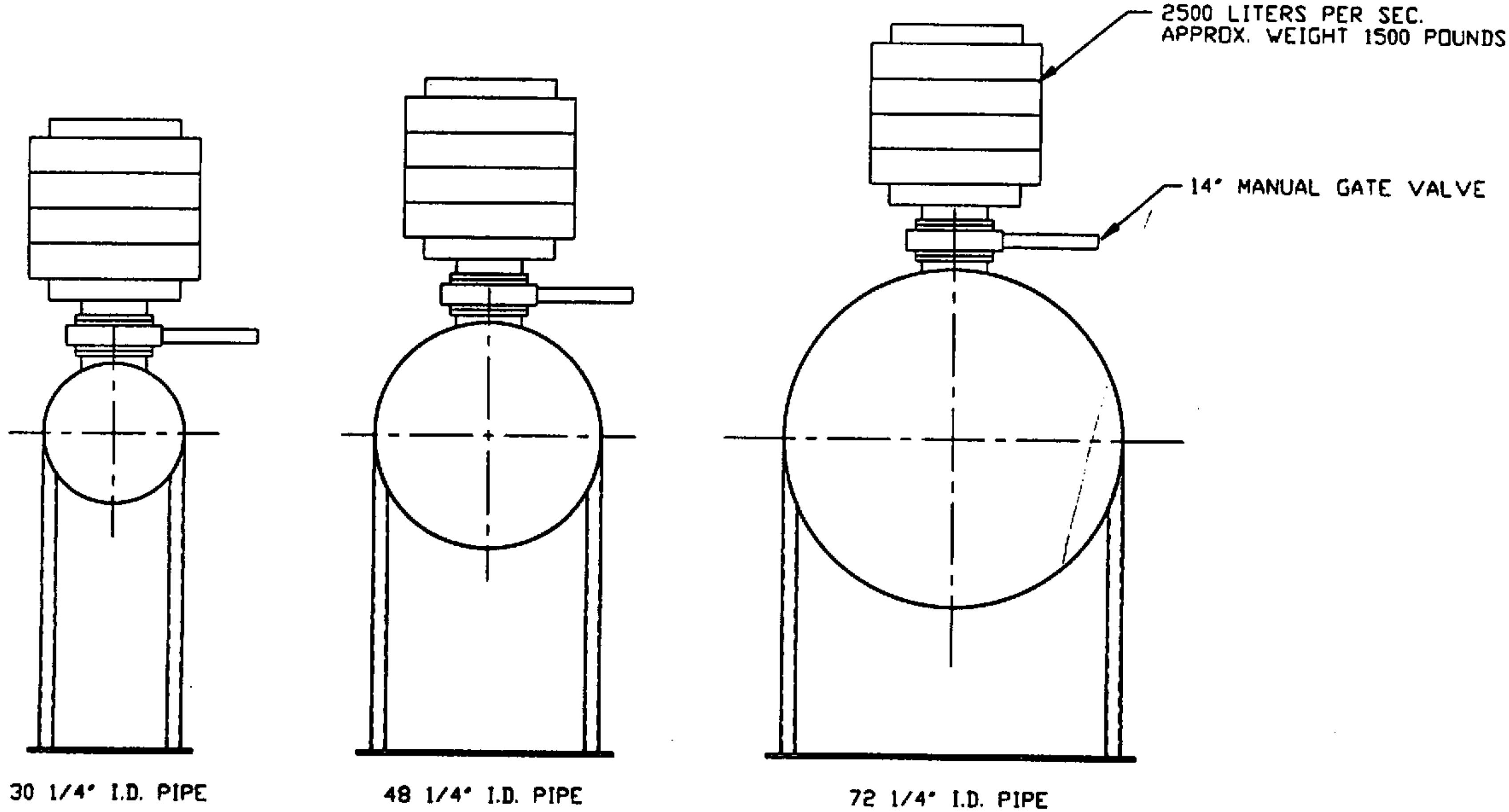
Refer to RFQ for warranty requirements.

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: ION PUMPS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-004

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE	4 Wk		X	2	X		
VENDOR Q.A. PLAN	4 Wk		X	2	X		
CLEANING PROCEDURE	4 Wk		X	2	X		
PREP FOR SHIPMENT PROCEDURE	4 Wk		X	2	X		
ASSEMBLY DRAWINGS	8 Wk		X	2	X		
DESIGN REVIEW	*	X			X		
IN-PROCESS INSPECTIONS	*	X		2	X		
OPERATION & MAINTENANCE MANUALS	12 Wk			5	X		
SHOP TEST PLAN	8 Wk		X	2	X		
SHOP TEST (WITH REPORT)	*	X		2	X		
SHOP DIMENSIONAL INSPECTION	*	X		2	X		
* PER APPROVED VENDOR SCHEDULE							



DO NOT SCALE THIS DWG

USED ON

NEXT ASSY

REV	DESCRIPTION	CHKD	DRWN	DATE	DESGN

ISSUE DESCRIPTION

PROCESS SYSTEMS INTERNATIONAL, INC.

ION PUMP SUPPORTS
LIGO VACUUM EQUIPMENT

SIZE B

REV 0

SCALE N.T.S.

SHEET 1 OF 1

SPECIFICATION FOR

112 AND 122 CM GATE VALVES

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE: Alan L Badhook

TECHNICAL DIRECTOR: D. C. McWilliams

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
3	TMS 12-26-95	D. M 2W 1-9-96	REVISED WELD STUB REQUIREMENTS PER DEO 0036
2	TMS 12-6-95	MCB 12/7/95	REVISED FOR RELEASE PER DEO 0029
1	TMS 11-9-95	D M W 11-9-95	REVISED PER CUSTOMER COMMENTS / DEO 0014
0	TMS 10-26-95	D M W 10-28-95	REVISED AND RELEASED FOR QUOTATION AND APPROVAL / DEO 0004
P1	10-19-95		Released per DEO 0005
P1	TMS 9-26-95		REVISED FOR UPDATED PRELIMINARY DESIGN

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number V049-2-005	Rev.
	D Moore 6/19/95	MCB 9/26/95	A	3

SPECIFICATION TABLE OF CONTENTS

Number

Rev.

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of the 112 cm and 122 cm gate valves for the LIGO vacuum system.

All attachments are incorporated herein by reference and made a part of this specification.

The specified equipment is for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF grant, includes two sites (Hanford Reservation, near Richland, WA and Livingston, LA). Each site contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

Type	Delivery Site	Quantity	Ends	Date
112 cm Valves (Electric)	Washington	6	BW/Flg	8/16/96
		6	Flg/Flg	9/19/97
	Louisiana	2	BW/Flg	8/10/97
		2	Flg/Flg	3/1/98
	Total	16		
112 cm Valves (Pneumatic)	Washington	2	BW/Flg	8/16/96
		2	Flg/Flg	9/1/97
	Louisiana	2	BW/Flg	8/10/97
		2	Flg/Flg	3/1/98
	Total	8		
122 cm Valves (Electric)	Washington	4	Flg/Flg	9/1/97
	Louisiana	2	BW/BW	8/10/97
		2	Flg/Flg	3/1/98
	Total	8		

2.2 Acceptances at the sites are expected to occur on a staggered basis, with final acceptance at Washington expected to occur about May 31, 1998, and about November 30, 1998 in Louisiana.

2.3 A "first article" valve shall be manufactured and tested (per Section 6.0 of this specification) as early as possible to allow design changes to be incorporated in the production lot of valves. Additional valves shall not be manufactured until the Buyer accepts the design of the first article valve after testing.

3.0 EQUIPMENT REQUIREMENTS

The 122 cm gate valves (mating to beam tubes) are used to isolate sections of the interferometer vacuum envelope from one another. The 112 cm gate valves serve the same function but are located near the 80K cryopumps.

4.0 DESIGN REQUIREMENTS

4.1 Mechanical Requirements

4.1.1 Gate valves shall be stainless steel (304L or 316L) with flange connections designed for double O-ring seals with grooves in the mating flanges supplied by others, or weld fittings as specified. Valves shall also have SS metal bellows stem feedthroughs, and shall be designed to seal in both directions.

4.1.2 Only non-contaminating and non-migratory lubrication shall be used on the internal mechanisms.

4.1.3 Valve body and flange leakage shall be measured to be less than 10^{-10} torr liter/sec of helium before shipment. Body flange faces shall be flat to within 0.010".

4.1.4 Gate valves shall have double viton gate seals and bonnet seals. Annular spaces between gate seals and bonnet seals shall be isolatable and designed to be pumped with an ion pump (supplied by others). Gate seals and bonnet seals shall be leak free to a level of 10^{-9} torr liter/sec of helium. Seal O-ring and annulus groove designs shall be subject to Buyer acceptance.

4.1.5 Valves of the same size and type shall be identical to minimize the number of required spare parts. Valves shall be rated for 10,000 cycles before service is required.

4.1.6 Valves shall be installed vertically with the actuators on top. Provision shall be made for supporting the valves from below. It is anticipated that four attachment points will be required.

4.1.7 Valves shall be bakeable to 150 C +/- 20 C (170 C maximum).

4.1.8 The valves (including their actuators) are exempted from the acoustic noise and vibration requirements of paragraphs 5.1.4, 5.1.5 and 5.2.1.3 of Attachment C of this specification.

4.1.9 Valve actuation shall induce no more than 0.01g peak-to-peak acceleration at any point on the valve mounting flanges or weld stubs.

4.1.10 Gate valves shall have a positive, padlockable device to prevent opening or closing. The valve shall be designed so that no damage occurs to the valve or to its actuator if valve actuation is attempted while the valve is locked open or closed.

4.1.11 Valve end connections shall be flanged or butt welded as denoted in Section 2.1, above. For valves with at least one end flanged, the valve shall be designed with the gate adjustment system facing a flanged end (accessible from that end when the valve is closed). For butt welded valve connections, the weld stub shall be 49.12" +/-0.02" ID with a 0.127" +/-0.007" wall thickness and a 10" length. For the two valves for shipment 8/10/97 to Louisiana, the length of the weld stubs shall be equal and sized to provide a total end-to-end dimension of 1 meter. The ends shall be square butt with the surface perpendicular to the tube axis and flat within 0.001". The surfaces shall be cylindrical and unobstructed for 6" from the end on the ouside, and for 2" on the inside. The sulfur content of the weld stub material shall not exceed 0.02 percent.

4.1.12 Gate valves shall be capable of stroking from fully open to sealed in 5 minutes or less, and from sealed to fully open in 5 minutes or less.

4.1.13 Valves shall be electrically or pneumatically actuated as denoted in Section 2.1, above.

4.1.14 Notwithstanding Paragraph 4.1.11, above, valves shall be designed to maintain the gate seal with vacuum or atmospheric pressure on either side of the gate. The valves shall also be designed for a piping load of 21,000 pounds in addition to the pressure load of vacuum on either side of the gate.

4.1.15 The clear aperture through the valve shall be not less than the nominal size (112 cm or 122 cm).

4.1.16 For flanged valves, the flange shall be consistent with the mating flanges shown in Attachment B. The flange face that mates with the O-ring seals shall be machined to a 32 microinch finish using a circular lay. Final flange mating details shall be subject to Buyer's acceptance.

4.1.17 Final assembly and cleaning of valves shall take place in a Federal Standard 209 Class 100 cleanroom environment.

4.2 Electrical Requirements

4.2.1 Instrumentation Requirements

Valves shall be provided with limit switches to indicate the fully opened and fully closed positions.

4.2.2 Controls Requirements

Each valve shall be provided with a controller for local open, close and stop operations. In addition, provide terminal strips in a junction box to interface with the future LIGO control system for remote open, close and stop operations. A bracket shall be provided for mounting of required controllers (e.g., speed controllers) at working height (exact location later). Controls shall be completely assembled, wired and tested prior to shipment.

4.2.3 Power Requirements: See Attachment C.

5.0 REQUIRED DOCUMENTATION

In addition to the documentation listed in Attachment C, the following documentation shall be provided prior to shipment:

- Leak test procedure and report (including data).
- Shock test procedure and report (including data)
- Manufacturer's standard QA reports (including final functional test reports)

6.0 SHOP TESTING

61 Operation of each valve for 20 cycles shall be demonstrated. This shall be done prior to final gate seal leak testing.

6.2 Each valve shall be tested for leakage per Paragraph 4.1.4 (using oil-free pumping equipment and leak detector) prior to shipment from the manufacturer. Each valve shall be baked at 150 C prior to leak checking. For dual gate seals and end seals, each seal shall be individually tested. For the end seals, the Vendor's test fixture shall allow testing of each seal individually. An RGA with calibrated leak shall be used in performing the leak testing.

6.3 One valve of each size and type of actuation shall be tested for shock. The valve shall be tested in the vertical position resting on a pad that deflects at least 0.1" under the static load of the valve, so as not to simulate a "hard mount". Testing shall be done both at atmospheric pressure and with the valve under vacuum. An accelerometer shall be mounted near a connecting flange (or weld stub) on the valve housing or near the edge of one of the flange covers. Separate measurements shall be taken in each of the three axes. The Buyer reserves the right to conduct an independent shock test.

7.0 INSPECTION

7.1 The inspections called for in Attachment C shall be performed by the Vendor.

7.2 Also, each valve shall be inspected for cleanliness by black light and RGA prior to shipment. Valves shall be recleaned if any contamination is found. Partial pressures of hydrocarbons greater than 2.0×10^{-10} Torr for any species shall be cause for rejection.

7.3 All valves shall be inspected for dimensional conformance to approved assembly drawings.

8.0 WARRANTY

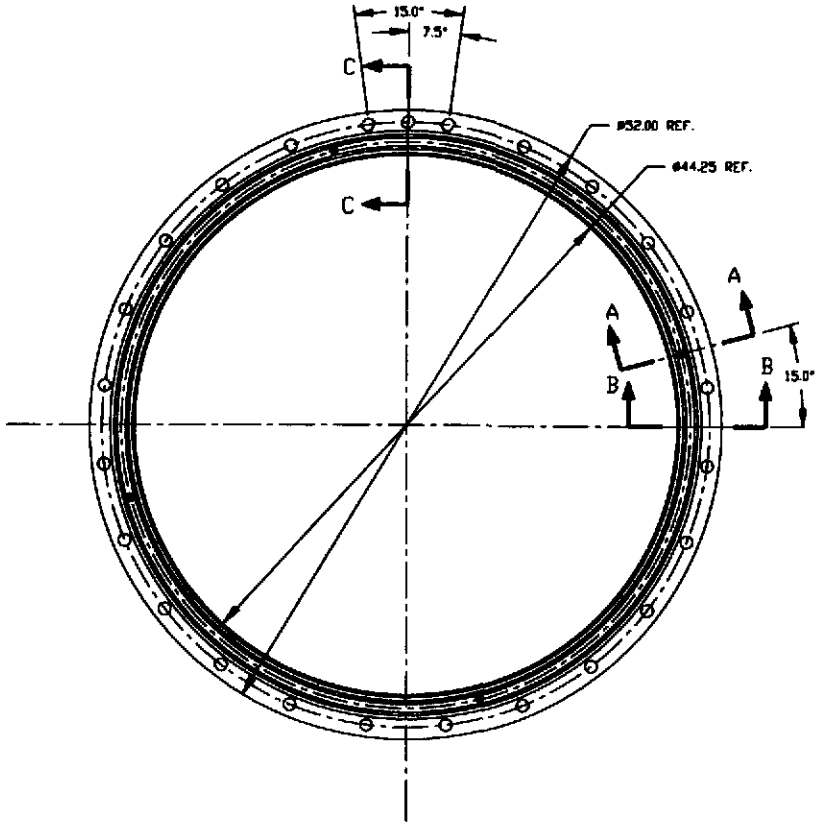
Refer to Specification V049-2-034, Purchased Equipment Commercial Requirements (attached to the Request for Quotation), for warranty requirements.

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT:112 & 122 cm. GATE VALVES	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-005

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE	2 wk		X	2	X		
VENDOR Q.A. PLAN	2 wk		X	2	X		
CLEANING PROCEDURE	2 wk		X	2	X		
PREP FOR SHIPMENT PROCEDURE	6 wk		X	2	X		
WELDING PROCEDURES	4 wk		X	2	X		
ASSEMBLY DRAWINGS	4 wk		X	2	X		
DESIGN REVIEW		X			X	Prior to release for fabrication	
CERTIFIED MATERIAL TEST REPORTS				2	X	Prior to release for fabrication	
IN-PROCESS INSPECTIONS	TBD	X		2	X		
OPERATION & MAINTENANCE MANUALS	8 wk			5	X		
SHOP TEST PLAN			X	2	X	Prior to release for fabrication	
SHOP TEST (WITH REPORT)		X		2	X	Prior to release for shipment	
SHOP DIMENSIONAL INSPECTION		X		2	X	Prior to release for shipment	



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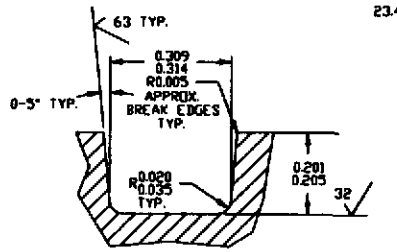
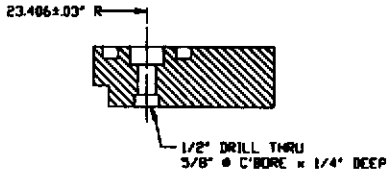
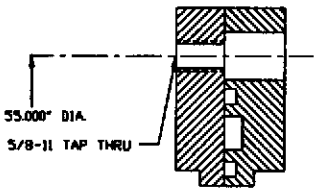


DETAIL "B"
2 PLACES
SCALE: 4x



SECTION "A"-"A"
4 PLACES @ 90°
SCALE: HALF



SECTION "C"-"C"
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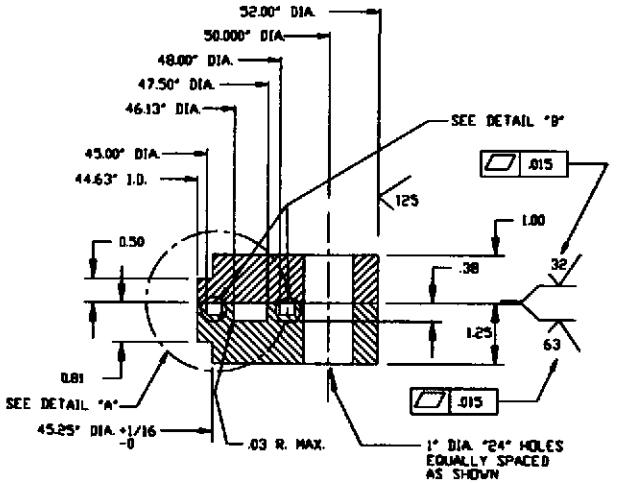

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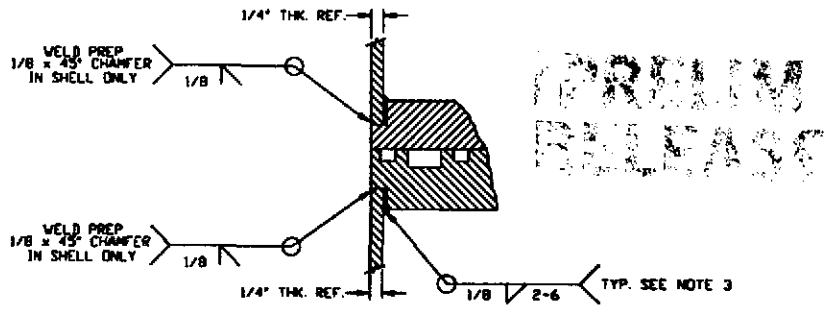


DETAIL "A"
SCALE: HALF

NOTE:

1. ALL MATERIAL TO BE 304L STAINLESS STEEL
2. FLANGES MUST BE PACKAGED AND SHIPPED IN ORDER TO TO MAINTAIN SURFACE FINISH AND FLATNESS TOLERANCE
3. WELDS MUST HAVE A MINIMUM LEG LENGHT (AS SHOWN) IN CONTACT WITH BOTH FLANGE AND SHELL. VOIDS IN SOCKET MUST BE COMPENSATED FOR WITH LARGER WELDS.

INNER O-RING .275 DIA. STOCK x 140" LG. VULCANIZED - BAKED VITON
OUTER O-RING .275 DIA. STOCK x 149 1/4" LG. VULCANIZED - BAKED VITON

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ± .010
THREE PLACE DECIMAL ± .005
FINISH ALL OVER

DO NOT SCALE THIS DWG.

DWG. NO.	DESCRIPTION
REFERENCE DRAWINGS	

USED ON
NEXT ASSY

REV.	DESCRIPTION	CHKD	DRAWN	DATE	APD
P1	PRELIMINARY	KMB		10-24-95	

ISSUE DESCRIPTION

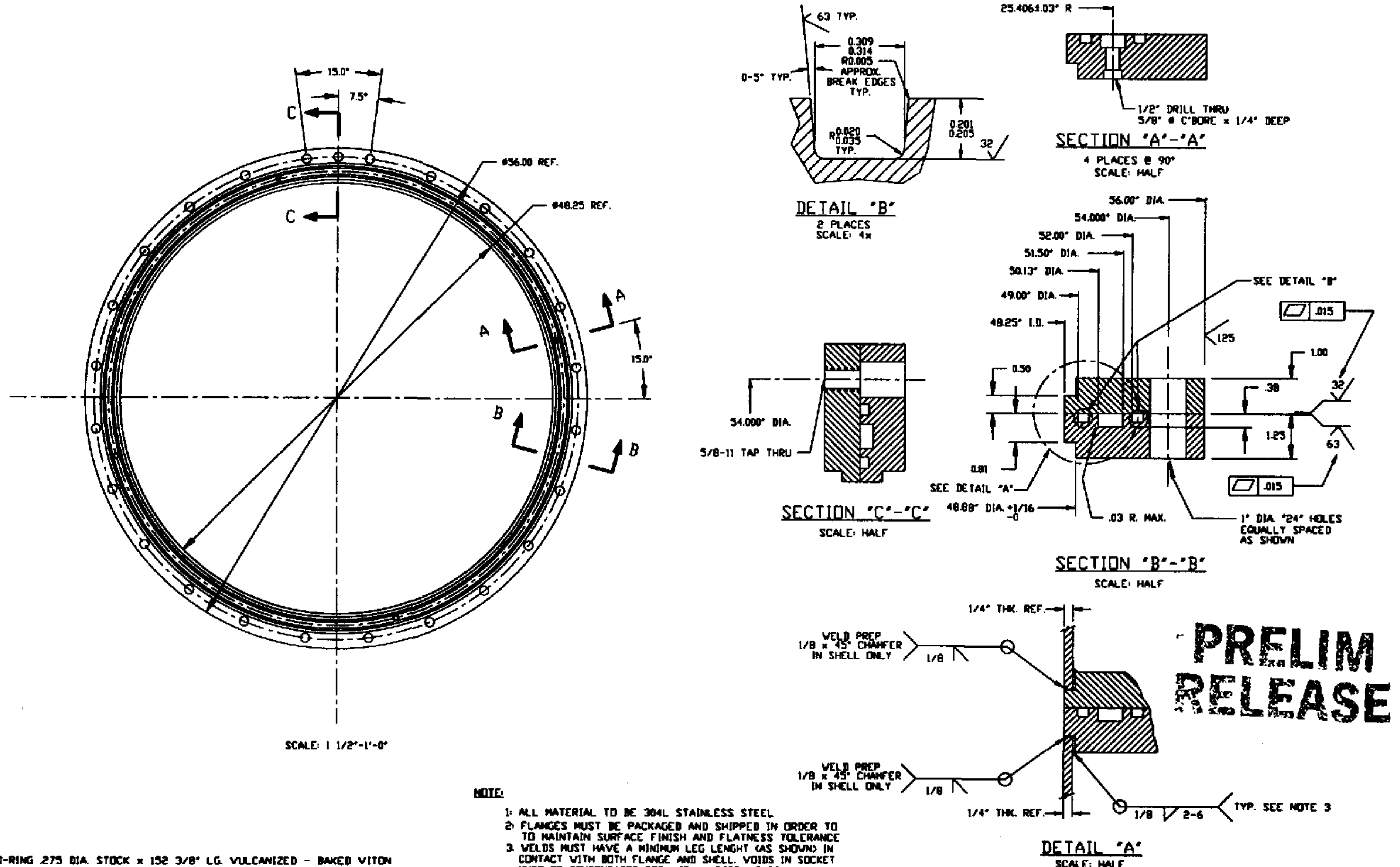
PROCESS SYSTEMS INTERNATIONAL INC.

44 5/8" I.D. FLANGE SET DETAIL

LIGO

CAD FILE	SIZE	DWG. NO.	REV.
V049487	C	V049-4-017	P1
SCALE: AS NOTED		SHEET 1 OF 1	

DCT 02, 1995 - 09:35:21



NOTE:

1. ALL MATERIAL TO BE 304L STAINLESS STEEL
2. FLANGES MUST BE PACKAGED AND SHIPPED IN ORDER TO TO MAINTAIN SURFACE FINISH AND FLATNESS TOLERANCE
3. WELDS MUST HAVE A MINIMUM LEG LENGHT (AS SHOWN) IN CONTACT WITH BOTH FLANGE AND SHELL. VOIDS IN SOCKET MUST BE COMPENSATED FOR WITH LARGER WELDS.

INNER O-RING .275 DIA. STOCK x 152 3/8" LG. VULCANIZED - BAKED VITON

OUTER O-RING .275 DIA. STOCK x 161 3/4" LG. VULCANIZED - BAKED VITON

DWG. NO.	DESCRIPTION
REFERENCE DRAWINGS	

DO NOT SCALE THIS DWG.

USED ON

NEXT ASS'Y

REV.	DESCRIPTION	CHKD	DRAWN	DATE	BED
P1	PRELIMINARY		KAR	10-24-95	

ISSUE DESCRIPTION

PROCESS SYSTEMS INTERNATIONAL, INC.

48 1/4" I.D. FLANGE SET DETAIL

LIGO

CAD FILE	SIZE	DWG. NO.	REV.
	C	V049-4-018	P1

SCALE AS NOTED — SHEET 1 OF 1

8 7 6 5 4 3 2 1

Oct 02 1995 - 09:36:12

SPECIFICATION FOR

6", 10" AND 14" GATE VALVES

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Thomas M. Stan

QUALITY ASSURANCE: A K Backhouse

TECHNICAL DIRECTOR: D. A. McIlwain

PROJECT MANAGER: Richard Bayley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	TMS 2-22-96	DMcI	REVISED FOR PURCHASE PER DEO 0070
0	TMS 11-2-95	DMcI 11-3-95	REVISED AND RELEASED FOR QUOTATION AND APPROVAL / DEO 0011

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED / DATE	APPROVED / DATE	Number V049-2-006	Rev.
	T. Stan 11-2-95	D. McI 11-3-95	A	1

SPECIFICATION TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of 6", 10" and 14" gate valves for the LIGO vacuum system.

All attachments are incorporated herein by reference and made a part of this specification.

The specified equipment is for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF grant, includes two sites (Hanford Reservation, near Richland, WA and Livingston, LA). Each site contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

	Quantity	Date
PSI (Westboro, MA)		
6"	0	6/1/96
10"	4	6/1/96
14"	1	6/1/96
Washington Site:		
6"	4	9/1/97
10"	16	9/1/97
14"	12	9/1/97
Louisiana Site:		
6"	3	3/1/98
10"	5	3/1/98
14"	5	3/1/98
Total Required		
6"	7	
10"	25	
14"	18	

2.2 Acceptances at the sites are expected to occur on a staggered basis, with final acceptance at Washington expected to occur about May 31, 1998, and about November 30, 1998 in Louisiana.

3.0 EQUIPMENT REQUIREMENTS

The 6", 10" and 14" gate valves (mating to 8" OD, 13 1/4" OD and 16 1/2" OD CF flanges, respectively) are used to isolate chamber vacuum roughing pump ports.

4.0 DESIGN REQUIREMENTS

4.1 Gate valves shall be stainless steel (304L or 316L) with CF flanges (see 3.0, above), and SS metal bellows stem feedthroughs, and shall be designed to seal in both directions.

4.2 Only non-contaminating and non-migratory lubrication shall be used on the internal mechanisms.

4.3 Valve body and flange total leakage shall be measured to be less than 10^{-10} torr liter/sec of helium before shipment.

4.4 Gate seal leakage shall be less than $1x\ 10^{-9}$ torr liter/sec of helium.

4.5 Gate seals shall be nonlubricated, prebaked Viton (DuPont Type E60C, Type A500 or Type V75, or Buyer-accepted equal).

4.6 Valves of the same size and type shall be identical to minimize the number of required spare parts. Valves shall be rated for 10,000 cycles before service is required.

4.7 Valves shall be manually actuated by a handwheel.

4.8 Gate valves shall have a positive, padlockable device to prevent opening or closing.

4.9 The valves are exempted form the acoustic noise and vibration requirements of paragraph 5.1.4 and 5.1.5 of Attachment B of this specification.

4.10 Valve actuation shall induce no more than 0.01g peak-to-peak acceleration (shock) at any point on the valve mounting flanges.

4.11 Valves shall be bakeable to 150 C +/-20 C (170 C maximum).

4.12 6" and 10" valves shall be provided with limit switches for the fully open and fully closed positions.

4.13 Final assembly and cleaning of valves shall take place in a Federal Standard 209 Class 100 cleanroom environment.

4.14 Each 14" valve shall be equipped with a 1 1/2" connection on the housing to allow rough pumping of the isolated equipment. This connection shall have a 2 3/4" CF flange with a blind, and shall be located so as to permit connection of an angle valve and pumping line.

4.15 Each 14" valve shall be sufficiently strong or reinforced to be able to be operated when installed in the horizontal position with a static load of 1,500 pounds immediately above it.

5.0 REQUIRED DOCUMENTATION

In addition to the documentation listed in Attachment A, the following documentation shall be provided prior to shipment:

- Leak test procedure and report (including data).
- Shock test procedure and report (including data).
- Manufacturer's standard QA reports (including final functional test reports)

6.0 SHOP TESTING

6.1 Each valve shall be tested for leakage (using oil-free pumping equipment and leak detector) prior to shipment from the manufacturer. An RGA with calibrated leak shall be used in performing the leak testing.

6.2 One valve of each size shall be tested for shock. The valve shall be tested in the vertical position resting on a pad that deflects at least 0.1" under the static load of the valve, so as not to simulate a "hard mount". Testing shall be done both at atmospheric pressure and with the valve under vacuum. An accelerometer shall be mounted near a connecting flange on the valve housing or near the edge of one of the flange covers. Separate measurements shall be taken in each of the three axes. The Buyer reserves the right to conduct an independent shock test.

7.0 INSPECTION

The inspections called for in Attachment A shall be performed by the Vendor. Also, each valve shall be inspected for cleanliness by black light and RGA prior to shipment. Valves shall be recleaned if any contamination is found.

8.0 WARRANTY

Refer to Specification V049-2-034, Purchased Equipment Commercial Requirements (attached to the Request for Quotation), for warranty requirements.

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: 10" and 14" GATE VALVES	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-006

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE			X	2	X		
VENDOR Q.A. PLAN			X	2	X		
CLEANING PROCEDURE			X	2	X		
PREP FOR SHIPMENT PROCEDURE			X	2	X		
WELDING PROCEDURES			X	2	X		
ASSEMBLY DRAWINGS			X	2	X		
DESIGN REVIEW		X			X		
CERTIFIED MATERIAL TEST REPORTS				2	X		
IN-PROCESS INSPECTIONS		X		2	X		
OPERATION & MAINTENANCE MANUALS				5	X		
SHOP TEST PLAN			X	2	X		
SHOP TEST (WITH REPORT)		X		2	X		

SPECIFICATION FOR

VACUUM GAUGES

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: T. Thomas Jr. Stan

QUALITY ASSURANCE: Alan R Bradbrook

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
O	SJC 1-31-96	D. M IW	RELEASE FOR QUOTATION PER DEO 0055
P1	10-19-95		Released per DEO 0005
P1	TMS 9-26-95		REVISED FOR UPDATED PRELIMINARY DESIGN

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number V049-2-007	Rev.
	T. Stan 6-14-95	REB 9/26/95		O

TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, and shipment of the vacuum gauges for the LIGO vacuum system. Gauges are arranged in pairs, with each pair consisting of a Pirani gauge and a cold cathode gauge.

All attachments are part of this specification.

The specified equipment is intended for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF contract, includes two installations at widely separated sites: near Hanford, WA and Livingston, LA. Each installation contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE FORMAT

2.1 Equipment delivery shall be as follows:

	Quantity	Date
Washington Site:	28	9/1/97
Louisiana Site:	15	3/1/98
Total Required	43	

2.2 It may be required to ship several of the above items to the Buyer directly (Westboro, Massachusetts).

2.3 Acceptances at the sites (the start of Vendor's warranty periods) are expected to occur on a staggered basis, with final acceptance at Washington expected to occur no later than May 31, 1998, and no later than November 30, 1998 in Louisiana. Portions of the equipment will be accepted earlier.

3.0 EQUIPMENT REQUIREMENTS

3.1 General

3.1.1 The vacuum gauges shall be provided in pairs consisting of one Pirani gauge and one cold cathode gauge to cover the pressure range from atmospheric down to 1 x 10^{-9} torr (nitrogen equivalent).

3.1.2 Gauges shall have local transmitters which shall be removable for bakeout.

3.2 Pirani Gauges

Pirani gauges shall operate from atmosphere to 10^{-4} torr.

3.3 Cold Cathode Gauges

Cold cathode gauges shall operate from 1 x 10^{-3} torr to 1 x 10^{-9} torr.

4.0 DESIGN REQUIREMENTS

4.1 Mechanical Requirements

4.1.1 The gauges shall be supplied mounted on 2 3/4" OD CF flanges on a piping tee for installation by others on the chambers.

4.1.2 Gauges shall be bakeable (if necessary to remove electronics, state max. bakeout temp. with electronics). To:

Pirani Gauges	250C
Cold Cathode Gauges	250C

4.2 Electrical Requirements

4.2.1 Instrumentation Requirements

Connectors for the gauges shall have locking, positive contact to the mating vacuum feedthrough, properly shielding the high voltage and signal connectors, and providing proper strain relief.

4.2.2 Controls Requirements

The transmitters shall operate on 24 VDC power and have analog outputs of 0-10 VDC and an adjustable setpoint switch contact. (Please state power requirements)

5.0 REQUIRED DOCUMENTATION

Documentation requirements listed in Attachment A shall be provided according to the Buyer's schedule (schedule later):

6.0 SHOP TESTING

The Vendor shall perform his standard tests.

7.0 INSPECTION

The inspections called for in Attachment A shall be performed by the Vendor:

8.0 WARRANTY

Refer to Attachment A, Section 15.0, and to Attachment B, General Provisions, Article 40 for warranty requirements.

ATTACHMENT "A"
LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: VACUUM GAUGES	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-007

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE			X	2	X		
VENDOR Q.A. PLAN			X	2	X		
ASSEMBLY DRAWINGS			X	2	X		
OPERATION & MAINTENANCE MANUALS				4	X		
SHOP TEST PLAN			X	2	X		
SHOP TEST (WITH REPORT)		X		2	X		

Date:
RFQ No. 96-007
Due Date:

TO:

SUBJECT: **REQUEST FOR QUOTATION - THIS IS NOT AN ORDER - URGENT**

DESCRIPTION: **Vacuum Gauges**

1. The RFQ No. must be on all quotations and correspondence.
2. This inquiry implies no obligation on the part of the Buyer.
3. We welcome any suggestions regarding substitute products, materials, or designs that will reduce price and/or technical risk.
4. Any deviations must be identified in bidder's quotation.
5. Quotations must state place of manufacture, submittal and delivery dates.
6. Attachments:
   a. Instruction to Bidders
   b. Pricing Sheet(s)
   c. Certificate of Compliance
   d. Specification No. V049-2-007
   e. Specification No. V049-2-034
   f.

Ronald B. Bento
Materials Manager

Date:
RFQ No.

Instruction To Bidders

1. Quotations are due by the close of business on 2/7/96.

   Send quotations in triplicate to:

   Process Systems International, Inc.
   ATTN: Mr. R. Bento
   20 Walkup Drive
   Westborough, MA 01581
   Tel: (508) 898-0205, Fax: (508) 898-0351

2. Please submit all questions, both technical and commercial, in writing to:

   Process Systems International, Inc.
   ATTN: Mr. R. Bento
   20 Walkup Drive
   Westborough, MA 01581
   Tel: (508) 898-0205, Fax: (508) 898-0351

3. Quotations must be signed by a corporate officer and include a current financial statement.

4. Quotations must be for firm-fixed pricing for the specified period of performance and valid for acceptance by Buyer through 60 days.

5. All bidders are requested to identify major cost drivers with cost saving alternatives and technical risk areas with proposed alternatives to reduce such risk.

6. Payment Terms:

   90% upon delivery of the item to the specified destination.
   10% upon final acceptance of the item by Buyer's Customer.

   Alternate payment terms specifying the price reduction will be considered. Payment terms will be considered in the price evaluation.

7. Shipping Terms are FOB destination to specified location. Bidder's pricing is to include freight and insurance.

8. Sales tax is to be excluded. Buyer will provide a resale exemption number.

9. Bidder to include in its quotation applicable field service rates valid through final acceptance.

10. Bidder to specify and price recommended spares for each site for start-up and for the first year of operation separately.

11. Items will be delivered as specified in the attached Equipment Specification. The Bidder shall specify the required release date to meet that schedule. Buyer will not be responsible for cost incurred by Bidder on items not released in writing. The Bidder shall submit a completed copy of the attached pricing sheet. Bidder shall also confirm drawing(s) and specification(s) submittal date.

12. All quotations must be submitted in strict compliance with this request for quotation in order to be considered for award. Quotations containing bidder's standard terms and conditions will be considered nonresponsive and subject to rejection at Buyer's option.

13. Quotations will be evaluated based on technical compliance with the specification, pricing, delivery, schedule of drawings, specifications and equipment, acceptance of the commercial terms and conditions, past experience for similar goods, management and financial capability to execute the scope of work, and overall responsiveness and conformance to this request for quotation including proposed pricing reductions. Buyer reserves the right to purchase from other than the low price bidder.

14. Bidder will identify bidder's key project personnel, including the project manager, and include their qualifications/resume in the quotation.

15. All quotations must include a signed Certificate of Compliance, RFQ/CC-95.

Date:
RFQ No.

PRICING SHEET

(To Be Completed By Bidder)

DESCRIPTION: The base price must be in full compliance with the request for quotation. Option(s) are to be priced as requested by Buyer. Bidder is requested to submit additional options that offer price reductions and specify where the deviatation is specifically addressed.

BASE: Attachments may be used to supplement and/or support the required information.

Item No.	Description	Qty	Destination	Release Date	Delivery Date	Unit Price	Total Price

Buyer Requested Options:

1. The Vendor shall supply a quote for a heater blanket for bake-out of the Pirani & Cold Cathode gauges.

Bidder Offered Options:

Spare Parts: **(Attach List by Grouping)**

Supply Bond:

CERTIFICATE OF COMPLIANCE

PSI INQUIRY NO. _____
BIDDER NAME: _____
BIDDER'S PROPOSAL NO. _____

INSTRUCTIONS: **This form must be completed by each bidder and must accompany the quotation. Any quotation not accompanied by a properly executed copy of this form will be considered nonresponsive.**

CHECK ONE BOX ONLY:

☐ **We certify that this proposal complies with the Request for Quotation, and all attachments thereto, as well as all referenced industry codes and standards.**

☐ **We certify that this quotation complies with the Request for Quotation, and all attachments thereto, as well as all referenced industry codes and standards, except for the comments/exceptions listed on the following page(s)**_____
_____.*

BY: _____
(Signature of Company Officer)

_____
(Name Typed or Printed)

TITLE: _____

DATE: _____

***NOTE:** **Each Request for Quotation document should be addressed separately. It will be assumed that Bidder is in complete compliance with any document not so addressed.**

RFQ/CC-95

Title: SPECIFICATION FOR BAKEOUT SYSTEM

SPECIFICATION FOR

BAKEOUT BLANKET SYSTEM

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Fadi Bath

QUALITY ASSURANCE: R R Bradbrook

TECHNICAL DIRECTOR: D O m c W Williams

PROJECT MANAGER: Rachel Bayley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
2	FAB 5-2-96	DMW 5-2-96	RELEASE FOR FDR (PER DEO # 0164)
1	4-5-96	4-5-96	RELEASE FOR INFO (PER DEO # 0111)
0	2-27-96	2-28-96	RELEASE FOR PURCHASE (PER DEO # 0073)
P2	1-15-96	1-15-96	RELEASE FOR QUOTE (BSC-PROTOTYPE ONLY)

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number V049-2-009	Rev. 2
	F. Bath	1-15-96	D. M. W	1-15-96		

SPECIFICATION TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, and shipment of the bakeout blanket system for the LIGO vacuum system.

All attachments are part of this specification.

The specified equipment is intended for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF contract, includes two installations at widely separated sites: near Hanford, WA and Livingston, LA. Each installation contains laser interferometers in an *L* shape with 4 *km* arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Only one bakeout blanket system is required. It must be designed to work on either the Washington or the Lousiana installation. The PLC control system and power controls will be provided by the buyer.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Blankets shall be provided as follows:

HAM Chamber

	Quantity	Date
PSI (Westboro, MA)	2	9/1/96
Washington Site	4	9/1/97

BSC Chamber

	Quantity	Date
Washington Site	3	9/1/96

Prototype BSC Chamber

	Quantity	Date
PSI (Westboro, MA)	1	4/30/96

Prototype Flange Covers (Per Sketch)

	Quantity	Date
PSI (Westboro, MA)	4	4/30/96

Mode Cleaner Tubes

	Quantity	Date
PSI (Westboro, MA)	5	9/1/96

Beam Tube Manifold Sections

	Quantity	Date
PSI (Westboro, MA)	5	9/1/96
Washington Site	4	9/1/97

2.2 Additionally, the Vendor shall supply bakeouts for the following items. Detailed dimensions are not yet defined, but approximate information is given.

Bellows (152 cm x 100 cm)

	Quantity	Date
PSI (Westboro, MA)	2	9/1/96
Washington Site	4	9/1/97

Gate Valve (152 cm)

	Quantity	Date
Washington Site	4	9/1/97

Gauge Sets (Per Sketch) (to 250 C)

	Quantity	Date
PSI (Westboro, MA)	6	9/1/96

Long 80 K Cryopump (Per Sketch)

	Quantity	Date
PSI (Westboro, MA)	1	9/1/96

Short 80 K Cryopump (Per Sketch)

	Quantity	Date
PSI (Westboro, MA)	1	9/1/96

Main Ion Pump

	Quantity	Date
PSI (Westboro, MA)	1	4/30/96
Washington Site	4	9/1/97

10" Gate Valves

	Quantity	Date
PSI (Westboro, MA)	1	4/30/96
Washington Site	3	9/1/97

14" Gate Valves

	Quantity	Date
PSI (Westboro, MA)	1	4/30/96
Washington Site	4	9/1/97

2.3 Acceptances at the sites (the start of Vendor's warranty periods) are expected to occur on a staggered basis, with final acceptance expected to occur no later than May 31, 1998. Portions of the equipment may be accepted earlier.

3.0 EQUIPMENT REQUIREMENTS

The bakeout system is used for initial conditioning of the LIGO vacuum vessels and components, and for periodic reconditioning. The blankets will be used to heat the system to $150^0C \pm 20^0C$ @ a rate of 1.8^0C/hr. For design purposes, the blankets shall be capable of heating the vessels and components to 200^0C in 48 hours. The blanket control system shall be capable of ramping the setpoint temperature to a desired target temperature at a desired rate, and maintain the target temperature +/-20C for all vessel or component surfaces. Several smaller blankets are needed for bellows, gate valves and vacuum gauge pairs, as noted in Section 2.3, above. Also note that bakeout blankets are needed for the main ion pumps.

The buyer will provide the programmable controls, power distribution with overload protection, and interconnecting cables.

4.0 DESIGN REQUIREMENTS

4.1 Mechanical Requirements

4.1.1 Heating blankets shall be of durable construction, designed to be installed, removed and reinstalled on the vessels without degradation.

4.1.2 Materials shall be non-shedding and designed for installation, removal and storage in a Fed. Std. 209 Class 50,000 cleanroom.

4.1.3 Insulation sizing shall result in a cost-effective system design (2 inch min.). The Vendor shall indicate the design heat loss with his proposal. K thermal conductivity, Cp specific heat and density data of the insulation shall be provided.

4.1.4 Components shall be identical to the maximum possible extent to minimize the number of required spare parts.

4.1.5 Each blanket shall be sized (area) so it is easily installed without requiring special equipment.

4.1.6 Each blanket shall be capable of being secured properly on the vessels/piping in any position (horizontal, vertical) without sliding off its desired location.

4.1.7 Each blanket shall be properly identified with a non-removable tag. Tagging shall be on the blanket outer section. Blanket identification shall match the bakeout blanket layout configuration as shown on Vendor's provided drawings. Tagging numbering method shall be coordinated with PSI.

4.1.8 Each blanket shall have approximately a 3" x 4" removable patch to allow the installation of the TC's onto the metal surface. This patch shall be in the middle of the blanket.

4.1.9 Outer and inner blanket cover material shall be submitted to the customer for approval prior to fabrication. Outer jacket shall be the low emisivity type.

4.2 Electrical Requirements

4.2.1 Instrumentation Requirements

4.2.1.1 Type "J", #20 AWG stranded not grounded, shielded, 300 volts, 260^{0}C teflon insulated control thermocouples (2 per blanket) shall be routed in each blanket. Provide 12" of TC wiring, on the TC side, to allow for easy installation of the TC's in direct contact with the surface being heated. TC wiring (type J) shall extend 3 feet minimum outside the blanket boundary. Also it shall be terminated in a TC (Type J) male connector (one per TC). TC wiring shall be routed away from power wiring and shall be tension relieved. Wiring shall be tagged.

4.2.2 Controls Requirements

4.2.2.1 Controls for local operation will be provided by the buyer.

4.2.3 Power Requirements

4.2.3.1 The system shall be powered from 277V power system.

4.2.3.2 Each blanket shall have its power wiring extend 3 feet minimum outside the blanket boundary. Also it shall be terminated in a male power plug. Make provisions for grounding. Wiring shall be tension relieved and routed away from TC wiring. Power wiring shall stranded copper, 600V, 260^{0}C minimum. Power requirements shall not exceed 8 amps per blanket, wiring shall be tagged.

4.2.3.3 The maximum BSC power available is 25 KW.
The maximum system power available is 180 KW.

4.3 Additional Requirements

4.3.1 Provide oversized blanket velcro and fiberglass thermal flaps. The thermal flap assemblies will ensure that there are no exposed air gaps between the individual heating blankets.

4.3.2 Provide nylon straps and fiberglass strap loops. The nylon strap assemblies will ensure that the individual heating blankets are cinched down tight against the BSC.

4.3.3 Provide two (2) thermocouple sensors per blanket as previously stated in Section 4.2.1.1.

5.0 REQUIRED DOCUMENTATION

In addition to the documentation listed in Attachment A & B, the following documentation shall be provided prior to shipment (schedule later):

- Blanket drawings detailing each blanket.
- Blanket heat transfer calculations.
- Blanket layout drawings for each bakeout configuration along with blanket identification (TAG number).
- Blanket tag number versus power consumption table.

6.0 SHOP TESTING

The Vendor shall perform his standard testing. The Buyer reserves the right to witness shop testing.

7.0 INSPECTION

The inspections called for in Attachment A & B shall be performed by the Vendor.

8.0 WARRANTY

Refer to V59049-2-034 (Commercial Requirements), General Provisions, for warranty requirements.

ATTACHMENT "A"
LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: BAKEOUT SYSTEM	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-009

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks: / Inspector: / Date:
MILESTONE SCHEDULE	2 WK		X	2	X	
VENDOR Q.A. PLAN	2 WK		X	2	X	
CLEANING PROCEDURE	2 WK		X	2	X	
PREP FOR SHIPMENT PROCEDURE	6 WK		X	2	X	
DELETED			X	2	X	
ASSEMBLY DRAWINGS	4 WK		X	2	X	
DESIGN REVIEW		X			X	PRIOR TO RELEASE FOR FABRICATION
CERTIFIED MATERIAL TEST REPORTS						
IN-PROCESS INSPECTIONS	TBD	X		2	X	
OPERATION & MAINTENANCE MANUALS	8 WK			5	X	
SHOP TEST PLAN			X	2	X	PRIOR TO RELEASE FOR FABRICATION
SHOP TEST (WITH REPORT)		X		2	X	PRIOR TO RELEASE FOR SHIPMENT
SHOP DIMENSIONAL INSPECTION		X		2	X	PRIOR TO RELEASE FOR SHIPMENT

ATTACHMENT C

VESSEL DRAWING

DRAWING NUMBER	REV	DESCRIPTION
V59049-4-001 Sheet 1	P6	BSC Details
V59049-4-001 Sheet 2	P6	BSC Details Lower
V59049-4-001 Sheet 3	P6	BSC Details Upper
V59049-4-001 Sheet 4	P6	BSC Details Roll-Up
V59049-4-001 Sheet 5	P6	BSC Details Stiffner
V59049-4-014	P3	BSC Tower Type II
V59049-4-019	P4	BSC 60 Flange Detail
V59049-4-022	P4	BSC 104 Flange Detail (Grooved)
V59049-4-023	P2	BSC Chamber Support Assembly
V59049-0-001 Sheet 1	0	Legend
V59049-0-001 Sheet 2	0	Station Diagram - Washington
V59049-0-001 Sheet 3	0	Station Diagram - Louisiana
V59049-4-025	P1	Annulus Piping
V59049-4-044	P1	Port Locations
V59049-4-041	P1	BSC-104 Flange Detail (Flat Face)
V59049-3-019 Sheet 1	0	Heater Blanket End Connector
V59049-3-019 Sheet 2	0	Blanket TC End Connector
V59049-3-019 Sheet 3	0	TC Installation Details

V049-2-009 REV. 1

Title: **SPECIFICATION FOR PORTABLE SOFT-WALLED CLEANROOMS**

SPECIFICATION FOR

PORTABLE SOFT-WALLED CLEANROOMS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: _____

QUALITY ASSURANCE: _____

TECHNICAL DIRECTOR: _____

PROJECT MANAGER: _____

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
0	SJC - 1/9/96	D. Wilcox	RELEASE PER DEO 0039

PROCESS SYSTEMS INTERNATIONAL, INC.					SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number V049-2-010	Rev. 0
	SJC	1-9-96	RJS	1/9/96		

SPECIFICATION TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, and shipment of the portable soft-walled cleanrooms for the LIGO vacuum system.

All attachments are part of this specification.

The specified equipment is intended for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF contract, includes two installations at widely separated sites: near Hanford, WA and Livingston, LA. Each installation contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

Cleanroom A (10'L x 16'W x 12'H) (HAM)
(All dimensions are internal)

	Quantity	Date
Washington Site:	1	9/1/97
Louisiana Site:	1	3/1/98
Total Required	2	

Cleanroom B (16'L x 16'W x 16'H) (BSC)
(All dimensions are internal)

	Quantity	Date
PSI (Westborough, MA)	1	4/1/96
PSI (Westborough, MA)	1*	4/1/96
PSI (Westborough, MA)	1	8/1/96
PSI (Westborough, MA)	1*	8/1/96
Washington Site:	3*	9/1/97
Washington Site:	1	9/1/97
Louisiana Site:	1	3/1/98
Louisiana Site:	1*	3/1/98
Total Required	10	

* With external attached gowning rooms

Gowning Rooms (4'L x 4'W x 8'H)
(All dimensions are internal)

	Quantity	**Date**
Washington Site	1	9/1/97
Louisiana Site	1	3/1/98
Total Required	2	

2.2 Acceptances at the sites (the start of Vendor's warranty periods) are expected to occur on a staggered basis, with final acceptance expected to occur no later than 9 months after shipment. Portions of the equipment may be accepted earlier.

3.0 EQUIPMENT REQUIREMENTS

The portable soft-walled cleanrooms are used to isolate sections of the interferometer vacuum envelope from the Fed. Std. 209 Class 50,000 building environment when opening chamber ports. The cleanrooms shall provide a Class 100 environment. Two different size cleanrooms are required, six with an externally attached garment/changing area. In addition, two stand-alone gowning rooms are requried.

4.0 DESIGN REQUIREMENTS

4.1 Mechanical Requirements

4.1.1 Filter modules shall be ducted to one or two blower units with prefilter capability. The blower units should be mounted to the ceiling frame design, but also have the capability to be remotely mounted up to 10 feet away.

4.1.2 Cleanroom ceiling structures (containing filter modules) shall be designed so that they can be lifted, moved and lowered onto the frame structure by an overhead crane.

4.1.3 Cleanrooms shall have casters (compatible with a cleanroom environment) to allow location adjustment of the cleanrooms after they have been lowered into place.

4.1.4 Cleanrooms shall be designed to mate and seal with each other to form larger cleanroom working spaces (velcro type closures).

4.1.5 Walls shall be clear vinyl curtain (40 mil).

4.1.6 Sealed fluorescent lighting shall be provided to give adequate illumination at work surface height.

4.1.7 Cleanroom shall be equipped with a means to seal around various diameter tubes entering the cleanroom. Approximate tube diameter may be from 3 to 5 ft. in as many as all four sides (only two sides for HAM cleanrooms) of the cleanrooms. When not in use, these holes shall be sealed with a velcro-attached piece. The bottom of these diameters shall have a velcro-sealed slit directly under it extending to the bottom of the wall to allow lowering the cleanroom into place over the tube.

4.1.8 Cleanrooms B shall have an opening in the ceiling to accommodate a 10' diameter chamber dome. The dome will be lifted by a crane approximately its entire length through the cleanroom ceiling. The cleanroom design shall provide contamination protection (e.g., bellows-sealed tube) to allow the dome to be raised to any position. A means of attaching the crane hook to the top of the dome shall be provided (e.g., velcro-sealed arm hole). The dome hole, when not in use, shall be closed by some form of velcro seal.

4.1.9 Cleanrooms B shall have some form of adjustable legs (2) that allow a reduction of height of approx. 3' on one side of the cleanroom.

4.1.10 Components shall be identical to the maximum possible extent to minimize the number of required spare parts.

4.1.11 The following shall also be supplied: (priced separately)

Two airborne particle counters (to 0.3 micron)

28 remote magnehelic gauges for measuring internal static pressure buildup and filter pressure drop

Eight Gowning Racks
Two Gowning Benches

4.2 Electrical Requirements

4.2.1 Controls Requirements

Separate controls shall be provided for the HEPA filtering system and for the lighting.

4.2.2 Power Requirements

A single, centrally located electrical service box shall be provided.

5.0 REQUIRED DOCUMENTATION

In addition to the documentation listed in Attachment A, the following documentation shall be provided prior to shipment (schedule later):

- System assembly and operating manual.
- The vendor is requested to provide an itemized list of all pertinent peripherals (apparel, etc.) for use in class 100 cleanroom.

6.0 SHOP TESTING

The Vendor shall perform his standard testing.

7.0 INSPECTION

The inspections called for in Attachment A shall be performed by the Vendor.

8.0 WARRANTY

Refer to Specification V049-2-034, Purchased Equipment Commercial Requirements (attached to the Requests for Quotation), for warranty requirements.

9.0 Q.A. REQUIREMENTS

Q.A. requirements shall be provided as specified on Attachment A.

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR: V59049.	JOB NO.: V59049
EQUIPMENT: PORTABLE CLEAN ROOMS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPECNO: V049-2-010

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE			X	2	X		
VENDOR Q.A. PLAN			X	2	X		
PREP FOR SHIPMENT PROCEDURE			X	2	X		
ASSEMBLY DRAWINGS			X	2	X		
DESIGN REVIEW		X			X		
OPERATION & MAINTENANCE MANUALS				5	X		
SHOP TEST PLAN (Vendor Std.)			X	2	X		
SHOP TEST (WITH REPORT)		X		2	X		
SHOP DIMENSIONAL INSPECTION		X		2	X		

DATE:
RFQ No. 96-010
DUE DATE:

TO:

SUBJECT: **REQUEST FOR QUOTATION - THIS IS NOT AN ORDER - URGENT**

DESCRIPTION: **Portable Softwall Cleanrooms**

1. The RFQ No. must be on all quotations and correspondence.
2. This inquiry implies no obligation on the part of the Buyer.
3. We welcome any suggestions regarding substitute products, materials, or designs that will reduce price and/or technical risk.
4. Any deviations must be identified in bidder's quotation.
5. Quotations must state place of manufacture, submittal and delivery dates.
6. Attachments:
   a. Instruction to Bidders
   b. Pricing Sheet(s)
   c. Certificate of Compliance
   d. Specification No. V049-2-010
   e. Specification No. V049-2-033, Rev. 2

Ronald B. Bento
Materials Manager

DATE:
RFQ No.

Instruction To Bidders

1. Quotations are due by the close of business on 1/19/96.

   Send quotations in triplicate to:

   Process Systems International, Inc.
   ATTN: Mr. R. Bento
   20 Walkup Drive
   Westborough, MA 01581
   (508) 898-0205, Fax: (508) 898-0351

2. Please submit all questions, both technical and commercial, in writing to:

   Process Systems International, Inc.
   ATTN:
   20 Walkup Drive
   Westborough, MA 01581
   (508) 898-0205; Fax (508) 898-0351

3. Quotations must be for firm-fixed pricing for the specified period of performance and valid for acceptance by Buyer through 60 days.

4. Payment Terms:

   90% upon delivery of the item to the specified destination.
   10% upon final acceptance of the item by Buyer's Customer.

   Alternate payment terms specifying the price reduction will be considered. Payment terms will be considered in the price evaluation.

5. Shipping Terms are FOB destination to specified location. Bidder's pricing is to include freight and insurance.

6. Sales tax is to be excluded. Buyer will provide a resale exemption number.

7. Bidder to include in its quotation applicable field service rates valid through final acceptance.

8. Bidder to specify and price recommended spares for each site for start-up and for the first year of operation separately.

9. Items will be delivered as specified in the attached Equipment Specification. The Bidder shall specify the required release date to meet that schedule. Buyer will not be responsible for cost incurred by Bidder on items not released in writing. The Bidder shall submit a completed copy of the attached pricing sheet. Bidder shall also confirm drawing(s) and specification(s) submittal date.

10. All quotations must be submitted in strict compliance with this request for quotation in order to be considered for award. Quotations containing bidder's standard terms and conditions will be considered nonresponsive and subject to rejection at Buyer's option.

11. Quotations will be evaluated based on technical compliance with the specification, pricing, delivery, schedule of drawings, specifications and equipment, acceptance of the commercial terms and conditions, past experience for similar goods, and overall responsiveness and conformance to this request for quotation including proposed pricing reductions. Buyer reserves the right to purchase from other than the low price bidder.

12. All quotations must include a signed Certificate of Compliance, RFQ/CC-95.

DATE:
RFQ No. 96-010

PRICING SHEET

(To Be Completed By Bidder)

DESCRIPTION: The base price must be in full compliance with the request for quotation. Option(s) are to be priced as requested by Buyer. Bidder is requested to submit additional options that offer price reductions and specify where the deviation is specifically addressed.

BASE: Attachments may be used to supplement and/or support the required information.

Item No.	Description	Qty.	Destination	Release Date	Delivery Date	Unit Price	Total Price
1.	Cleanroom A	2	As noted in spec.				
2.	Cleanroom B with integral gowning room	6	As noted in spec.				
3.	Cleanroom B	4	As noted in spec.				
4.	Gowning room	2	As noted in spec.				

Buyer Requested Options:

1. The vendor shall supply a quote for (2) airborne particle counters (to 0.3 microns).
2. The vendor shall supply a quote for (28) magnehelic gauges for measuring static pressure buildup and filter pressure drop.
3. The vendor shall supply a quote for (8) gowning racks and (2) gowning benches.

Bidder Offered Options:

Spare Parts: **(Attach List by Grouping)**

Supply Bond:

CERTIFICATE OF COMPLIANCE

PSI INQUIRY NO. _____
BIDDER NAME: _____
BIDDER'S PROPOSAL NO. _____

INSTRUCTIONS: **This form must be completed by each bidder and must accompany the quotation. Any quotation not accompanied by a properly executed copy of this form will be considered nonresponsive.**

CHECK ONE BOX ONLY:

☐ **We certify that this proposal complies with the Request for Quotation, and all attachments thereto, as well as all referenced industry codes and standards.**

☐ **We certify that this quotation complies with the Request for Quotation, and all attachments thereto, as well as all referenced industry codes and standards, except for the comments/exceptions listed on the following page(s)** _____
_____.*

BY: _____
(Signature of Company Officer)

_____
(Name Typed or Printed)

TITLE: _____

DATE: _____

***NOTE:** **Each Request for Quotation document should be addressed separately. It will be assumed that Bidder is in complete compliance with any document not so addressed.**

RFQ/CC-95

Title: SPECIFICATION FOR CLEAN AIR SUPPLY SYSTEMS

SPECIFICATION FOR

CLEAN AIR SUPPLY SYSTEMS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Thomas M. Stein

QUALITY ASSURANCE: Allan L Bradbood

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	TAMS 5-5-96	D. McW	REVISED FOR PURCHASE PER DCO 0081
0	TAMS 12-14-95	DMcW 12-14-95	REVISED & RELEASED FOR QUOTATION
P1	10-19-95		Released per DEO 0005
P1	TAMS 9-21-95		REVISED FOR UPDATED PRELIMINARY DESIGN

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number V049-2-011 / Rev. 1
	T. Stein	6-14-95	Rcs	7/26/95	

SPECIFICATION TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of clean air supply systems for the LIGO vacuum system. The systems will supply clean and dry air for equipment venting and purging, and for air showers in various vacuum vessels.

All attachments are incorporated herein by reference and made a part of this specification.

The specified equipment is intended for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF grant, includes two sites (Hanford Reservation, near Richland, WA and Livingston, LA). Each site contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

	Quantity	Date
Westboro (PSI)		
50 CFM	2	11/1/96
200 CFM	0	11/1/96
Washington Site:		
50 CFM	4	9/1/97
200 CFM	1	9/1/97
Louisiana Site:		
50 CFM	0	3/1/98
200 CFM	1	3/1/98
Total Required		
50 CFM	6	
200 CFM	2	

2.2 The first unit of each size shall be a "prototype" and shall be inspected for cleanliness prior to the release for subsequent units. The first units will also be tested for noise and vibration by the Buyer.

2.3 Acceptances at the sites are expected to occur on a staggered basis no more than 120 days after delivery, with final acceptance at Westboro expected to occur about January 2, 1997; about May 31, 1998 in Washington; and about November 30, 1998 in Louisiana.

3.0 EQUIPMENT REQUIREMENTS

The clean air supply systems will be used to provide air for equipment venting and purging, and for air showers in various vacuum chambers. The air at the supply point shall be 50 SCFM (6 systems) or 200 SCFM (2 systems) minimum. It shall be filtered through prefilters and HEPA filters to provide air meeting Fed. Std. 209 Class 100. It shall be dried to -60 C dew point (at atmospheric pressure), and provided at a minimum pressure of 30 psig. Supply air to the systems will be ambient indoor air. Air compressors shall be non-lubricated with filtered suction. Performance for flow, dewpoint and particle count shall be guaranteed. Commercially packaged compressors, dryers and filters (subject to PSI approval) used in these systems need not meet Attachment B of this specification.

As a minimum, the following components shall be provided:

- A receiver with manual drain and automatic start/stop capbilities for the compressor. (System operation will be continuous for periods of several hours to several weeks, with variable flow rates.)
- Hydrocarbon removal adsorbers with sample taps upstream and downstream.
- An inlet air filter capable of taking air from an adjacent room (piping by others).
- Dryer blowdown silencers suitable for locating outside of the building by others.
- A 0.01 micron sterile final filter with stainless steel housing.

4.0 DESIGN REQUIREMENTS

4.1 Mechanical Requirements

4.1.1 Systems of each size shall be self-contained and identical to minimize the number of required spare parts.

4.1.2 Any required utility connections (such as for cooling water) shall be manifolded to a single connection point and terminated appropriately (such as with an isolation valve).

4.1.3 The acoustic noise and vibration requirements detailed in Section 5.1 of Attachment B do not apply to the clean air supply systems. However, reasonable measures shall be taken to minimize vibration.

4.1.4 The final filter and all downstream materials shall be stainless steel (304, 304L, 316 or 316L).

4.1.5 The 200 CFM systems shall be water cooled and the 50 CFM units air cooled.

4.1.6 Manifolding and/or proper compressor cabinet connections shall be provided to allow a single air inlet from an adjacent room (piping and silencer by others). The compressor inlet shall be filtered.

4.1.7 Building access for installation is through 8' wide by 8' high doorways. Therefore, each skid must be sufficiently less than those dimensions to allow adequate clearance. If necessary, it would be acceptable to remove an item from the skid for installation, then reinstall it on the skid. Access space will be provided by others around the skid. Skid equipment arrangements are subject to Buyer's approval. CAD drawings and files are preferred, AutoCAD 12, if possible.

4.1.8 All piping shall be detergent washed and rinsed to remove all traces of oils. No hydrocarbons shall be used on the process surfaces of the compressors during their manufacture, and none shall be used in making up piping joints. All dryer vessels, filter housings and other components shall be free of hydrocarbons, and inspected to ensure that they are clean and dry.

4.1.9 The clean air supply systems shall not introduce hydrocarbons into the air stream.

4.1.10 Blowdown from compressor unloading may be vented into the compressor cabinet if it does not result in a significant increase in noise.

4.1.11 The sample taps upstream and downstream of the hydrocarbon removal adsorbers shall be valved and have 1/4" male Swagelok thread for customer connection.

4.2 Electrical Requirements

4.2.1 Instrumentation Requirements

Appropriate gauges for local operation and monitoring shall be provided.

4.2.2 Controls Requirements

4.2.2.1 Controls for local operation shall be provided. In addition, provide terminal strips in junction boxes with dry contacts to indicate that the systems are running or not.

4.2.2.2 Systems shall be stopped and started by hand switches located on the system skid. The compressors shall be started and stopped automatically based on pressure in the discharge receiver tank.

4.2.2.3 Provide a receiver low pressure switch for alarm, wired to dry contacts on terminal strip in above junction box (see 4.2.2.1, above).

4.2.2.4 Provide a dryer failure to switch alsrm wired to the compressor panel, and a common out alarm for the compressor.

4.2.3 Power Requirements

4.2.3.1 Required controllers and overload protection shall be provided on the system skids.

4.2.3.2 A single disconnect switch for each system shall be provided on each skid. An additional disconnect for each dryer system shall also be provided.

4.2.3.3 All wiring, conduits and terminations between skid components shall be provided, with only a single power feed necessary for field connection.

4.2.3.4 A single 480/277 V, 3 phase, 4 wire (with ground) circuit will supply power to the system.

4.2.3.5 All starters, switches and overload protection devices shall be provided by the Vendor.

4.2.3.6 All instrument wiring shall be segregated in separate conduits based on signal voltages (one type per conduit). Barriers shall be used to separate terminal blocks of different voltages.

4.2.3.7 The system shall meet the requirements of the N.E.C. and all local codes.

5.0 REQUIRED DOCUMENTATION

In addition to the documentation listed in Attachment B, the following documentation shall be provided prior to shipment:

- System installation and operating manual
- Certified test results

6.0 SHOP TESTING

The Vendor shall perform his standard testing (tests for one system of each size to be witnessed by the Buyer). In addition, the Buyer will make measurements of flow, dewpoint, hydrocarbons and particle count for the delivered air, and noise and vibration.

7.0 INSPECTION

The inspections called for in Attachment B shall be performed by the Vendor. Also, all equipment and components shall be inspected in accordance with Paragraph 4.1.8, above.

8.0 WARRANTY

Refer to PSI Specification V049-2-034, Purchased Equipment Commercial Requirements, for warranty requirements.

ATTACHMENT "A"
LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: CLEAN AIR SUPPLY SYSTEMS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-011

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE	2 wk		X	2	X		
VENDOR Q.A. PLAN	2 wk		X	2	X		
CLEANING PROCEDURE	2 wk		X	2	X		
PREP FOR SHIPMENT PROCEDURE	6 wk		X	2	X		
Deleted			X	2	X		
ASSEMBLY DRAWINGS	6 wk		X	2	X		
DESIGN REVIEW		X			X	Prior to release for fabrication	
Deleted				2	X		
Deleted		X		2	X		
OPERATION & MAINTENANCE MANUALS	8 wk			5	X		
SHOP TEST PLAN			X	2	X	Prior to release for fabrication	
SHOP TEST (WITH REPORT)		X		2	X	Prior to release for shipment	

Title: **SPECIFICATION FOR LN2 DEWARS**

SPECIFICATION FOR

LN_2 DEWARS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE: Alan L Bradbrook

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Richard Berg Jr

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	DM 4/30/96	RES 4/3/96	Revised per DEO # 0154
ø	DM 3/5/96	D. McWilliams	Initial release PER DEO 0083 FOR QUOTE

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE DM	APPROVED DATE D. McWilliams	Number V049-2-013	Rev. 1

SPECIFICATION TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the manufacturing engineering, materials, fabrication, assembly, inspection, testing, preparation for shipping, and shipment of LN_2 dewars for the LIGO vacuum system.

All attachments are part of this specification.

The specified equipment is intended for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF contract, includes two installations at widely separated sites: near Hanford, WA and Livingston, LA. Each installation contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

	Quantity	Date	PSI P/N
10,000 Gallon (minimum net after 90 days)			V0492013 P1
Washington Site:	6	9/1/97	
Louisiana Site:	2	3/1/98	
Total Required	8		

	Quantity	Date	PSI P/N
12,000 Gallon (minimum net after 90 days)			V0492013 P2
Washington Site:	2	9/1/97	
Louisiana Site:	2	3/1/98	
Total Required	4		

2.2 Acceptances at the sites (the start of Vendor's warranty periods) are expected to occur on a staggered basis, with final acceptance expected to occur no later than May 31, 1998. Portions of the equipment may be accepted earlier.

3.0 EQUIPMENT REQUIREMENTS

The dewars shall have minimum usable capacities as shown in Section 2.2, above, after accounting for boil-off losses due to parasitic heat loads over a storage time of 90 days without refilling at an ambient temperature of 100 F. The dewar boil-off rate shall be noted. Each dewar shall be provided with an ambient air vaporizer with associated controls to maintain dewar pressure at a design LN_2 consumption rate of 200 gallons per hour. In addition, a vaporizer to provide warm nitrogen at a flow of 11,000 SCFH shall be provided (regulators will be provided by others).

4.0 DESIGN REQUIREMENTS

4.1 The Vendor shall use his standard dewar design, subject to the requirements listed below, indicating the design pressure and temperatures. The Vendor shall fabricate and test the vessels according to this specification and the attached drawings.

4.2 Dewars shall have either a stainless steel or a 9% Nickel steel (ASTM A353) inner vessel and carbon steel outer vessel, with skirts or legs and lifting lugs. They shall be designed to be mounted on a concrete pad outdoors in a vertical position. The suggested footprint for the anchor bolts is a circle with a 52 inch radius. Footpads may extend beyond this circle by a reasonable amount. The Vendor shall advise PSI with his bid if there is a significant deviation from this requirement in his design.

4.3 The inner vessel shall be ASME Section VIII, Division 1 Code stamped.

4.4 Vessels shall have an electrical grounding connection (lug).

4.5 An outer vessel relief device sized in accordance with CGA requirements shall be provided. The inner vessel relief shall meet ASME requirements.

4.6 In addition to the Vendor's standard level gauge, the Vendor shall provide pressure taps to install a level transmitter supplied by Buyer.

4.7 The Vendor shall provide a self-contained vent line back pressure regulator as shown on the P&ID.

4.8 The Vendor shall provide a self contained pressure regulator for the vaporizer loop to maintain dewar pressure as shown on the P&ID.

4.9 The inner vessel shall have a dual relief valve/rupture disc arrangement as shown on the P&ID.

4.10 The bottom liquid draw line will mate with stainless steel vacuum - jacketted pipe (supplied by others). The inlet of the liquid draw line shall be 18" above the bottom of the dewar inner vessel, facing down, in order to minimize the possibility of ice particles being drawn into the line.

4.11 The dewar shall be suitable for the following outdoor ambient conditions:

Winter: 15 deg. F dry bulb
Summer: 96 deg. dry bulb, 68 deg. F wet bulb.

4.12 The following paragraphs of Attachment B are not applicable:

5.1.4	5.1.5	5.1.7
6.3	6.4	6.5
9.4	11.3	11.4

5.0 REQUIRED DOCUMENTATION

Documentation requirements listed in Attachment A shall be provided according to the Buyer's schedule (schedule later). In addition, the following shall be provided:

- Copies of the material test reports for pressure boundary material
- Copies of ASME Manufacturer's Code Data Report.
- All documentation shall be supplied to the PSI Quality Assurance Manager at the time of shipment.

6.0 SHOP CLEANING/TESTING

The Vendor shall follow his standard cleaning and testing procedures.

7.0 INSPECTION

The inspections called for in Attachment A shall be performed by the Vendor.

8.0 WARRANTY

Refer to Attachment A, Section 15.0, and to Attachment B, General Provisions, Article 40 for warranty requirements.

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: LIQUID NITROGEN DEWARS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-013

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE	2 Wk		X	2	X		
VENDOR Q.A. PLAN	2 Wk		X	2	X		
CLEANING PROCEDURE	4 Wk		X	2	X		
PREP FOR SHIPMENT PROCEDURE	6 Wk		X	2	X		
ASSEMBLY DRAWINGS	2 Wk		X	2	X		
DESIGN REVIEW	*	X			X	PRIOR TO RELEASE FOR FABRICATION	
IN-PROCESS INSPECTIONS	*	X		2	X	PRIOR TO RELEASE FOR FABRICATION	
OPERATION & MAINTENANCE MANUALS	12 Wk			5	X		
SHOP TEST PLAN	8 Wk		X	2	X	PRIOR TO RELEASE FOR FABRICATION	
SHOP TEST (WITH REPORT)	*	X		2	X	PRIOR TO RELEASE FOR SHIPMENT	
SHOP DIMENSIONAL INSPECTION	*	X		2	X		
WELDING PROCEDURES	4 Wk		X	2	X		
* PER APPROVED VENDOR SCHEDULE							

Title: SPECIFICATION FOR VACUUM JACKETED PIPING

SPECIFICATION FOR

VACUUM JACKETED PIPING

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Thomas M. Stan

QUALITY ASSURANCE: Alan L Bradbury

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Bill Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
P1	10-19-95		Released per DEO 0005
P1	TAMES 9-26-95		REVISED FOR UPDATED PRELIMINARY DESIGN

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE T. Stan 6-14-95	APPROVED DATE AES 9/26/95	Number V049-2-016	Rev. P1

SPECIFICATION TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, and shipment of vacuum jacketed piping for the LIGO vacuum system. The piping will be used in liquid and gaseous nitrogen service at the 80 K cryopumps.

All attachments are part of this specification.

The specified equipment is intended for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF contract, includes two installations at widely separated sites: near Hanford, WA and Livingston, LA. Each installation contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

	Quantity	Date	Price
Washington Site:			
Supply Line	8	9/1/97	
Return Line	8	9/1/97	
Louisiana Site:			
Supply Line	4	3/1/98	
Return Line	4	3/1/98	
Total Required			
Supply Line	12		
Return Line	12		

2.2 Acceptances at the sites (the start of Vendor's warranty periods) are expected to occur on a staggered basis, with final acceptance expected to occur no later than May 31, 1998. Portions of the equipment may be accepted earlier.

3.0 EQUIPMENT REQUIREMENTS

The piping will be used in liquid and gaseous nitrogen service at the 80 K cryopumps. The supply line piping shall have a heat leak no greater than 0.581 Btu/hr-ft for LN_2.

4.0 DESIGN REQUIREMENTS

4.1 The piping shall be in accordance with the attached drawings.

4.2 The piping shall meet the Vendor's standards.

5.0 REQUIRED DOCUMENTATION

In addition to the documentation listed in Attachment A, the following documentation shall be provided prior to shipment (schedule later):

- Final drawings for review of layout.

6.0 SHOP TESTING

The Vendor shall perform his standard testing.

7.0 INSPECTION

The inspections called for in Attachment A shall be performed by the Vendor:

8.0 WARRANTY

Refer to Attachment A, Section 15.0, and to Attachment B, General Provisions, Article 40 for warranty requirements.

SPECIFICATION FOR

AMBIENT AIR VAPORIZERS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE: A.K. Bradbrook

TECHNICAL DIRECTOR: _____

PROJECT MANAGER: _____

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
Ø	DM 2/20/96		Initial release DEO # 0067

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number A V049-2-055 Rev. Ø
	DM	2/20/96	D. Miller	2-23-96	

TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of the ambient air vaporizers for the LIGO vacuum system.

All attachments are incorporated herein by reference and made a part of this specification.

The specified equipment is for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF grant, includes to sites (Hanford Reservation, near Richland, WA, and Livingston, LA). Each site contains laser interferometers components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

PSI P/N	Type	Delivery Site	Quantity	Ends	Date
V0492055 P1	10600 SCFH min. capacity	Washington	2	MPT	8/7/97
		Louisiana	2	MPT	2/5/98
		Total	4		
V0492055 P2	5300 SCFH min. capacity	Washington	6	MPT	8/7/97
		Louisiana	2	MPT	2/5/98
		Total	8		

3.0 EQUIPMENT REQUIREMENTS

3.1 The ambient air vaporizers will be used to vaporize liquid nitrogen at a supply pressure of approximately 10 psig for the purpose of warming up the LIGO 80K cryopumps.

4.0 DESIGN REQUIREMENTS

4.1 Mechanical Requirements

4.1.1 The vaporizers shall be an all welded aluminum alloy construction designed to be used outdoors, and mounted directly to a concrete pad by means of anchor bolts.

4.1.2 The vaporizer duty cycle will be 12 hours of continuous use followed by an extended period (greater than 7 days) during which no gas will be flowing through it.

4.1.3 The vaporizer design shall be based on the flow rates specified in paragraph 2.1, and a 20 deg. F approach temperature under the following ambient conditions:

Winter:	15 deg. F dry bulb
Summer:	96 deg. dry bulb, 68 deg. F wet bulb

4.1.4 The maximum allowable pressure drop across the vaporizer shall be as follows:

10600 SCFH vaporizer	2.0 psid
5300 SCFH vaporizer	1.0 psid

4.2 Electrical Requirements
Not applicable.

4.2.1 Instrumentation Requirements
None required.

4.2.2 Power requirements
Not applicable.

4.2.3 The following paragraphs of Attachment B are not applicable:

3.2	5.1.5	5.1.7
5.1.4	5.2	8.2
8.4	9.3	9.4
11.3	11.4	

5.0 REQUIRED DOCUMENTATION

In addition to the documentation listed in Attachment B, the following documentation shall be provided prior to shipment:

- Manufacturer's standard QA reports (including final functional test reports).

6.0 SHOP TESTING

The equipment shall be tested in accordance with the manufacturer's standard shop test.

7.0 INSPECTION

7.1 All testing and inspections called for in Attachment B (Specification V049-2-033, General Equipment Requirements) shall be performed by the Vendor. Additional quality assurance requirements are listed in Attachment A, Quality Assurance Requirements Summary.

8.0 WARRANTY

Refer to Specification V049-2-034, Purchased Equipment Commercial Requirements (attached to the Request for Quotation), for warranty requirements.

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: AMBIENT AIR VAPORIZERS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-055

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE	2 Wk		X	2	X		
VENDOR Q.A. PLAN	2 Wk		X	2	X		
CLEANING PROCEDURE	4 Wk		X	2	X		
PREP FOR SHIPMENT PROCEDURE	6 Wk		X	2	X		
ASSEMBLY DRAWINGS	4 Wk		X	2	X		
DESIGN REVIEW	*	X			X	PRIOR TO RELEASE FOR FABRICATION	
IN-PROCESS INSPECTIONS	*	X		2	X	PRIOR TO RELEASE FOR FABRICATION	
OPERATION & MAINTENANCE MANUALS	12 Wk			5	X		
SHOP TEST PLAN	8 Wk		X	2	X	PRIOR TO RELEASE FOR FABRICATION	
SHOP TEST (WITH REPORT)	*	X		2	X	PRIOR TO RELEASE FOR SHIPMENT	
SHOP DIMENSIONAL INSPECTION	*	X		2	X		
WELDING PROCEDURES	4 Wk		X	2	X		
* PER APPROVED VENDOR SCHEDULE							

SPECIFICATION FOR

80K PUMP REGENERATION HEATERS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE: A K Budlong

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Richard Boyle

ELECTRICAL/ INSTRUMENTATION Jan Bird

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
∅	DM	DMcW	Initial release

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number A V049-2-056	Rev.
	DMoore 2/23/96	D. McW		

TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of the 80K pump regeneration heaters for the LIGO vacuum system.

All attachments are incorporated herein by reference and made a part of this specification.

The specified equipment is for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF grant, includes to sites (Hanford Reservation, near Richland, WA, and Livingston, LA). Each site contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometers components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

PSI P/N	Type	Delivery Site	Quantity	Nozzles	Date
V0492056 P1	10600 SCFH min. capacity	Washington	2	Flg or BW	8/7/97
		Louisiana	2	Flg or BW	2/5/98
		Total	4		
V0492056 P2	5300 SCFH min. capacity	Washington	6	Flg or BW	8/7/97
		Louisiana	2	Flg or BW	2/5/98
		Total	8		

3.0 EQUIPMENT REQUIREMENTS

3.1 The regeneration heaters will be used to heat nitrogen gas at a supply pressure of approximately 10 psig for the purpose of warming up the LIGO 80K cryopumps.

4.0 DESIGN REQUIREMENTS

4.1 Mechanical Requirements

4.1.1 The heaters shall be an all welded stainless steel construction designed to be used outdoors, and mounted on a skid, provided by PSI, by means of threaded studs or bolts. The heater elements shall be accessible and removable by means of a flanged connection.

4.1.2 The heater duty cycle will be 12 hours of continuous use followed by an extended period (greater than 7 days) during which no gas will be flowing through it.

4.1.3 The heater design shall be based on the flow rates specified in paragraph 2.1, under the following ambient conditions:

Minimum Gas Supply Temperature	-5 deg. F.
Required Outlet Temperature	
5300 SCFH Heater	375 deg. F
10600 SCFH Heater	360 deg. F

Ambient Conditions:

Winter	15 deg. F dry bulb
Summer	96 deg. F. dry bulb, 68 deg. F. wet bulb

4.1.4 The maximum allowable pressure drop across the heater shall be as follows:

10600 SCFH heater	1.0 psid
5300 SCFH heater	1.0 psid

4.1.5 Nozzles sizes for the heaters shall be as follows:

10600 SCFH heater	1-1/2 inch IPS inlet 3 inch IPS outlet
5300 SCFH heater	1-1/2 inch IPS inlet 1-1/2 inch IPS outlet

4.2 Electrical Requirements
Refer to Attachment B.

4.2.1 Instrumentation Requirements
Two type "K" thermocouples shall be internally mounted in the heater cavity. One will be used for a high temperature alarm status, The other will be used as a spare. Thermocouples shall be #20 AWG, ungrounded, and shielded. A type "K" female connector and dedicated knockout, separate from power, shall be provided.

4.2.2 Controls Requirements
The Vendor shall supply a zero crossing type SCR controller for adjustment of the power applied to the heater. This unit shall be proportionately sized based upon the the heater power requirements. The input signal will be 4-20 ma. Status indication in the form of relay outputs shall be required, at a minimum for:

a) Shorted SCR indication
b) SCR "on" indication

The SCR unit shall be supplied in a NEMA 4X enclosure.

4.2.3 Power Requirements: A dedicated power knockout and power terminals shall be provided. The available power is a 480V, 3 phase, 4 wire system.

4.2.4 The following paragraphs of Attachment B are not applicable:

5.1.1	5.1.4	5.1.5
5.1.6	5.1.7	5.1.11
5.2.1.3	6.3	8.2
8.4	9.4	11.3
14.0		

5.0 REQUIRED DOCUMENTATION

In addition to the documentation listed in Attachment B, the following documentation shall be provided prior to shipment:

- Manufacturer's standard QA reports (including final functional test reports).

6.0 SHOP TESTING

6.1 The equipment shall be tested in accordance with the manufacturer's standard shop test.

7.0 INSPECTION

7.1 All testing and inspections called for in Attachment B (Specification V049-2-033, General Equipment Requirements) shall be performed by the vendor. Additional quality assurance requirements are listed in Attachment A, Quality Assurance Requirements Summary.

8.0 WARRANTY

Refer to Specification V049-2-034, Purchased Equipment Commercial Requirements (attached to the Request for Quotation), for warranty requirements.

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: REGENERATION HEATERS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-056

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE	2 Wk		X	2	X		
VENDOR Q.A. PLAN	2 Wk		X	2	X		
CLEANING PROCEDURE	4 Wk		X	2	X		
PREP FOR SHIPMENT PROCEDURE	6 Wk		X	2	X		
ASSEMBLY DRAWINGS	4 Wk		X	2	X		
DESIGN REVIEW	*	X			X	PRIOR TO RELEASE FOR FABRICATION	
IN-PROCESS INSPECTIONS	*	X		2	X	PRIOR TO RELEASE FOR FABRICATION	
OPERATION & MAINTENANCE MANUALS	12 Wk			5	X		
SHOP TEST PLAN	8 Wk		X	2	X	PRIOR TO RELEASE FOR FABRICATION	
SHOP TEST (WITH REPORT)	*	X		2	X	PRIOR TO RELEASE FOR SHIPMENT	
SHOP DIMENSIONAL INSPECTION	*	X		2	X		
WELDING PROCEDURES	4 Wk		X	2	X		
* PER APPROVED VENDOR SCHEDULE							

SPECIFICATION FOR

SMALL VACUUM VALVES

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Thomas M. Stan

PROCESS ENGINEER: Roberto Thom.

QUALITY ASSURANCE: Alan K Bradbrook

TECHNICAL DIRECTOR: D. O. McCullough

PROJECT MANAGER: Richard Boyle

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
O	TMS 2-29-96	D. McCullough	RELEASED FOR QUOTE PER DEO 0075

PROCESS SYSTEMS INTERNATIONAL, INC. — **SPECIFICATION**

INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number	Rev.
	T. Stan	2-29-96	K&B	2/21/96	V049-2-059	O

SPECIFICATION TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of small (1 1/2" and 2 1/2") high vacuum and ultra high vacuum angle valves for the LIGO vacuum system.

The specified equipment is for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF grant, includes two sites (Hanford Reservation, near Richland, WA and Livingston, LA). Each site contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

	Quantity	Date
PSI (Westboro, MA)		
1 1/2" High Vac	1	6/1/96
2 1/2" High Vac	1	6/1/96
1 1/2" Ultra High Vac	2	6/1/96
2 1/2" Ultra High Vac	2	6/1/96
Washington Site:		
1 1/2" High Vac	86	9/1/97
2 1/2" High Vac	46	9/1/97
1 1/2" Ultra High Vac	50	9/1/97
2 1/2" Ultra High Vac	18	9/1/97
Louisiana Site:		
1 1/2" High Vac	50	3/1/98
2 1/2" High Vac	23	3/1/98
1 1/2" Ultra High Vac	25	3/1/98
2 1/2" Ultra High Vac	6	3/1/98
Total Required		
1 1/2" High Vac	137	
2 1/2" High Vac	70	
1 1/2" Ultra High Vac	77	
2 1/2" Ultra High Vac	26	

2.2 Acceptances at the sites are expected to occur on a staggered basis, with final acceptance at Washington expected to occur about May 31, 1998, and about November 30, 1998 in Louisiana.

3.0 DESIGN REQUIREMENTS

3.1 Angle valves shall be 304L or 316L stainless steel (304 or 316 stainless steel is acceptable if the valves are unavailable in L grade SS).

3.2 End connections shall be CF flanges.

3.3 The valves shall have stainless steel metal bellows stem feedthroughs.

3.4 Neither the body leakage not the seat leakage shall exceed 1 x 10^{-9} torr liters/sec of helium.

3.5 The valves shall be designed to seal in both directions.

3.6 The internal valve mechanisms shall be non-lubricated.

3.7 Valves shall be manually actuated by a handwheel.

3.8 Valves shall be bakeable to 150 C +/-20 C (170 C maximum).

3.9 The valves shall be cleaned in accordance with the Vendor's standard procedures applicable to the valve service.

4.0 REQUIRED DOCUMENTATION

Engineering drawings shall be submitted for approval prior to fabrication. Manufacturer's standard QA reports shall be provided prior to shipment:

5.0 SHOP TESTING

Each valve shall be tested for leakage (using oil-free pumping equipment and leak detector) prior to shipment from the manufacturer

6.0 INSPECTION

The Vendor's standard inspections shall be performed. Also, each valve shall be inspected for cleanliness by black light prior to shipment. Valves shall be recleaned if any contamination is found.

Title: **SPECIFICATION FOR CLEAN QUARTER-TURN VALVES**

SPECIFICATION FOR

CLEAN QUARTER-TURN VALVES

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Thomas M. Starr

PROCESS ENGINEER: Roberto Thew

QUALITY ASSURANCE: Alan L Buckbook

TECHNICAL DIRECTOR: D.C. McWilliams

PROJECT MANAGER: Bud Bayly

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

0	TMS 3-1-96	D.McW 3-5-96	RELEASED FOR QUOTE PER DCO 077
REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE

PROCESS SYSTEMS INTERNATIONAL, INC.					**SPECIFICATION**	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number **V049-2-060**	Rev.
	T.M. Starr	3-1-96	RES			0

SPECIFICATION TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of 2" clean quarter-turn valves for the LIGO vacuum system. These valves will be used in Federal Standard 209 Class 100 air service.

The specified equipment is for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF grant, includes two sites (Hanford Reservation, near Richland, WA and Livingston, LA). Each site contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

	Quantity	Date
Washington Site:	12	9/1/97
Louisiana Site:	5	3/1/98
Total Required	17	

2.2 Acceptances at the sites are expected to occur on a staggered basis, with final acceptance at Washington expected to occur about May 31, 1998, and about November 30, 1998 in Louisiana.

3.0 DESIGN REQUIREMENTS

3.1 The valves shall be either butterfly, ball or plug style.

3.2 The valves shall be 304L or 316L stainless steel (304 or 316 stainless steel is acceptable if the valves are unavailable in L grade SS).

3.3 End connections shall be CF flanges.

3.4 The valves shall be designed to seal in both directions.

3.5 The internal valve mechanisms shall be non-lubricated.

3.6 The valves shall be cleaned in accordance with the Vendor's standard procedure for valves intended for use in Federal Standard 209 Class 100 clean air service..

3.7 Valves shall be manually actuated.

4.0 REQUIRED DOCUMENTATION

Engineering drawings shall be submitted for approval prior to fabrication. Manufacturer's standard QA reports shall be provided prior to shipment:

5.0 SHOP TESTING

Manufacturer's standard testing shall be performed.

6.0 INSPECTION

The Vendor's standard inspections shall be performed. Also, each valve shall be inspected for cleanliness by black light prior to shipment. Valves shall be recleaned if any contamination is found.

SPECIFICATION FOR

LIGO CRYOGENIC CONTROL VALVES

FOR

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

Job No. V59049

INSTRUMENTATION/ ELECTRICAL ENGINEER: F. Bark

PROJECT ENGINEER: Dave Moore

TECHNICAL DIRECTOR: D. M. Williams

PROJECT MANAGER: Bill Bayle

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
Ø	DM 2/29/96	D M W	Initial release PER D800076 FOR QUOTE

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number V049-2-062	Rev. Ø
	D Moore 2/29/96	D M W 3-11-96		

TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of the cryogenic control valves for the LIGO vacuum system.

All attachments are incorporated herein by reference and made a part of this specification.

The specified equipment is for use as part of the Vacuum Equipment supplied for the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO, which is operated by Caltech and MIT under an NSF grant, includes to sites (Hanford Reservation, near Richland, WA, and Livingston, LA). Each site contains laser interferometers in an L shape with 4 km arms, a vacuum system for the sensitive interferometers components and optical beams, and other support facilities.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

1.1 Furnished By The Seller

a. Control valves of the quantity and type designated on the attached valve data sheets.

b. Shop testing and inspection of valves.

c. Drawings and data as indicated in this specification.

2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

PSI P/N	Type	Delivery Site	Quantity	Date
V0492062 P1	Cryogenic Control Valve	Costa Mesa, CA	12	8/23/96

3.0 EQUIPMENT REQUIREMENTS

3.1 The control valves will be used to supply liquid nitrogen for the purpose of maintaining a liquid level in the LIGO 80K cryopumps.

4.0 DESIGN REQUIREMENTS

4.1 In addition to the requirements in this section, process, mechanical, and electrical requirements for the specific application are given on the valve data sheets and/or schedules attached to this specification.

4.1.1 Valves shall be suitable for outdoor service at the LIGO sites located near Richland, Washington and Livingston, Louisiana.

4.2 Valves shall be vacuum jacketted or shall be capable of being equipped with vacuum jacketting by the Buyer. The vendor shall state in his quotation if vacuum jacketing is supplied with the valves.

4.3 In addition to those listed in Attachment C, the following codes and standards shall apply:

B16.25 Butt Welding Ends

B16.37 Hydrostatic Testing of Control Valves

4.4 Electrical design and material shall conform with the latest edition of the National Electrical Code, and shall carry the Underwriters Laboratory or Factory Mutual label, except for material for which UL listing criterion has not been established.

4.5 Valves for cryogenic service shall be extended stem type.

4.6 The Vendor shall indicate if the "top works" (actuator, etc.) of the valve are self supporting as supplied, or if additional supports are required, and if so, shall indicate support points to be used. This information shall be submitted with the quotation.

4.7 Electrical/Instrumentation Requirements

4.7.1 All instruments shall have watertight enclosures for outdoor service.

4.7.2 All devices and instrumentation shall be mounted on the valve/actuator assemblies with appropriate heavy duty brackets. This includes transducers, positioners, combination electro-pneumatic positioners, solenoids, air regulator sets, etc. All such items shall be tubed to the diaphragm by the Seller.

4.7.3 All solenoid valves shall be stainless steel ASCO or approved equal. When high capacity type solenoids are specified on the valve data sheets, the Seller shall select the orifice size and diaphragm connection so the that Buyer's required closing times are met. All solenoid valves shall be supplied with high temperature coils suitable for the intended service and design ambient conditions. Solenoid coil voltage shall be 24VDC. The solenoid valve shall be a three way ASCO valve installed at the positioner discharge side. It shall exhaust the positioner to atmosphere when de-energized.

4.7.4 Limit switches, as per the data sheet, shall be double-pole, double-thro (DPDT), hermetically sealed proximity type, rated 120 VAC, 5 amps (minimum), (Go Systems or equal).

4.7.5 The I/P shall operate on a 4-20 mA signal.

4.8 The following paragraphs of Attachment B are not applicable:

5.1.1	5.1.5	5.1.6
5.1.7	5.1.11	5.2.1.3
6.3	8.2	8.4
9.4	11.3	14.0

4.9 Utilities

Refer to Attachment C.

5.0 REQUIRED DOCUMENTATION

In addition to the documentation listed in Attachment B, the following documentation shall be provided prior to shipment:

5.1 Manufacturer's standard QA reports (including final functional test reports).

5.2 Process Data

*1. Confirmation of the required C_V (or C_g) as shown on the attached data sheets, based on the flows and pressure drops allowed.

*2. If no C_V or (or C_g) is indicated on the attached data sheets, the vendor shall supply such data.

*3. A table or graph showing C_V (or C_g) versus percent of valve travel.

*4. Completed PSI valve data sheets.

*This data must be submitted with Vendor's proposal for evaluation prior to award of contract.

5.3 Mechanical Data

1. Outline dimension drawings and weight (including operators and accessories).

2. Identification and description of all components and accessories.

5.4 Assembly Drawings

Assembly drawings shall be prepared by the vendor shall be submitted to the Purchaser for information only. Four (4) copies (two [2] reproducibles and two [2] prints) shall be submitted to the Purchaser within four (4) weeks ARO. This includes drawings of any purchased items. These drawings must show general and overall dimensions, details of internal parts, estimated weights, and all material used for construction. Drawings shall be certified as dimensionally correct. Certified catalog cuts are acceptable.

5.5 Drawing Review

Drawing approval is not required from the Buyer before starting fabrication. The Buyer's review of the Vendor's drawings is of a general nature. Review of any drawings by the Buyer does not serve as acceptance of any errors or deviations from these specifications or instructions relating to the work. The Vendor shall call attention to any such deviations by a separate written notice when submitting the drawings for review. Unless specific written approval is obtained from the Purchaser, deviations are not acceptable.

5.6 Changes

If changes are made to any drawings after drawing submittal the Vendor shall furnish copies to the Buyer showing all changes clearly identified on the drawing.

6.0 SHOP TESTING

6.1 The equipment shall be tested in accordance with the manufacturer's standard shop test.

7.0 INSPECTION

7.1 All testing and inspections called for in Attachment B (Specification V049-2-033, General Equipment Requirements) shall be performed by the vendor. Additional quality assurance requirements are listed in Attachment A, Quality Assurance Requirements Summary.

8.0 WARRANTY

8.1 Refer to Specification V049-2-034, Purchased Equipment Commercial Requirements (attached to the Request for Quotation), for warranty requirements.

8.2 Performance Guarantee

The valves must be sized to allow the specific flow rates while operating with the designated pressure drops.

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: CRYOGENIC CONTROL VALVES	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-062

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE	2 Wk		X	2	X		
VENDOR Q.A. PLAN	2 Wk		X	2	X		
CLEANING PROCEDURE	4 Wk		X	2	X		
PREP FOR SHIPMENT PROCEDURE	6 Wk		X	2	X		
ASSEMBLY DRAWINGS	4 Wk		X	2	X		
DESIGN REVIEW	*	X			X	PRIOR TO RELEASE FOR FABRICATION	
IN-PROCESS INSPECTIONS	*	X		2	X	PRIOR TO RELEASE FOR FABRICATION	
OPERATION & MAINTENANCE MANUALS	12 Wk			5	X		
SHOP TEST PLAN	8 Wk		X	2	X	PRIOR TO RELEASE FOR FABRICATION	
SHOP TEST (WITH REPORT)	*	X		2	X	PRIOR TO RELEASE FOR SHIPMENT	
SHOP DIMENSIONAL INSPECTION	*	X		2	X		
WELDING PROCEDURES	4 Wk		X	2	X		
* PER APPROVED VENDOR SCHEDULE							

Attachment B

PSI Valve Data Sheets

INSTRUMENTS, PRIMARY ELEMENTS AND CONTROL VALVES

PSI S20

PROJECT LIGO
UNIT 80K Pump
P.O.
ITEM
CONTRACT
MFR SERIAL*

Data Sheet 1 of 1
SPEC V049-2-062
TAG —
DWG V049-0-006
SERVICE

1 Fluid Liquid Nitrogen — Crit Pres PC 492.28 psia

	SERVICE CONDITIONS	Units	Max. Flow LIQUID	Max. Flow VAPOR	Norm Flow LIQUID	Norm Flow VAPOR	Min. Flow LIQUID	Min. Flow VAPOR
2	Flow Rate	(lbm/hr)	31.91				9.00	
3	Inlet Pressure	10 psig						
4	Outlet Pressure	5 psig						
5	Inlet Temperature	-312°F						
6	Spec Wt/Spec Grav/Mol Wt							
7	Viscosity/Spec Heats Ratio	cP	.128	.0056			.128	.0056
8	Vapor Pressure Pv	29.7 psia						
9	*Required Cv		.031				.009	
10	*Travel	%						
11	Allowable SPL	dBA						
11	*Predicted SPL	dBA						

12 LINE: LN2 SUPPLY

13 Pipe Line Size / In 1/2", Sch 10S
14 & Schedule / Out 1/2", Sch 10S
15 Pipe Line Insulation Vacuum jacketted

VALVE BODY/BONNET:

16 *Type Globe or angle
17 *Size ANSI Class 150
18 Max Press/Temp 50 psig / 302 F
19 *Mfr & Model
20 *Body/Bonnet Matl SS / SS
21 *Liner Material/ID /
22 End / In B.W.
23 Connection / Out B.W.
24 Flg Face Finish
25 End Ext/Matl /
26 *Flow Direction
27 *Type of Bonnet extended stem
28 Lub & Iso Valve Lube
29 *Packing Material
30 *Packing Type
31

TRIM:

32 *Type
33 *Size Rated Travel
34 *Characteristics
35 *Balanced/Unbalanced
36 *Rated Cv Fl Xt
37 *Plug/Ball Material /
37 *Disk Material
38 *Seat Material
39 *Cage/Guide Material
40 *Stem Material
41
42

SPECIALS/ACCESSORIES:

43 NEC Class Group Div
44 NOTES:
45 1. Flashing service
46
47
48
49
50
51
52

ACTUATOR:

53 * Type Cylinder
54 *Mfr & Model
55 * Size Eff Area
56 On/Off Modulating YES
57 Spring Action Open/Close F.C.
58 *Max Allowable Pressure
59 *Min Required Pressure
60 Available Air Supply Pressure:
61 Max 80 psig Min
62 *Bench Range /
63 Act Orientation
64 Handwheel Type
65 Air Failure Valve Set at
66

67 *Input Signal ~~(psig)~~ 4 to 20 mA

POSITIONER:

68 *Type Electro-pneumatic
69 *Mfr & Model
70 *On Incr Signal Output Incr/Decr
71 Gauges By-pass
72 *Cam Characteristics
73 *Input signal (psig)

SWITCHES:

74 Type limit Quantity 1
75 *Mfr & Model
76 Contacts/Rating /
77 Actuation Points valve closed
78

AIR SET:

79 *Mfr & Model
80 *Set Pressure
81 Filter Gauge
82

TESTS:

83 *HydroPressure
84 ANSI/FCI Leakage Class
85 Max. Shutoff Diff. Press. (psi)
86

Rev.	Date	Revision	Orig.	App.
Ø	2/28/96		DM	

Pg 2 of 2

* Information supplied by manufacturer unless already specified.

PSI FORM S20.50, Rev. 2

Title: **SPECIFICATION FOR FABRICATION of BAKEOUT CONTROL SYSTEM CABINET**

SPECIFICATION FOR

FABRICATION of BAKEOUT CONTROL SYSTEM CABINET

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: [signatures]

ELECTRICAL : [signature]

QUALITY ASSURANCE: Alan L Bradbrook

TECHNICAL DIRECTOR: D. A. McWilliam

PROJECT MANAGER: [signature]

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	PPS	HB 3-26-96	Issues for Purchase, DEO # 095
Ø	—	—	Issued for Bid DEO #089

PROCESS SYSTEMS INTERNATIONAL, INC. — **SPECIFICATION**

INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number	Rev.
	PPS	3/12/96	D McW	3 12	V049-2-068	1

TABLE OF CONTENTS

1 SCOPE OF WORK

This specification establishes minimum requirements for material, fabrication, documentation, packing, and shipping to Process Systems International, Westborough, MA. of the control system cabinet(s) in accordance with drawings and attachments.

2 DRAWING AND SPECIFICATION INTENT

2.1 Intent of the Drawings and Specifications is to assist and guide the Vendor and to establish minimum requirements.

2.2 Drawings indicate arrangement and approximate location of components.

2.3 Comply with specific, detailed requirements indicated in lieu of generally stated requirements.

2.4 Portions of these Drawings and Specifications are abbreviated and may include incomplete statements. Infer the omitted words or phrases such as "the Vendor shall", "shall be", "as indicated on the drawings", "in accordance with details", "a", "the", and "all".

2.5 Drawings and Specifications do not undertake to indicate every item necessary to produce a complete installation of the Work indicated or specified.

3 DEFINITIONS (ALSO SEE THE GENERAL CONDITIONS)

By Others	Work not under this Contract.
Indicated	Shown or noted.
Install	Place, secure, and connect.
Labeled	Approved by nationally recognized testing company.
Permitted	As by code, Contract Documents, or Buyer.
Provide	Furnish and install.
Buyer	Process Systems International (PSI).
Required	As by code or Contract Documents.
Submittal	Information required to show that the proposed equipment meets project requirements.
Use	Provide material or equipment referenced.
Vendor	Successful bidder accepting responsibility for equipment fabrication.
Work	Material, equipment and fabrication and other requirements as established in the Contract Documents.

Wire (Verb)	Connect to equipment indicated and provide wiring required for connection.
Wiring	Conductors, raceways, and accessories as required for a complete installation.

4 EXCEPTIONS

Exceptions to the specification shall be specifically brought out under a schedule titled, "Schedule of Deviations". In the absence of the "Schedule of Deviations," it shall be deemed that the Vendor's offer is fully in compliance with this specification.

5 CODES AND STANDARDS

5.1 Comply with requirements of NFPA 70 (NEC) and NFPA 79 (Electrical Standard for Industrial Machinery).

5.2 The Drawings and Specifications do not undertake to repeat requirements written in the above code and standard.

6 LABELED EQUIPMENT

Provide labeled equipment where recognized national testing company standards, such as UL, exist.

7 INSTALLATION RESTRICTIONS

7.1 Arrange and install equipment in accordance with the manufacturer's specifications and as indicated on Drawings.

7.2 Permanently install a cabinet designation nameplate in a conspicuous location as indicated on Drawings.

7.3 Label equipment with designation as indicated. Use adhesive backed labels with 1/8" high lettering as applicable.

7.4 Label terminal strips as indicated using manufacturer's printed terminal strips labels.

8 SPECIFIED EQUIPMENT AND SUBSTITUTIONS

8.1 The manufacturer of the equipment specified is used as the basis of the design and to establish quality required for this project.

8.2 The description following a catalog number is basically to identify the product, but it may also call for accessories, options, and modifications which are beyond the cataloged product.

8.3 Submit proposed substitutions to Buyer for acceptance. With submittal, provide details of necessary changes to accommodate substitutions. Submit samples if requested.

9 WIRING SYSTEMS

9.1 POWER WIRE, 480 & 277 VAC

9.1.1 Provide #14 AWG or larger single, stranded copper, type MTW, conductors rated 90°C, 600 volts unless otherwise specified.

9.1.2 Use colored coded insulation in sizes up to #8 AWG, except up to #6 AWG for grounding conductors, and black insulated conductors in larger sizes (see *WIRING IDENTIFICATION*).

9.1.3 See *TESTING*.

9.2 CONTROL WIRING, 120 VAC

9.2.1 Provide #16 AWG or larger single, stranded copper conductors with Type MTW insulation rated for 90°C and 600 volts unless otherwise indicated. Install conductors in wireway marked "AC WIREWAY" as indicated.

9.2.2 Use colored coded insulation (see *WIRING IDENTIFICATION*).

9.2.3 See *TESTING*..

9.3 CONTROL WIRING, 24 VDC (discrete signals)

9.3.1 Provide #18 AWG or larger single, stranded copper conductors with Type MTW insulation rated for 90°C and 600 volts unless otherwise indicated. Install conductors in wireway marked "DC WIREWAY" as indicated.

9.3.2 See *TESTING*..

9.4 INSTRUMENT WIRING

9.4.1 4-20mA analog signals: Provide #18 AWG stranded copper, shielded twisted pair, single or multi-pair cables as indicated, rated 90°C and 300 volts. Install in wireway marked "DC WIREWAY" as indicated.

9.4.2 Thermocouple: Provide #20 AWG ANSI type JX, solid thermocouple extension cable shielded, rated 105°C and 300 volts.

9.4.3 See *TESTING*.

9.5 WIRING IDENTIFICATION

9.5.1 Power Wiring

9.5.1.1 Color code 480/277 volt conductors as follows:

line A . . . . . brown
line B . . . . . orange
line C . . . . . yellow
neutral . . . . . gray
ground . . . . . green

9.5.2 Control Wiring

9.5.2.1 Color code 208/120 volt conductors as follows:

120 VAC—line . . . . . red
120 VAC—neutral . . . white
24 VDC . . . . . blue
ground. . . . . green

9.5.2.2 Identify each single conductor at each end with indicated wire number or designation. Use self laminating, printed, Brady type wire marker.

9.5.3 Instrument Wiring

9.5.3.1 Shielded twisted pair cables shall have one black and one white conductor.

9.5.3.2 Identify each cable end with indicated cable number or designation. Use self laminating, printed, Brady type wire marker.

9.6 WIRING INSTALLATION

9.6.1 Provide sufficient wire length to permit grouping and training the wires and cables. Where applicable, use self-locking nylon wire ties; cut off loose ends. Take care not to exceed manufacturer's wire bending radii. Do not allow wiring to bear against edges of enclosures. Replace wiring cut too short to meet installation requirements.

9.7 WIRING TERMINATIONS AND CONNECTORS

9.7.1 Power Wiring

9.7.1.1 Where more than one conductor requires termination and terminals are not provided as part of the equipment, provide screw or pressure type insulated terminal blocks.

9.7.1.2 Tighten screw type hardware in accordance with manufacturer's published torque values. If not available, comply with UL 486A standards.

9.7.2 Control Wiring

9.7.2.1 Where more than one conductor requires termination and terminals are not provided as part of the equipment, provide screw or pressure type insulated terminal blocks.

9.7.2.2 Install stripped wire ends into terminal and tighten to manufacturers specifications. Do not install more than two wires in any one terminal point.

9.7.2.3 Remove insulation from ends of conductors using mechanical or electric heat type stripper.

9.7.3 Instrument Wiring

9.7.3.1 Where shielding is noted as "CUT AND TAPE", shielding shall be cut back and shall not be visible, or protrude from insulating sleeve.

9.7.3.2 Coil, insulate, and label ends of spare conductors.

9.7.3.3 Remove insulation from ends of conductors using mechanical or electric heat type stripper.

9.8 EQUIPMENT GROUNDING CONDUCTORS

9.8.1 Where a ground lug is attached to a painted panel, remove paint under lug prior to the installation of ground lug.

9.8.2 If a grounding stud or existing panel mounting bolt is used, secure grounding conductor with ring type compression terminal, *star* type washer between the panel and grounding terminal, and hex nut.

10 TESTING

10.1 No equipment shall be energized without consent of the Buyer.

10.2 It is the Vendor's responsibility to conduct tests without damage to equipment.

10.3 CONTROL AND INSTRUMENT WIRE TESTING

10.3.1 Check point-to-point continuity of each conductor to ensure that wiring is intact and terminated at the proper place at both ends.

10.3.2 Verify wire connections are made in accordance with terminal wiring diagrams and schedules.

10.3.3 Using highlighter (transparent marker), indicate on terminal wiring diagram sheets that each wire and connection has been verified. Make these sheets available to Buyer.

10.3.4 Replace defective wiring and retest.

10.4 RECEPTACLES TESTING

Test polarity and grounding of each receptacle device.

10.5 SCHEDULING, NOTIFYING, AND WITNESSING TESTING

Provide the Buyer with at least seven days notification of scheduled testing. With the notification, include a list of proposed tests and the expected time to perform these tests.

11 INSPECTION

The responsibility for inspection rests with the manufacturer; however, Buyer reserves the right to review equipment at any time during fabrication to assure that the materials and workmanship are in accordance with this specification and the code.

12 RELEASE FOR SHIPMENT

The Vendor shall have a signed "Release for Shipment" form provided by the Buyer's Quality Assurance representative prior to full or partial shipment of product.

13 WARRANTY

The construction of equipment shall be performed in the highest manner of workmanship using only new and unused top quality materials. The equipment shall be guaranteed against defects in materials and workmanship for a period of one year from the date of placement in service.

14 RECORD DRAWINGS

Maintain a set of prints marking them to accurately reflect the actual fabrication. Deliver the set of marked prints to Buyer prior to shipment.

15 EQUIPMENT DELIVERY SCHEDULE

One cart is required May 17, 1996 :

APPENDIX I

DRAWING LIST / CART

GENERAL INFORMATION DRAWINGS

V049-3-014	Rev 0	PLC/PC/Data Acquisition Layout

CABINET LAYOUT DRAWINGS

V049-3-013	Rev 0	Assembly, Heater Control Cart (6 sheets)

CABINET SCHEMATIC DRAWINGS

V049-3-011	Rev 0	Elect Schematic, Control System (8 sheets)
V049-3-012	Rev 0	Elect Schematic, Heater Power (2 sheets)

APPENDIX II

ITEMS FURNISHED BY BUYER / CART

Allen-Bradley PLC Equipment

(1)	1771-A3B	12 Slot Chassis
(1)	1785-L30B	PLC 5/30
(1)	1771-DMC	Co-Processor Module
(1)	1771-DRS1	1 MEG memory expansion for 1771-DMC
(1)	1784-KTX	DH+ PC Interface Module
(1)	1771-CP1	Power Supply Cable
(1)	1771-P7	16 Amp Power Supply
(7)	1771-OAD	120 VDC 16 Point Output Module
(1)	1771-IAD	120 VDC 16 Point Input Module

Personnel Computer

(1)	P5-120	Gateway-2000 120 Pentium PC with 16 MB Ram, 1.2 GB HD, 6X CD-ROM, 3.5" 1.44 MB V036-3-17" SVGA Monitor, Desktop Case, 104+ Keyboard, Microsoft Mouse, running on Windows NT

Tempscan-1000A Thermocouple Acquisition System

(1)	TEMPSCAN-1000A	Main Chassis, includes rack mounting hardware
(1)	EXP/11A	10 Slot expansion chassis, cable and rack mounting hardware
(6)	TEMPTC-32A	32 Channel T/C scanning Module for Non-Grounded T/C's
(1)	RS-232 Cable	PC/AT serial port RS-232/422 Cable (9/25 pin sub-D) to TEMPSCAN-1000A 6 feet long

APPENDIX III

BILL OF MATERIALS / CART

BILL OF MATERIALS (DWG V049-3-013)

ITEM	QTY	P/N	VENDOR	DESCRIPTION
1	2 EA	800MR-A2AS	ALLEN BRADLEY	PUSH BUTTON, BLACK FLUSH, 1 NO, 1 NC
2	1 EA	800MR-H32BLAS	ALLEN BRADLEY	KEY-LOCK SWITCH, 2 POS, 1 NO, 1 NC
3	1 EA	800MR-FX6A4S	ALLEN BRADLEY	PUSH BUTTON, RED MSHRM, 1 NO, 1 NC
4	4 EA	1492-PD3183	ALLEN BRADLEY	POWER DISTRIBUTION BLOCK
5	12 EA	199-DR1	ALLEN BRADLEY	1 METER SYMMETRICAL DIN RAIL
6	99 EA	1492-UF8	ALLEN BRADLEY	FUSE BLOCK, 30A, 600VAC
7	8 EA	1492-N23	ALLEN BRADLEY	END ANCHOR
8	2 EA	97 3100 A 14S-7 S	AMPHENOL	CONNECTOR, 3 POLE
9	35 LF	4A-0405	ANIXTER	CABLE, 5/C 4 AWG, TYPE SO
10	35 LF	4A-1203	ANIXTER	CABLE, 3/C 12 AWG., TYPE SO
11	1 EA	4SSL 1/2	APPLETON	4" X 2 1/8" HANDY BOX
12	1 EA	2510	APPLETON	DUPLEX RECEPTACLE COVER
13	1 EA	ER-16823	BUD INDUSTRIES	24" RACK ENCLOSURE
14	1 EA	ER-16873	BUD INDUSTRIES	24" ADD-A-RACK ENCLOSURE
15	2 EA	ER-16833	BUD INDUSTRIES	24" RACK STEEL DOOR
16	2 PR	PMR-9451	BUD INDUSTRIES	RACK PANEL MOUNTING RAILS
17	1 PR	AB-1854	BUD INDUSTRIES	19" TO 24" X 7" ADAPTER
18	1 PR	AB-1855	BUD INDUSTRIES	19" TO 24" X 8 3/4" ADAPTER
19	1 PR	AB-1856	BUD INDUSTRIES	19" TO 24" X 10 1/2" ADAPTER
20	2 PR	RC-7761	BUD INDUSTRIES	4" X 1 1/4" CASTER W/BRAKE
21	1 EA	SH-2488	BUD INDUSTRIES	24" SLIDING SHELF
22	1 EA	PA-2405 MG	BUD INDUSTRIES	24" X 8 3/4" BLANK RACK PANEL
23	96 EA	KTK-10	BUSS	FUSE, 10A, 500VAC
24	1 EA	MDA-20	BUSS	FUSE, 20A, 250V, 1/4 X 1 1/4
25	2 EA	MDA-8	BUSS	FUSE, 8A, 250V, 1/4 X 1 1/4
26	1 EA	MDA-5	BUSS	FUSE, 5A, 250V, 1/4 X 1 1/4
27	1 EA	MDA-1	BUSS	FUSE, 1A, 250V, 1/4 X 1 1/4
28	7 EA	MDA-1/2	BUSS	FUSE, 1/2A, 250V, 1/4 X 1 1/4
29	1 EA	874-N5	EDWARDS	ALARM HORN, SURFACE MOUNT, 120VAC
30	1 EA	90R-N5	EDWARDS	ALARM BEACON, RED, 120VAC
31	15 EA	199 095.13	ENTRELEC	FUSE HOLDER, 25A, 600VAC
32	1 EA	116 951.15	ENTRELEC	FUSE HOLDER END SECTION
33	20 EA	115 486.03	ENTRELEC	TERMINAL BLOCK, 20A, 600VAC
34	1 EA	118 368.16	ENTRELEC	TERMINAL BLOCK END SECTION
35	2 EA	103 002.26	ENTRELEC	END STOP
36	2 EA	231 030.24	ENTRELEC	MARKING TAGS, 5MM, 1-100

ITEM	QTY	P/N	VENDOR	DESCRIPTION
37	2 EA	234 030.27	ENTRELEC	MARKING TAGS, 8MM, 1-100
38	15 EA	167 075.25	ENTRELEC	FUSE BLOWN INDICATOR
39	1 EA	TED134060WL	GE	CIRCUIT BREAKER, 480VAC/60A/3PH.
40	1 EA	TEDUV1	GE	UNDERVOLTAGE RELEASE, 120VAC
41	1 EA	TEDAS2AB1R	GE	AUXILIARY SWITCH
42	2 EA	A-LF16M18	HOFFMAN	FLUORESCENT LIGHT, 120VAC
43	1 EA	5262	HUBBELL	15A DUPLEX RECEPTACLE
44	1 EA	074-01-032	HUBBELL	CORD GRIP, 1.35 CORD DIA
45	1 EA	074-01-010	HUBBELL	CORD GRIP, .616 CORD DIA.
46	1 EA	2311	HUBBELL	MALE PLUG, 20A, 125V
47	1 EA	560P7W	HUBBELL	MALE PLUG, 60A, 3 PH. Y 277/480
48	1 EA	6531-ULM	INDUSTRIAL COMPUTER	19" RACK MOUNT FOR 17" MONITOR
49	1 EA	I-115	ISLATROL	POWER FILTER, 115VAC, 1PH. 15A
50	2 EA	15295A32	McMASTER-CARR	HEAVY-DUTY STORAGE HOOK
51	4 EA	8890T14	McMASTER-CARR	LIFTING EYE, 3/8"-16
52	112 EA	50F2741	NEWARK	PLUG, 2 POLE, 20A, 600V, PANEL MNT
53	3 PK	50F2730	NEWARK	TERMINAL, MALE, BRASS, CRIMP,100 PCS
54	4 EA	TJP-4-48-J	OMEGA	TYPE "J" CONNECTOR PANEL, 12 X 4
55	2 EA	LAM2A2/0-14-6	PANDUIT	POWER LUG
56	24 LF	E1.5X3LG6	PANDUIT	WIREWAY, 1 1/2" X 3"
57	24 LF	C1.5LG6	PANDUIT	WIREWAY COVER, 1 1/2" X 3"
58	12 LF	E2X3LG6	PANDUIT	WIREWAY, 2" X 3"
59	12 LF	C2LG6	PANDUIT	WIREWAY COVER, 2" X 3"
60	6 LF	E3X3LG6	PANDUIT	WIREWAY, 3" X 3"
61	6 LF	C3LG6	PANDUIT	WIREWAY COVER, 3"
62	34 EA	ARC.68-S6-Q	PANDUIT	ADJUSTABLE RELEASE CLAMP
63	97 EA	K10P-11A15-120	POTTER & BRUMFIELD	RELAY,120VAC, 277VAC 10A CONTACT
64	97 EA	27E895	POTTER & BRUMFIELD	RELAY SOCKET
65	97 EA	20C297	POTTER & BRUMFIELD	HOLD DOWN SPRING
66	1 EA	SH2484	BUD INDUSTRIES	24" FIXED SHELF
67	2 EA	TJP-2-24-J	OMEGA	TYPE "J" CONNECTOR PANEL, 12 X 2
68	2 EA	A-EK460NDH	HOFFMAN	ELECTRICAL DOOR INTERLOCK
69	2 EA	FNQ-1/10	BUSS	FUSE, 1/10A, 500V, TIME DELAY
70	2 EA	35301	THOMAS & BETTS	COPPER GROUND LUG, #10 SCREW
71	1 EA	A-VK44	HOFFMAN	LOUVER PLATE KIT
72	1 EA	194L-E25-1751	ALLEN BRADLEY	25A LOAD SWITCH
73	1 EA	194L-HCB-001	ALLEN BRADLEY	25A LOAD SWITCH ACTIVATOR
74	1 EA	800MR-P16AS	ALLEN BRADLEY	PILOT LIGHT, AMBER, 120VAC

ITEM	QTY	P/N	VENDOR	DESCRIPTION
75	1 EA	97-3106-A-14S-7 P	AMPHENOL	PLUG, 3 POLE
76	1 EA			RESISTOR, 1/4 WATT, 150 OHM, 5%
77	1 LF	3610T13	McMASTER CARR	#8 STAINLESS STEEL SASH CHAIN
78	1 PR	SA-1349	BUD INDUSTRIES	CHASSIS SUPPORT ANGLE
79	1 EA	PA-2402 MG	BUD INDUSTRIES	24" x 3 1/2" BLANK RACK PANEL
80	1 EA	QS3294	EMED CO.	CAUTION LABEL: MULTIPLE ELECTRICAL SOURCES
81	1 EA	Q53204	EMED CO.	CAUTION LABEL: LOCK OUT POWER

ATTACHMENT "A"

PAINTING REQUIREMENTS

1 SCOPE

This attachment establishes minimum requirements for paint material, application, and durability of smooth and textured finishes to equipment as indicated on the Drawings and as follows .

2 SURFACE PREPARATION

2.1 Remove dirt, oil products, water vapor, oxidation, slag, scale, flux, and other foreign materials from surfaces to be painted in accordance with good commercial practice and industry accepted methods. Clean surfaces with solvent prior to painting.

2.2 Use industry-accepted fillers to cover minor surface imperfections such as press-in stud heads, flat head screws, rivets, indentations, and welds.

3 PRIME COAT

Apply Sherwin-Williams Polane spray fill D61-A23. Sand smooth after application.

4 FINISH COAT

4.1 Phathalo Blue, Textured Coating:
Apply Sherwin-Williams Polane "T", #F63TX-L-1465 (PSI stores # 300614).

4.2 Carbide Black:
Apply Sherwin-Williams Polane "T", #F63-B12. (PSI stores #300608)

4.3 Submit proposed substitutions to Buyer for acceptance.

NOTE: THERE IS NO REV. 0

PROCESS SYSTEMS INTERNATIONAL, INC. WESTBOROUGH, MA				
REV.	DEO #	DATE	BY:	CHECK
1	0084	03/11/96	RJW	FAB
2	0155	05/06/96	DJP	F. Bath

PROJECT: LIGO

TITLE: **INSTRUMENT LIST**

ENGINEERING CALCULATIONS

NO: V049-1-036

BY: D. PARENTI DEPT.: I/E

PROJECT NO: V59049

PURPOSE:

Final Design Review (FDR)

METHOD:

NA

ASSUMPTIONS:

NA

INPUTS:

NA

REFERENCES:

LIGO—E950088-03E, ICD: VE-CC

CALCULATIONS:

PSI Rev 1 P&Ids V049-0-series

CONCLUSIONS:

NA

NOTES:

Supersedes V049-1-036, Rev 1

V049-1-036, REV. 2

LIGO INSTRUMENT LIST

DATE: 5-7-96
PREPARED BY: D. PARENTI
CHECKED BY: F. Barb

DWG	PI&D INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
006	LIC - 0100	WACS	WCP1 80K Cryopump Level Control Loop Output	AO				1								
006	LT - 0100	WACS	WCP1 80K Cryopump Level Transmitter	AI			1						089	0	100	% Level
006	LV - 0100	WACS	WCP1 80K Cryopump Level Control Valve	-									062			
006	LY - 0100	WACS	WCP1 80K Cryopump Level Control Loop Output	AO				1								
006	XV - 0100	WACS	WCP1 80K Cryopump Level Control Valve Solenoid	DO		1										
006	ZSC - 0100	WACS	WCP1 80K Cryopump Level Control Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	062			
006	PI - 0101	WACS	WCP1 80K Cryopump Discharge Pressure Indication	-												
006	PT - 0101	WACS	WCP1 80K Cryopump Discharge Pressure Transmitter	AI			1						090	0	25	PSIG
006	TE - 0102	WACS	WCP1 80K Cryopump Discharge Thermocouple	T/C					1							
006	TI - 0102	WACS	WCP1 80K Cryopump Discharge Temperature Indication	-												
006	JC - 0103	WACS	WCP1 80K Cryopump Regen SCR Controller	AI			1									
006	TIC - 0103	WACS	WCP1 80K Cryopump Regen Loop Temperature Control	-												
006	TSH - 0103	WACS	WCP1 80K Cryopump Regen Loop HI Temperature	-												
006	TY - 0103	WACS	WCP1 80K Cryopump Regen Loop Temperature Control Loop Output	AO				1								
006	TE - 0103A	WACS	WCP1 80K Cryopump Regen Loop Thermocouple	T/C-T					1				091	-320	700	Deg F
006	TE - 0103B	WACS	WCP1 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	TE - 0103C	WACS	WCP1 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	FE - 0104	WACS	WCP1 80K Cryopump Regen Loop Pitot Tube Flow Element	-									079	0	12,000	SCFH
006	FI - 0104	WACS	WCP1 80K Cryopump Regen Loop Flow Indicator	-									088	0	12,000	SCFH
006	LT - 0105	WACS	WCP1 80K Dewar Level Transmitter	AI			1						089	0	100	% Level
006	PI - 0105	WACS	WCP1 LN2 Dewar Pressure Indicator	-												
006	LI - 0105A	WACS	WCP1 LN2 Dewar Level Indicator	-												
006	LI - 0105B	WACS	WCP1 LN2 Dewar Level Indication	-												
006	RD - 0106	WACS	WCP1 LN2 Dewar Rupture Disc	-												
006	RV - 0106	WACS	WCP1 LN2 Dewar Relief Valve	-												
006	RD - 0107	WACS	WCP1 LN2 Dewar Rupture Disc	-												
006	RV - 0107	WACS	WCP1 LN2 Dewar Relief Valve	-												
006	RV - 0108	WACS	WCP1 LN2 Dewar Relief Valve	-												
013	HV - 0109	WACS	Vertex Beam Tube 10" Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
013	ZSC - 0109	WACS	Vertex Beam Tube 10" Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
013	ZSO - 0109	WACS	Vertex Beam Tube 10" Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
003	II - 0111	WACS	WBSC1 75 L/S Ion Pump Current Indication	AI			1						004			
003	XIC - 0111	WACS	WBSC1 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
006	RV - 0112	WACS	WCP1 LN2 Dewar Pressure Control Relief Valve	-												
006	PCV - 0113	WACS	WCP1 LN2 Dewar Vent Pressure Control Valve	-												
012	PE - 0114A	WACS	WCP1 Pirani Gauge Tube	-									007			
012	PI - 0114A	WACS	WCP1 Lo Vacuum Pressure Indication	-												
012	PT - 0114A	WACS	WCP1 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
012	PE - 0114B	WACS	WCP1 Ion Gauge Tube	-									007			
012	PI - 0114B	WACS	WCP1 HI Vacuum Pressure Indication	-												
012	PT - 0114B	WACS	WCP1 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
004	II - 0115	WACS	WHAM1 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0115	WACS	WHAM1 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
004	II - 0117	WACS	WHAM2 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0117	WACS	WHAM2 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
013	EV - 0119	WACS	Vertex Section Isolation Valve	-						GNB Corp	122CM, Gate Valve, Electric, Tag WVG1	554617	005			
013	HS - 0119	WACS	Vertex Section Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0119	WACS	WGV1 25 L/S Ion Pump Current Indication	AI			1						004			
013	SC - 0119	WACS	Vertex Section Isolation Valve Controller	-												
013	XA - 0119	WACS	Vertex Section Isolation Valve Common Alarm	DI	1											
005	XIC - 0119	WACS	WGV1 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
013	ZSC - 0119	WACS	Vertex Section Isolation Valve Closed	DI	1					GNB Corp	122CM, Gate Valve, Electric, Tag WVG1	554617	005			

DATE: _____
PREPARED BY: _____
CHECKED BY: _____

V049-1-036, REV. 2

LIGO INSTRUMENT LIST

DWG	P&ID INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
013	ZSO - 0119	WACS	Vertex Section Isolation Valve Open	DI	1					GNB Corp	122CM, Gate Valve, Electric, Tag WVG1	554617	005			
002	PC - 0120	WACS	WBSC2 Pressure Control Valve Controller	-									061			
002	PCV - 0120	WACS	WBSC2 Pressure Control Valve	-									061			
002	PY - 0120	WACS	WBSC2 Pressure Control Loop Output	AO				1								
002	PE - 0120A	WACS	WBSC2 Pirani Gauge Tube	-									007			
002	PI - 0120A	WACS	WBSC2 Lo Vacuum Pressure Indication	-												
002	PT - 0120A	WACS	WBSC2 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
002	PE - 0120B	WACS	WBSC2 Ion Gauge Tube	-									007			
002	PI - 0120B	WACS	WBSC2 HI Vacuum Pressure Indication	-												
002	PT - 0120B	WACS	WBSC2 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
002	II - 0121	WACS	WBSC2 75 L/S Ion Pump Current Indication	AI			1						004			
002	XIC - 0121	WACS	WBSC2 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
006	PI - 0122	WACS	WCP1 LN2 Dewar Pressure Control Indicator	-												
006	PCV - 0123	WACS	WCP1 LN2 Dewar Pressure Control Valve	-												
012	PE - 0124A	WACS	Left Manifold Beam Tube Pirani Gauge Tube	-									007			
012	PI - 0124A	WACS	Left Manifold Beam Tube Lo Vacuum Pressure Indication	-												
012	PT - 0124A	WACS	Left Manifold Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
012	PE - 0124B	WACS	Left Manifold Beam Tube Ion Gauge Tube	-									007			
012	PI - 0124B	WACS	Left Manifold Beam Tube HI Vacuum Pressure Indication	-												
012	PT - 0124B	WACS	Left Manifold Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
004	II - 0125	WACS	WHAM3 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0125	WACS	WHAM3 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
004	II - 0127	WACS	WHAM4 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0127	WACS	WHAM4 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
013	EV - 0129	WACS	Vertex Section Isolation Valve	-						GNB Corp	122CM, Gate Valve, Electric, Tag WVG2	554617	005			
013	HS - 0129	WACS	Vertex Section Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0129	WACS	WGV2 25 L/S Ion Pump Current Indication	AI			1						004			
013	SC - 0129	WACS	Vertex Section Isolation Valve Controller	-												
013	XA - 0129	WACS	Vertex Section Isolation Valve Common Alarm	DI	1											
005	XIC - 0129	WACS	WGV2 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
013	ZSC - 0129	WACS	Vertex Section Isolation Valve Closed	DI	1					GNB Corp	122CM, Gate Valve, Electric, Tag WVG2	554617	005			
013	ZSO - 0129	WACS	Vertex Section Isolation Valve Open	DI	1					GNB Corp	122CM, Gate Valve, Electric, Tag WVG2	554617	005			
003	II - 0131	WACS	WBSC3 75 L/S Ion Pump Current Indication	AI			1						004			
003	XIC - 0131	WACS	WBSC3 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
008	RV - 0132	WACS	WCP1 LN2 Dewar Pressure Control Relief Valve	-												
008	RV - 0133	WACS	WCP1 80K Cryopump Discharge Relief Valve	-												
015	PE - 0134A	WACS	WCP2 Pirani Gauge Tube	-									007			
015	PI - 0134A	WACS	WCP2 Lo Vacuum Pressure Indication	-												
015	PT - 0134A	WACS	WCP2 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
015	PE - 0134B	WACS	WCP2 Ion Gauge Tube	-									007			
015	PI - 0134B	WACS	WCP2 HI Vacuum Pressure Indication	-												
015	PT - 0134B	WACS	WCP2 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
004	II - 0135	WACS	WHAM5 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0135	WACS	WHAM5 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
006	RV - 0136	WACS	WCP1 LN2 Dewar Relief Valve	-												
004	II - 0137	WACS	WHAM6 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0137	WACS	WHAM6 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
014	EV - 0139	WACS	Diagonal Section Isolation Valve	-						GNB Corp	122CM, Gate Valve, Electric, Tag WVG3	554617	005			
014	HS - 0139	WACS	Diagonal Section Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0139	WACS	WGV3 25 L/S Ion Pump Current Indication	AI			1						004			
014	SC - 0139	WACS	Diagonal Section Isolation Valve Controller	-												
014	XA - 0139	WACS	Diagonal Section Isolation Valve Common Alarm	DI	1											

DATE: _____
PREPARED BY: _____
CHECKED BY: _____

V049-1-036, REV. 2

LIGO INSTRUMENT LIST

DWG	PI&D INFORMATION			I/O BREAKDOWN					EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
005	XIC - 0139	WACS	WGV3 25 L/S Ion Pump Controller	-					Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
014	ZSC - 0139	WACS	Diagonal Section Isolation Valve Closed	DI	1				GNB Corp	122CM, Gate Valve, Electric, Tag WVG3	554617	005			
014	ZSO - 0139	WACS	Diagonal Section Isolation Valve Open	DI	1				GNB Corp	122CM, Gate Valve, Electric, Tag WVG3	554617	005			
002	PC - 0140	WACS	WBSC4 Pressure Control Valve Controller	-								061			
002	PCV - 0140	WACS	WBSC4 Pressure Control Valve	-								061			
002	PY - 0140	WACS	WBSC4 Pressure Control Loop Output	AO				1							
002	PE - 0140A	WACS	WBSC4 Pirani Gauge Tube	-								007			
002	PI - 0140A	WACS	WBSC4 Lo Vacuum Pressure Indication	-											
002	PT - 0140A	WACS	WBSC4 Pirani Gauge Transmitter	AI			1						1 x 10-3	1000	TORR
002	PE - 0140B	WACS	WBSC4 Ion Gauge Tube	-								007			
002	PI - 0140B	WACS	WBSC4 HI Vacuum Pressure Indication	-											
002	PT - 0140B	WACS	WBSC4 Ion Gauge Transmitter	AI			1						3 x 10-11	1 x 10-2	TORR
002	II - 0141	WACS	WBSC4 75 L/S Ion Pump Current Indication	AI			1					004			
002	XIC - 0141	WACS	WBSC4 75 L/S Ion Pump Controller	-					Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
006	RV - 0142	WACS	WCP2 LN2 Dewar Pressure Control Relief Valve	-											
006	PCV - 0143	WACS	WCP2 LN2 Dewar Vent Pressure Control Valve	-											
015	PE - 0144A	WACS	Right Manifold Beam Tube Pirani Gauge Tube	-								007			
015	PI - 0144A	WACS	Right Manifold Beam Tube Lo Vacuum Pressure Indication	-											
015	PT - 0144A	WACS	Right Manifold Beam Tube Pirani Gauge Transmitter	AI			1						1 x 10-3	1000	TORR
015	PE - 0144B	WACS	Right Manifold Beam Tube Ion Gauge Tube	-								007			
015	PI - 0144B	WACS	Right Manifold Beam Tube HI Vacuum Pressure Indication	-											
015	PT - 0144B	WACS	Right Manifold Beam Tube Ion Gauge Transmitter	AI			1						3 x 10-11	1 x 10-2	TORR
013	HV - 0145	WACS	Vertex Beam Tube 6" Pumpout Port Valve	-					Varian Vacu Products	6" SST Gate Valve	555029	006			
013	ZSC - 0145	WACS	Vertex Beam Tube 6" Pumpout Port Valve Closed	DI	1				Varian Vacu Products	6" SST Gate Valve	555029	006			
013	ZSO - 0145	WACS	Vertex Beam Tube 6" Pumpout Port Valve Open	DI	1				Varian Vacu Products	6" SST Gate Valve	555029	006			
012	HV - 0146	WACS	Left Manifold Beam Tube 6" Pumpout Port Valve	-					Varian Vacu Products	6" SST Gate Valve	555029	006			
012	ZSC - 0146	WACS	Left Manifold Beam Tube 6" Pumpout Port Valve Closed	DI	1				Varian Vacu Products	6" SST Gate Valve	555029	006			
012	ZSO - 0146	WACS	Left Manifold Beam Tube 6" Pumpout Port Valve Open	DI	1				Varian Vacu Products	6" SST Gate Valve	555029	006			
012	HV - 0147	WACS	Left Manifold Beam Tube 10" Pumpout Port Valve	-					Varian Vacu Products	10" SST Gate Valve	555029	006			
012	ZSC - 0147	WACS	Left Manifold Beam Tube 10" Pumpout Port Valve Closed	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			
012	ZSO - 0147	WACS	Left Manifold Beam Tube 10" Pumpout Port Valve Open	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			
012	HV - 0148	WACS	WCP1 80K Cryopump Pumpout Port Valve	-					Varian Vacu Products	10" SST Gate Valve	555029	006			
012	ZSC - 0148	WACS	WCP1 80K Cryopump Pumpout Port Valve Closed	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			
012	ZSO - 0148	WACS	WCP1 80K Cryopump Pumpout Port Valve Open	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			
014	EV - 0149	WACS	Diagonal Section Isolation Valve	-					GNB Corp	122CM, Gate Valve, Electric, Tag WVG4	554617	005			
014	HS - 0149	WACS	Diagonal Section Isolation Valve Open/Close Switch	DO		1						005			
005	II - 0149	WACS	WGV4 25 L/S Ion Pump Current Indication	AI			1					004			
014	SC - 0149	WACS	Diagonal Section Isolation Valve Controller	-											
014	XA - 0149	WACS	Diagonal Section Isolation Valve Common Alarm	DI	1										
005	XIC - 0149	WACS	WGV4 25 L/S Ion Pump Controller	-					Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
014	ZSC - 0149	WACS	Diagonal Section Isolation Valve Closed	DI	1				GNB Corp	122CM, Gate Valve, Electric, Tag WVG4	554617	005			
014	ZSO - 0149	WACS	Diagonal Section Isolation Valve Open	DI	1				GNB Corp	122CM, Gate Valve, Electric, Tag WVG4	554617	005			
006	LIC - 0150	WACS	WCP2 80K Cryopump Level Control Loop Output	AO				1							
006	LT - 0150	WACS	WCP2 80K Cryopump Level Transmitter	AI			1					089	0	100	% Level
006	LV - 0150	WACS	WCP2 80K Cryopump Level Control Valve	-								062			
006	LY - 0150	WACS	WCP2 80K Cryopump Level Control Loop Output	AO				1							
006	XV - 0150	WACS	WCP2 80K Cryopump Level Control Valve Solenoid	DO		1									
006	ZSC - 0150	WACS	WCP2 80K Cryopump Level Control Valve Closed	DI	1							062			
006	PI - 0151	WACS	WCP2 80K Cryopump Discharge Pressure Indication	-											
006	PT - 0151	WACS	WCP2 80K Cryopump Discharge Pressure Transmitter	AI			1					090	0	25	PSIG
006	TE - 0152	WACS	WCP2 80K Cryopump Discharge Thermocouple	T/C				1							
006	TI - 0152	WACS	WCP2 80K Cryopump Discharge Temperature Indication	-											

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DWG	P&ID INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
013	HS - 0163A	WACS	WIP3-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
013	II - 0163A	WACS	WIP3-1 2500 L/S Ion Pump Current Indication	AI			1						004			
013	XA - 0163A	WACS	WIP3-1 2500 L/S Ion Pump Fault Alarm	DI	1											
013	EI - 0163B	WACS	WIP3-2 2500 L/S Ion Pump Voltage Indication	AI			1						004			
013	HS - 0163B	WACS	WIP3-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
013	II - 0163B	WACS	WIP3-2 2500 L/S Ion Pump Current Indication	AI			1						004			
013	XA - 0163B	WACS	WIP3-2 2500 L/S Ion Pump Fault Alarm	DI	1											
013	HS - 0163C	WACS	WIP3-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
013	HS - 0163D	WACS	WIP3-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
013	XIC - 0164	WACS	WIP4 2500 L/S Ion Pump Controller	-						Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
013	EI - 0164A	WACS	WIP4-1 2500 L/S Ion Pump Voltage Indication	AI			1						004			
013	HS - 0164A	WACS	WIP4-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
013	II - 0164A	WACS	WIP4-1 2500 L/S Ion Pump Current Indication	AI			1						004			
013	XA - 0164A	WACS	WIP4-1 2500 L/S Ion Pump Fault Alarm	DI	1											
013	EI - 0164B	WACS	WIP4-2 2500 L/S Ion Pump Voltage Indication	AI			1						004			
013	HS - 0164B	WACS	WIP4-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
013	II - 0164B	WACS	WIP4-2 2500 L/S Ion Pump Current Indication	AI			1						004			
013	XA - 0164B	WACS	WIP4-2 2500 L/S Ion Pump Fault Alarm	DI	1											
013	HS - 0164C	WACS	WIP4-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
013	HS - 0164D	WACS	WIP4-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
012	XIC - 0165	WACS	WIP5 2500 L/S Ion Pump Controller	-						Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
012	EI - 0165A	WACS	WIP5-1 2500 L/S Ion Pump Voltage Indication	AI			1						004			
012	HS - 0165A	WACS	WIP5-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
012	II - 0165A	WACS	WIP5-1 2500 L/S Ion Pump Current Indication	AI			1						004			
012	XA - 0165A	WACS	WIP5-1 2500 L/S Ion Pump Fault Alarm	DI	1											
012	EI - 0165B	WACS	WIP5-2 2500 L/S Ion Pump Voltage Indication	AI			1						004			
012	HS - 0165B	WACS	WIP5-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
012	II - 0165B	WACS	WIP5-2 2500 L/S Ion Pump Current Indication	AI			1						004			
012	XA - 0165B	WACS	WIP5-2 2500 L/S Ion Pump Fault Alarm	DI	1											
012	HS - 0165C	WACS	WIP5-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
012	HS - 0165D	WACS	WIP5-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
015	XIC - 0166	WACS	WIP6 2500 L/S Ion Pump Controller	-						Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
015	EI - 0166A	WACS	WIP6-1 2500 L/S Ion Pump Voltage Indication	AI			1						004			
015	HS - 0166A	WACS	WIP6-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
015	II - 0166A	WACS	WIP6-1 2500 L/S Ion Pump Current Indication	AI			1						004			
015	XA - 0166A	WACS	WIP6-1 2500 L/S Ion Pump Fault Alarm	DI	1											
015	EI - 0166B	WACS	WIP6-2 2500 L/S Ion Pump Voltage Indication	AI			1						004			
015	HS - 0166B	WACS	WIP6-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
015	II - 0166B	WACS	WIP6-2 2500 L/S Ion Pump Current Indication	AI			1						004			
015	XA - 0166B	WACS	WIP6-2 2500 L/S Ion Pump Fault Alarm	DI	1											
015	HS - 0166C	WACS	WIP6-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
015	HS - 0166D	WACS	WIP6-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
014	XIC - 0167	WACS	WIP7 2500 L/S Ion Pump Controller	-						Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
014	EI - 0167A	WACS	WIP7-1 2500 L/S Ion Pump Voltage Indication	AI			1						004			
014	HS - 0167A	WACS	WIP7-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
014	II - 0167A	WACS	WIP7-1 2500 L/S Ion Pump Current Indication	AI			1						004			
014	XA - 0167A	WACS	WIP7-1 2500 L/S Ion Pump Fault Alarm	DI	1											
014	EI - 0167B	WACS	WIP7-2 2500 L/S Ion Pump Voltage Indication	AI			1						004			
014	HS - 0167B	WACS	WIP7-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
014	II - 0167B	WACS	WIP7-2 2500 L/S Ion Pump Current Indication	AI			1						004			
014	XA - 0167B	WACS	WIP7-2 2500 L/S Ion Pump Fault Alarm	DI	1											
014	HS - 0167C	WACS	WIP7-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			

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DWG	P&ID INFORMATION			I/O BREAKDOWN					EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
014	HS - 0167D	WACS	WIP7-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1						004			
014	XIC - 0168	WACS	WIP8 2500 L/S Ion Pump Controller	-					Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
014	EI - 0168A	WACS	WIP8-1 2500 L/S Ion Pump Voltage Indication	AI			1					004			
014	HS - 0168A	WACS	WIP8-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1						004			
014	II - 0168A	WACS	WIP8-1 2500 L/S Ion Pump Current Indication	AI			1					004			
014	XA - 0168A	WACS	WIP8-1 2500 L/S Ion Pump Fault Alarm	DI	1										
014	EI - 0168B	WACS	WIP8-2 2500 L/S Ion Pump Voltage Indication	AI			1					004			
014	HS - 0168B	WACS	WIP8-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1						004			
014	II - 0168B	WACS	WIP8-2 2500 L/S Ion Pump Current Indication	AI			1					004			
014	XA - 0168B	WACS	WIP8-2 2500 L/S Ion Pump Fault Alarm	DI	1										
014	HS - 0168C	WACS	WIP8-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1						004			
014	HS - 0168D	WACS	WIP8-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1						004			
012	HS - 0169	WACS	WCP1 80K Cryopump Inlet Isolation Valve Open/Close Switch	DO		1						005			
005	II - 0169	WACS	WGV6 25 L/S Ion Pump Current Indication	AI			1					004			
005	XIC - 0169	WACS	WGV6 25 L/S Ion Pump Controller	-					Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
012	XV - 0169	WACS	WCP1 80K Cryopump Inlet Isolation Valve	-					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag WVG6	554617	005			
012	XY - 0169	WACS	WCP1 80K Cryopump Inlet Isolation Valve Solenoid	-					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag WVG6	554617	005			
012	ZSC - 0169	WACS	WCP1 80K Cryopump Inlet Isolation Valve Closed	DI	1				GNB Corp	112CM, Gate Valve, Pnewmatic, Tag WVG6	554617	005			
012	ZSO - 0169	WACS	WCP1 80K Cryopump Inlet Isolation Valve Open	DI	1				GNB Corp	112CM, Gate Valve, Pnewmatic, Tag WVG6	554617	005			
002	PC - 0170	WACS	WBSC7 Pressure Control Valve Controller	-								061			
002	PCV - 0170	WACS	WBSC7 Pressure Control Valve	-								061			
002	PY - 0170	WACS	WBSC7 Pressure Control Loop Output	AO				1							
002	PE - 0170A	WACS	WBSC7 Pirani Gauge Tube	-								007			
002	PI - 0170A	WACS	WBSC7 Lo Vacuum Pressure Indication	-											
002	PT - 0170A	WACS	WBSC7 Pirani Gauge Transmitter	AI			1						1 x 10-3	1000	TORR
002	PE - 0170B	WACS	WBSC7 Ion Gauge Tube	-								007			
002	PI - 0170B	WACS	WBSC7 Hi Vacuum Pressure Indication	-											
002	PT - 0170B	WACS	WBSC7 Ion Gauge Transmitter	AI			1						3 x 10-11	1 x 10-2	TORR
002	II - 0171	WACS	WBSC7 75 L/S Ion Pump Current Indication	AI			1					004			
002	XIC - 0171	WACS	WBSC7 75 L/S Ion Pump Controller	-					Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
006	PI - 0172	WACS	WCP2 LN2 Dewar Pressure Control Indicator	-											
006	PCV - 0173	WACS	WCP2 LN2 Dewar Pressure Control Valve	-											
014	HV - 0174	WACS	Diagonal Beam Tube 10" Pumpout Port Valve	-					Varian Vacu Products	10" SST Gate Valve	555029	006			
014	ZSC - 0174	WACS	Diagonal Beam Tube 10" Pumpout Port Valve Closed	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			
014	ZSO - 0174	WACS	Diagonal Beam Tube 10" Pumpout Port Valve Open	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			
018	PSV - 0175	WACS	Class 100 Air Pressure Safety Valve	-											
015	HV - 0176	WACS	Right Manifold Beam Tube 6" Pumpout Port Valve	-					Varian Vacu Products	6" SST Gate Valve	555029	006			
015	ZSC - 0176	WACS	Right Manifold Beam Tube 6" Pumpout Port Valve Closed	DI	1				Varian Vacu Products	6" SST Gate Valve	555029	006			
015	ZSO - 0176	WACS	Right Manifold Beam Tube 6" Pumpout Port Valve Open	DI	1				Varian Vacu Products	6" SST Gate Valve	555029	006			
015	HV - 0177	WACS	Right Manifold Beam Tube 10" Pumpout Port Valve	-					Varian Vacu Products	10" SST Gate Valve	555029	006			
015	ZSC - 0177	WACS	Right Manifold Beam Tube 10" Pumpout Port Valve Closed	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			
015	ZSO - 0177	WACS	Right Manifold Beam Tube 10" Pumpout Port Valve Open	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			
015	HV - 0178	WACS	WCP2 80K Cryopump Pumpout Port Valve	-					Varian Vacu Products	10" SST Gate Valve	555029	006			
015	ZSC - 0178	WACS	WCP2 80K Cryopump Pumpout Port Valve Closed	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			
015	ZSO - 0178	WACS	WCP2 80K Cryopump Pumpout Port Valve Open	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			
015	HS - 0179	WACS	WCP2 80K Cryopump Outlet Isolation Valve Open/Close Switch	DO		1						005			
005	II - 0179	WACS	WGV7 25 L/S Ion Pump Current Indication	AI			1					004			
005	XIC - 0179	WACS	WGV7 25 L/S Ion Pump Controller	-					Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
015	XV - 0179	WACS	WCP2 80K Cryopump Outlet Isolation Valve	-					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag WVG7	554617	005			
015	XY - 0179	WACS	WCP2 80K Cryopump Outlet Isolation Valve Solenoid	-					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag WVG7	554617	005			
015	ZSC - 0179	WACS	WCP2 80K Cryopump Outlet Isolation Valve Closed	DI	1				GNB Corp	112CM, Gate Valve, Pnewmatic, Tag WVG7	554617	005			
015	ZSO - 0179	WACS	WCP2 80K Cryopump Outlet Isolation Valve Open	DI	1				GNB Corp	112CM, Gate Valve, Pnewmatic, Tag WVG7	554617	005			

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DWG	PI&D INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
002	PC - 0180	WACS	WBSC8 Pressure Control Valve Controller	-									061			
002	PCV - 0180	WACS	WBSC8 Pressure Control Valve	-									061			
002	PY - 0180	WACS	WBSC8 Pressure Control Loop Output	AO				1								
002	PE - 0180A	WACS	WBSC8 Pirani Gauge Tube	-									007			
002	PI - 0180A	WACS	WBSC8 Lo Vacuum Pressure Indication	-												
002	PT - 0180A	WACS	WBSC8 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
002	PE - 0180B	WACS	WBSC8 Ion Gauge Tube	-									007			
002	PI - 0180B	WACS	WBSC8 HI Vacuum Pressure Indication	-												
002	PT - 0180B	WACS	WBSC8 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
002	II - 0181	WACS	WBSC8 75 L/S Ion Pump Current Indication	AI			1						004			
002	XIC - 0181	WACS	WBSC8 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
006	RV - 0182	WACS	WCP2 LN2 Dewar Pressure Control Relief Valve	-												
006	RV - 0183	WACS	WCP2 80K Cryopump Discharge Relief Valve	-												
018	PCV - 0184	WACS	Class 100 Air Seal Gas Pressure Control Valve	-												
018	PI - 0184	WACS	Class 100 Air Seal Gas Pressure Indicator	-												
004	II - 0185	WACS	WHAM7 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0185	WACS	WHAM7 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
012	II - 0186	WACS	75 L/S Ion Pump Current Indication Left Beam Manifold	AI			1						004			
012	XIC - 0186	WACS	75 L/S Ion Pump Controller Left Beam Manifold	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
004	II - 0187	WACS	WHAM8 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0187	WACS	WHAM8 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
015	II - 0188	WACS	75 L/S Ion Pump Current Indication Right Beam Manifold	AI			1						004			
015	XIC - 0188	WACS	75 L/S Ion Pump Controller Right Beam Manifold	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
015	HS - 0189	WACS	WCP2 80K Cryopump Inlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0189	WACS	WGV8 25 L/S Ion Pump Current Indication	AI			1						004			
005	XIC - 0189	WACS	WGV8 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
015	XV - 0189	WACS	WCP2 80K Cryopump Inlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Pnewmatic, Tag WVG8	554617	005			
015	XY - 0189	WACS	WCP2 80K Cryopump Inlet Isolation Valve Solenoid	-						GNB Corp	112CM, Gate Valve, Pnewmatic, Tag WVG8	554617	005			
015	ZSC - 0189	WACS	WCP2 80K Cryopump Inlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag WVG8	554617	005			
015	ZSO - 0189	WACS	WCP2 80K Cryopump Inlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag WVG8	554617	005			
006	RV - 0190	WACS	WCP2 LN2 Dewar Relief Valve	-												
004	II - 0191	WACS	WHAM9 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0191	WACS	WHAM9 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
004	II - 0193	WACS	WHAM10 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0193	WACS	WHAM10 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
004	II - 0195	WACS	WHAM11 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0195	WACS	WHAM11 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
004	II - 0197	WACS	WHAM12 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0197	WACS	WHAM12 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
018	PCV - 0198	WACS	Class 100 Air Pressure Control Valve	-												
018	PI - 0198	WACS	Class 100 Air Pressure Indicator	-												
006	LIC - 0200	WAMS	WCP3 80K Cryopump Level Control Loop Output	AO				1								
006	LT - 0200	WAMS	WCP3 80K Cryopump Level Transmitter	AI			1						089	0	100	% Level
006	LV - 0200	WAMS	WCP3 80K Cryopump Level Control Valve	-									062			
006	LY - 0200	WACS	WCP3 80K Cryopump Level Control Loop Output	AO				1								
006	XV - 0200	WAMS	WCP3 80K Cryopump Level Control Valve Solenoid	DO		1										
006	ZSC - 0200	WAMS	WCP3 80K Cryopump Level Control Valve Closed	DI	1								062			
006	PI - 0201	WAMS	WCP3 80K Cryopump Discharge Pressure Indication	-												
006	PT - 0201	WAMS	WCP3 80K Cryopump Discharge Pressure Transmitter	AI			1						090	0	25	PSIG
006	TE - 0202	WAMS	WCP3 80K Cryopump Discharge Thermocouple	T/C					1							
006	TI - 0202	WAMS	WCP3 80K Cryopump Discharge Temperature Indication	-												
006	JC - 0203	WACS	WCP3 80K Cryopump Regen SCR Controller	AI			1									

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LIGO INSTRUMENT LIST

DWG	P&ID INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
006	TIC - 0203	WAMS	WCP3 80K Cryopump Regen Loop Temperature Control	-												
006	TSH - 0203	WAMS	WCP3 80K Cryopump Regen Loop Ht Temperature	-												
006	TY - 0203	WAMS	WCP3 80K Cryopump Regen Loop Temperature Control Loop Output	AO				1								
006	TE - 0203A	WAMS	WCP3 80K Cryopump Regen Loop Thermocouple	T/C-T					1				091	-320	700	Deg F
006	TE - 0203B	WAMS	WCP3 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	TE - 0203C	WAMS	WCP3 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	FE - 0204	WAMS	WCP3 80K Cryopump Regen Loop Pitot Tube Flow Element	-									079	0	12,000	SCFH
006	FI - 0204	WAMS	WCP3 80K Cryopump Regen Loop Flow Indicator	-									068	0	12,000	SCFH
006	LT - 0205	WAMS	WCP3 LN2 Dewar Level Transmitter	AI			1						089	0	100	% Level
006	PI - 0205	WAMS	WCP3 LN2 Dewar Pressure Indicator	-												
006	LI - 0205A	WAMS	WCP3 LN2 Dewar Level Indicator	-												
006	LI - 0205B	WAMS	WCP3 LN2 Dewar Level Indication	-												
006	RD - 0206	WAMS	WCP3 LN2 Dewar Rupture Disc	-												
006	RV - 0206	WAMS	WCP3 LN2 Dewar Relief Valve	-												
006	RD - 0207	WAMS	WCP3 LN2 Dewar Rupture Disc	-												
006	RV - 0207	WAMS	WCP3 LN2 Dewar Relief Valve	-												
006	RV - 0208	WAMS	WCP3 LN2 Dewar Relief Valve	-												
011	EV - 0209	WAMS	WCP3 80K Cryopump Outlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag WVG9	554617	005			
011	HS - 0209	WAMS	WCP3 80K Cryopump Outlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0209	WAMS	WGV9 25 L/S Ion Pump Current Indication	AI			1						004			
011	SC - 0209	WAMS	WCP3 80K Cryopump Outlet Isolation Valve Controller	-												
011	XA - 0209	WAMS	WCP3 80K Cryopump Outlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0209	WAMS	WGV9 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
011	ZSC - 0209	WAMS	WCP3 80K Cryopump Outlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG9	554617	005			
011	ZSO - 0209	WAMS	WCP3 80K Cryopump Outlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG9	554617	005			
002	PC - 0210	WAMS	WBSC6 Pressure Control Valve Controller	-									061			
002	PCV - 0210	WAMS	WBSC6 Pressure Control Valve	-									061			
002	PY - 0210	WAMS	WBSC6 Pressure Control Loop Output	AO				1								
002	PE - 0210A	WAMS	WBSC6 Pirani Gauge Tube	-									007			
002	PI - 0210A	WAMS	WBSC6 Lo Vacuum Pressure Indication	-												
002	PT - 0210A	WAMS	WBSC6 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
002	PE - 0210B	WAMS	WBSC6 Ion Gauge Tube	-									007			
002	PI - 0210B	WAMS	WBSC6 Ht Vacuum Pressure Indication	-												
002	PT - 0210B	WAMS	WBSC6 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
002	II - 0211	WAMS	WBSC6 75 L/S Ion Pump Current Indication	AI			1						004			
002	XIC - 0211	WAMS	WBSC6 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
006	RV - 0212	WAMS	WCP3 LN2 Dewar Pressure Control Relief Valve	-												
006	PCV - 0213	WAMS	WCP3 LN2 Dewar Vent Pressure Control Valve	-												
011	EV - 0219	WAMS	WCP3 80K Cryopump Inlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag WVG10	554617	005			
011	HS - 0219	WAMS	WCP3 80K Cryopump Inlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0219	WAMS	WGV10 25 L/S Ion Pump Current Indication	AI			1						004			
011	SC - 0219	WAMS	WCP3 80K Cryopump Inlet Isolation Valve Controller	-												
011	XA - 0219	WAMS	WCP3 80K Cryopump Inlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0219	WAMS	WGV10 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
011	ZSC - 0219	WAMS	WCP3 80K Cryopump Inlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG10	554617	005			
011	ZSO - 0219	WAMS	WCP3 80K Cryopump Inlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG10	554617	005			
006	PI - 0222	WAMS	WCP3 LN2 Dewar Pressure Control Indicator	-												
006	PCV - 0223	WAMS	WCP3 LN2 Dewar Pressure Control Valve	-												
011	EV - 0229	WAMS	WCP4 80K Cryopump Outlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag WVG11	554617	005			
011	HS - 0229	WAMS	WCP4 80K Cryopump Outlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0229	WAMS	WGV11 25 L/S Ion Pump Current Indication	AI			1						004			
011	SC - 0229	WAMS	WCP4 80K Cryopump Outlet Isolation Valve Controller	-												

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DWG	P&ID INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-High or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
011	XA - 0229	WAMS	WCP4 80K Cryopump Outlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0229	WAMS	WGV11 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
011	ZSC - 0229	WAMS	WCP4 80K Cryopump Outlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG11	554617	005			
011	ZSO - 0229	WAMS	WCP4 80K Cryopump Outlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG11	554617	005			
006	RV - 0232	WAMS	WCP3 LN2 Dewar Pressure Control Relief Valve	-												
006	RV - 0233	WAMS	WCP3 80K Cryopump Discharge Relief Valve	-												
006	RV - 0236	WACS	WCP3 LN2 Dewar Relief Valve	-												
011	EV - 0239	WAMS	WCP4 80K Cryopump Inlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag WVG12	554617	005			
011	HS - 0239	WAMS	WCP4 80K Cryopump Inlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0239	WAMS	WGV12 25 L/S Ion Pump Current Indication	AI			1						004			
011	SC - 0239	WAMS	WCP4 80K Cryopump Inlet Isolation Valve Controller	-												
011	XA - 0239	WAMS	WCP4 80K Cryopump Inlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0239	WAMS	WGV12 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
011	ZSC - 0239	WAMS	WCP4 80K Cryopump Inlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG12	554617	005			
011	ZSO - 0239	WAMS	WCP4 80K Cryopump Inlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG12	554617	005			
011	HV - 0240	WAMS	WCP3 80K Cryopump Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
011	ZSC - 0240	WAMS	WCP3 80K Cryopump Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
011	ZSO - 0240	WAMS	WCP3 80K Cryopump Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
011	HV - 0241	WAMS	Left Mid Beam Tube 10" Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
011	ZSC - 0241	WAMS	Left Mid Beam Tube Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
011	ZSO - 0241	WAMS	Left Mid Beam Tube Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
011	HV - 0242	WAMS	WCP4 80K Cryopump Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
011	ZSC - 0242	WAMS	WCP4 80K Cryopump Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
011	ZSO - 0242	WAMS	WCP4 80K Cryopump Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
011	PE - 0243A	WAMS	Left Mid Beam Tube Pirani Gauge Tube	-									007			
011	PI - 0243A	WAMS	Left Mid Beam Tube Lo Vacuum Pressure Indication	-												
011	PT - 0243A	WAMS	Left Mid Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
011	PE - 0243B	WAMS	Left Mid Beam Tube Ion Gauge Tube	-									007			
011	PI - 0243B	WAMS	Left Mid Beam Tube HI Vacuum Pressure Indication	-												
011	PT - 0243B	WAMS	Left Mid Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
011	PE - 0244A	WAMS	WCP3 Pirani Gauge Tube	-									007			
011	PI - 0244A	WAMS	WCP3 Lo Vacuum Pressure Indication	-												
011	PT - 0244A	WAMS	WCP3 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
011	PE - 0244B	WAMS	WCP3 Ion Gauge Tube	-									007			
011	PI - 0244B	WAMS	WCP3 HI Vacuum Pressure Indication	-												
011	PT - 0244B	WAMS	WCP3 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
011	PE - 0245A	WAMS	WCP4 Pirani Gauge Tube	-									007			
011	PI - 0245A	WAMS	WCP4 Lo Vacuum Pressure Indication	-												
011	PT - 0245A	WAMS	WCP4 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
011	PE - 0245B	WAMS	WCP4 Ion Gauge Tube	-									007			
011	PI - 0245B	WAMS	WCP4 HI Vacuum Pressure Indication	-												
011	PT - 0245B	WAMS	WCP4 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
011	PE - 0246A	WAMS	Left Mid Beam Tube Pirani Gauge Tube	-									007			
011	PI - 0246A	WAMS	Left Mid Beam Tube Lo Vacuum Pressure Indication	-												
011	PT - 0246A	WAMS	Left Mid Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
011	PE - 0246B	WAMS	Left Mid Beam Tube Ion Gauge Tube	-									007			
011	PI - 0246B	WAMS	Left Mid Beam Tube HI Vacuum Pressure Indication	-												
011	PT - 0246B	WAMS	Left Mid Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
011	XIC - 0247	WAMS	WIP9 2500 L/S Ion Pump Controller	-						Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
011	EI - 0247A	WAMS	WIP9-1 2500 L/S Ion Pump Voltage Indication	AI			1						004			
011	HS - 0247A	WAMS	WIP9-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
011	II - 0247A	WAMS	WIP9-1 2500 L/S Ion Pump Current Indication	AI			1						004			

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DWG	PI&D INFORMATION			I/O BREAKDOWN					EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
011	XA - 0247A	WAMS	WIP9-1 2500 L/S Ion Pump Fault Alarm	DI	1											
011	EI - 0247B	WAMS	WIP9-2 2500 L/S Ion Pump Voltage Indication	AI			1						004			
011	HS - 0247B	WAMS	WIP9-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
011	II - 0247B	WAMS	WIP9-2 2500 L/S Ion Pump Current Indication	AI			1						004			
011	XA - 0247B	WAMS	WIP9-2 2500 L/S Ion Pump Fault Alarm	DI	1											
011	HS - 0247C	WAMS	WIP9-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
011	HS - 0247D	WAMS	WIP9-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
006	LIC - 0250	WAMS	WCP4 80K Cryopump Level Control Loop Output	AO				1								
006	LT - 0250	WAMS	WCP4 80K Cryopump Level Transmitter	AI			1						089	0	100	% Level
006	LV - 0250	WAMS	WCP4 80K Cryopump Level Control Valve	-									062			
006	LY - 0250	WACS	WCP4 80K Cryopump Level Control Loop Output	AO				1								
006	XV - 0250	WAMS	WCP4 80K Cryopump Level Control Valve Solenoid	DO		1										
006	ZSC - 0250	WAMS	WCP4 80K Cryopump Level Control Valve Closed	DI	1								026			
006	PI - 0251	WAMS	WCP4 80K Cryopump Discharge Pressure Indication	-												
006	PT - 0251	WAMS	WCP4 80K Cryopump Discharge Pressure Transmitter	AI			1						090	0	25	PSIG
006	TE - 0252	WAMS	WCP4 80K Cryopump Discharge Thermocouple	T/C					1							
006	TI - 0252	WAMS	WCP4 80K Cryopump Discharge Temperature Indication	-												
006	JC - 0253	WACS	WCP4 80K Cryopump Regen SCR Controller	AI			1									
006	TIC - 0253	WAMS	WCP4 80K Cryopump Regen Loop Temperature Control	-												
006	TSH - 0253	WAMS	WCP4 80K Cryopump Regen Loop HI Temperature	-												
006	TY - 0253	WAMS	WCP4 80K Cryopump Regen Loop Temperature Control Loop Output	AO				1								
006	TE - 0253A	WAMS	WCP4 80K Cryopump Regen Loop Thermocouple	T/C-T					1				091	-320	700	Deg F
006	TE - 0253B	WAMS	WCP4 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	TE - 0253C	WAMS	WCP4 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	FE - 0254	WAMS	WCP4 80K Cryopump Regen Loop Pitot Tube Flow Element	-									079	0	12,000	SCFH
006	FI - 0254	WAMS	WCP4 80K Cryopump Regen Loop Flow Indicator	-									088	0	12,000	SCFH
006	LT - 0255	WAMS	WCP4 LN2 Dewar Level Transmitter	AI			1						089	0	100	% Level
006	PI - 0255	WAMS	WCP4 LN2 Dewar Pressure Indicator	-												
006	LI - 0255A	WAMS	WCP4 LN2 Dewar Level Indicator	-												
006	LI - 0255B	WAMS	WCP4 LN2 Dewar Level Indication	-												
006	RD - 0256	WAMS	WCP4 LN2 Dewar Rupture Disc	-												
006	RV - 0256	WAMS	WCP4 LN2 Dewar Relief Valve	-												
006	RD - 0257	WAMS	WCP4 LN2 Dewar Rupture Disc	-												
006	RV - 0257	WAMS	WCP4 LN2 Dewar Relief Valve	-												
006	RV - 0258	WAMS	WCP4 LN2 Dewar Relief Valve	-												
011	PSV - 0260	WAMS	Class 100 Air Pressure Safety Valve	-												
011	PCV - 0261	WAMS	Class 100 Air Seal Gas Pressure Control Valve	-												
011	PI - 0261	WAMS	Class 100 Air Seal Gas Pressure Indicator	-												
006	RV - 0262	WAMS	WCP4 LN2 Dewar Pressure Control Relief Valve	-												
006	PCV - 0263	WAMS	WCP4 LN2 Dewar Vent Pressure Control Valve	-												
006	PI - 0272	WAMS	WCP4 LN2 Dewar Pressure Control Indicator	-												
006	PCV - 0273	WAMS	WCP4 LN2 Dewar Pressure Control Valve	-												
006	RV - 0282	WAMS	WCP4 LN2 Dewar Pressure Control Relief Valve	-												
006	RV - 0283	WAMS	WCP4 80K Cryopump Discharge Relief Valve	-												
011	PCV - 0284	WAMS	Class 100 Air Pressure Control Valve	-												
011	PI - 0284	WAMS	Class 100 Air Pressure Indicator	-												
006	RV - 0290	WACS	WCP4 LN2 Dewar Relief Valve	-												
006	LIC - 0300	WAMS	WCP5 80K Cryopump Level Control Output	AO				1								
006	LT - 0300	WAMS	WCP5 80K Cryopump Level Transmitter	AI			1						089	0	100	% Level
006	LV - 0300	WAMS	WCP5 80K Cryopump Level Control Valve	-									062			
006	LY - 0300	WACS	WCP5 80K Cryopump Level Control Loop Output	AO				1								
006	XV - 0300	WAMS	WCP5 80K Cryopump Level Control Valve Solenoid	DO		1										

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DWG	PI&D INFORMATION			I/O BREAKDOWN					EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
006	ZSC - 0300	WAMS	WCP5 80K Cryopump Level Control Valve Closed	DI	1								026			
006	PI - 0301	WAMS	WCP5 80K Cryopump Discharge Pressure Indication	-												
006	PT - 0301	WAMS	WCP5 80K Cryopump Discharge Pressure Transmitter	AI			1						090	0	25	PSIG
006	TE - 0302	WAMS	WCP5 80K Cryopump Discharge Thermocouple	T/C					1							
006	TI - 0302	WAMS	WCP5 80K Cryopump Discharge Temperature Indication	-												
006	JC - 0303	WACS	WCP5 80K Cryopump Regen SCR Controller	AI			1									
006	TIC - 0303	WAMS	WCP5 80K Cryopump Regen Loop Temperature Control	-												
006	TSH - 0303	WAMS	WCP5 80K Cryopump Regen Loop HI Temperature	-												
006	TY - 0303	WAMS	WCP5 80K Cryopump Regen Loop Temperature Control Loop Output	AO				1								
006	TE - 0303A	WAMS	WCP5 80K Cryopump Regen Loop Thermocouple	T/C-T					1				091	-320	375°F	Deg F
006	TE - 0303B	WAMS	WCP5 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	TE - 0303C	WAMS	WCP5 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	FE - 0304	WAMS	WCP5 80K Cryopump Regen Loop Pitot Tube Flow Element	-									079	0	12,000	SCFH
006	FI - 0304	WAMS	WCP5 80K Cryopump Regen Loop Flow Indicator	-									088	0	12,000	SCFH
006	LT - 0305	WAMS	WCP5 LN2 Dewar Level Transmitter	AI			1						089	0	100	% Level
006	PI - 0305	WAMS	WCP5 LN2 Dewar Pressure Indicator	-												
006	LI - 0305A	WAMS	WCP5 LN2 Dewar Level Indicator	-												
006	LI - 0305B	WAMS	WCP5 LN2 Dewar Level Indication	-												
006	RD - 0306	WAMS	WCP5 LN2 Dewar Rupture Disc	-												
006	RV - 0306	WAMS	WCP5 LN2 Dewar Relief Valve	-												
006	RD - 0307	WAMS	WCP5 LN2 Dewar Rupture Disc	-												
006	RV - 0307	WAMS	WCP5 LN2 Dewar Relief Valve	-												
006	RV - 0308	WAMS	WCP5 LN2 Dewar Relief Valve	-												
016	EV - 0309	WAMS	WCP5 80K Cryopump Outlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag WVG13	554617	005			
016	HS - 0309	WAMS	WCP5 80K Cryopump Outlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0309	WAMS	WGV13 25 L/S Ion Pump Current Indication	AI			1						004			
016	SC - 0309	WAMS	WCP5 80K Cryopump Outlet Isolation Valve Controller	-												
016	XA - 0309	WAMS	WCP5 80K Cryopump Outlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0309	WAMS	WGV13 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
016	ZSC - 0309	WAMS	WCP5 80K Cryopump Outlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG13	554617	005			
016	ZSO - 0309	WAMS	WCP5 80K Cryopump Outlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG13	554617	005			
002	PC - 0310	WAMS	WBSC5 Pressure Control Valve Controller	-									061			
002	PCV - 0310	WAMS	WBSC5 Pressure Control Valve	-									061			
002	PY - 0310	WAMS	WBSC5 Pressure Control Loop Output	AO				1								
002	PE - 0310A	WAMS	WBSC5 Pirani Gauge Tube	-									007			
002	PI - 0310A	WAMS	WBSC5 Lo Vacuum Pressure Indication	-												
002	PT - 0310A	WAMS	WBSC5 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
002	PE - 0310B	WAMS	WBSC5 Ion Gauge Tube	-									007			
002	PI - 0310B	WAMS	WBSC5 HI Vacuum Pressure Indication	-												
002	PT - 0310B	WAMS	WBSC5 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
002	II - 0311	WAMS	WBSC5 75 L/S Ion Pump Current Indication	AI			1						004			
002	XIC - 0311	WAMS	WBSC5 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
006	RV - 0312	WAMS	WCP5 LN2 Dewar Pressure Control Relief Valve	-												
006	PCV - 0313	WAMS	WCP5 LN2 Dewar Vent Pressure Control Valve	-												
016	EV - 0319	WAMS	WCP5 80K Cryopump Inlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag WVG14	554617	005			
016	HS - 0319	WAMS	WCP5 80K Cryopump Inlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0319	WAMS	WGV14 25 L/S Ion Pump Current Indication	AI			1						004			
016	SC - 0319	WAMS	WCP5 80K Cryopump Inlet Isolation Valve Controller	-												
016	XA - 0319	WAMS	WCP5 80K Cryopump Inlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0319	WAMS	WGV14 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
016	ZSC - 0319	WAMS	WCP5 80K Cryopump Inlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG14	554617	005			
016	ZSO - 0319	WAMS	WCP5 80K Cryopump Inlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG14	554617	005			

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DWG	PI&D INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
006	PI - 0322	WAMS	WCP5 LN2 Dewar Pressure Control Indicator	-												
006	PCV - 0323	WAMS	WCP5 LN2 Dewar Pressure Control Valve	-												
016	EV - 0329	WAMS	WCP6 80K Cryopump Outlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag WVG15	554617	005			
016	HS - 0329	WAMS	WCP6 80K Cryopump Outlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0329	WAMS	WGV15 25 L/S Ion Pump Current Indication	AI			1						004			
016	SC - 0329	WAMS	WCP6 80K Cryopump Outlet Isolation Valve Controller	-												
016	XA - 0329	WAMS	WCP6 80K Cryopump Outlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0329	WAMS	WGV15 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
016	ZSC - 0329	WAMS	WCP6 80K Cryopump Outlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG15	554617	005			
016	ZSO - 0329	WAMS	WCP6 80K Cryopump Outlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG15	554617	005			
006	RV - 0332	WAMS	WCP5 LN2 Dewar Pressure Control Relief Valve	-												
006	RV - 0333	WAMS	WCP5 80K Cryopump Discharge Relief Valve	-												
006	RV - 0336	WACS	WCP5 LN2 Dewar Relief Valve	-												
016	EV - 0339	WAMS	WCP6 80K Cryopump Inlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag WVG16	554617	005			
016	HS - 0339	WAMS	WCP6 80K Cryopump Inlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0339	WAMS	WGV16 25 L/S Ion Pump Current Indication	AI			1						004			
016	SC - 0339	WAMS	WCP6 80K Cryopump Inlet Isolation Valve Controller	-												
016	XA - 0339	WAMS	WCP6 80K Cryopump Inlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0339	WAMS	WGV16 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
016	ZSC - 0339	WAMS	WCP6 80K Cryopump Inlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG16	554617	005			
016	ZSO - 0339	WAMS	WCP6 80K Cryopump Inlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG16	554617	005			
016	HV - 0340	WAMS	WCP5 80K Cryopump Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
015	ZSC - 0340	WAMS	WCP5 80K Cryopump Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
016	ZSO - 0340	WAMS	WCP5 80K Cryopump Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
015	HV - 0341	WAMS	Right Mid Beam Tube 10" Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
016	ZSC - 0341	WAMS	Right Mid Beam Tube Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
016	ZSO - 0341	WAMS	Right Mid Beam Tube Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
016	HV - 0342	WAMS	WCP6 80K Cryopump Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
016	ZSC - 0342	WAMS	WCP6 80K Cryopump Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
016	ZSO - 0342	WAMS	WCP6 80K Cryopump Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
016	PE - 0343A	WAMS	Right Mid Beam Tube Pirani Gauge Tube	-									007			
016	PI - 0343A	WAMS	Right Mid Beam Tube Lo Vacuum Pressure Indication	-												
016	PT - 0343A	WAMS	Right Mid Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
016	PE - 0343B	WAMS	Right Mid Beam Tube Ion Gauge Tube	-									007			
016	PI - 0343B	WAMS	Right Mid Beam Tube HI Vacuum Pressure Indication	-												
016	PT - 0343B	WAMS	Right Mid Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
016	PE - 0344A	WAMS	WCP5 Pirani Gauge Tube	-									007			
016	PI - 0344A	WAMS	WCP5 Lo Vacuum Pressure Indication	-												
016	PT - 0344A	WAMS	WCP5 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
016	PE - 0344B	WAMS	WCP5 Ion Gauge Tube	-									007			
015	PI - 0344B	WAMS	WCP5 HI Vacuum Pressure Indication	-												
016	PT - 0344B	WAMS	WCP5 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
016	PE - 0345A	WAMS	WCP6 Pirani Gauge Tube	-									007			
016	PI - 0345A	WAMS	WCP6 Lo Vacuum Pressure Indication	-												
016	PT - 0345A	WAMS	WCP6 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
016	PE - 0345B	WAMS	WCP6 Ion Gauge Tube	-									007			
016	PI - 0345B	WAMS	WCP6 HI Vacuum Pressure Indication	-												
016	PT - 0345B	WAMS	WCP6 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
016	PE - 0346A	WAMS	Right Mid Beam Tube Pirani Gauge Tube	-									007			
016	PI - 0346A	WAMS	Right Mid Beam Tube Lo Vacuum Pressure Indication	-												
016	PT - 0346A	WAMS	Right Mid Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
016	PE - 0346B	WAMS	Right Mid Beam Tube Ion Gauge Tube	-									007			

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V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
016	PI - 0346B	WAMS	Right Mid Beam Tube HI Vacuum Pressure Indication	-												
016	PT - 0346B	WAMS	Right Mid Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
016	XIC - 0347	WAMS	WIP10 2500 L/S Ion Pump Controller	-						*Varian Vacu Products*	*2500 L/S Noble Diode Ion Pump Controller*	554936	004			
016	EI - 0347A	WAMS	WIP10-1 2500 L/S Ion Pump Voltage Indication	AI			1						004			
016	HS - 0347A	WAMS	WIP10-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
016	II - 0347A	WAMS	WIP10-1 2500 L/S Ion Pump Current Indication	AI			1						004			
016	XA - 0347A	WAMS	WIP10-1 2500 L/S Ion Pump Fault Alarm	DI	1											
016	EI - 0347B	WAMS	WIP10-2 2500 L/S Ion Pump Voltage Indication	AI			1						004			
016	HS - 0347B	WAMS	WIP10-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
016	II - 0347B	WAMS	WIP10-2 2500 L/S Ion Pump Current Indication	AI			1						004			
016	XA - 0347B	WAMS	WIP10-2 2500 L/S Ion Pump Fault Alarm	DI	1											
016	HS - 0347C	WAMS	WIP10-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
016	HS - 0347D	WAMS	WIP10-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
006	LIC - 0350	WAMS	WCP6 80K Cryopump Level Control Loop Output	AO				1								
006	LT - 0350	WAMS	WCP6 80K Cryopump Level Transmitter	AI			1						089	0	100	% Level
006	LV - 0350	WAMS	WCP6 80K Cryopump Level Control Valve	-									062			
006	LY - 0350	WACS	WCP6 80K Cryopump Level Control Loop Output	AO				1								
006	XV - 0350	WAMS	WCP6 80K Cryopump Level Control Valve Solenoid	DO		1										
006	ZSC - 0350	WAMS	WCP6 80K Cryopump Level Control Valve Closed	DI	1								026			
006	PI - 0351	WAMS	WCP6 80K Cryopump Discharge Pressure Indication	-												
006	PT - 0351	WAMS	WCP6 80K Cryopump Discharge Pressure Transmitter	AI			1						090	0	25	PSIG
006	TE - 0352	WAMS	WCP6 80K Cryopump Discharge Thermocouple	T/C					1							
006	TI - 0352	WAMS	WCP6 80K Cryopump Discharge Temperature Indication	-												
006	JC - 0353	WACS	WCP6 80K Cryopump Regen SCR Controller	AI			1									
006	*TIC - 0353*	WAMS	*WCP6 80K Cryopump Regen Loop Temperature Control*	-												
006	TSH - 0353	WAMS	WCP6 80K Cryopump Regen Loop HI Temperature	-												
006	TY - 0353	WAMS	WCP6 80K Cryopump Regen Loop Temperature Control Loop Output	AO				1								
006	TE - 0353A	WAMS	WCP6 80K Cryopump Regen Loop Thermocouple	T/C-T					1				091	-320	700	Deg F
006	TE - 0353B	WAMS	WCP6 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	TE - 0353C	WAMS	WCP6 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	FE - 0354	WAMS	WCP6 80K Cryopump Regen Loop Pitot Tube Flow Element	-									079	0	12,000	SCFH
006	FI - 0354	WAMS	WCP6 80K Cryopump Regen Loop Flow Indicator	-									088	0	12,000	SCFH
006	LT - 0355	WAMS	WCP6 LN2 Dewar Level Transmitter	AI			1						089	0	100	% Level
006	PI - 0355	WAMS	WCP6 LN2 Dewar Pressure Indicator	-												
006	LI - 0355A	WAMS	WCP6 LN2 Dewar Level Indicator	-												
006	LI - 0355B	WAMS	WCP6 LN2 Dewar Level Indication	-												
006	RD - 0356	WAMS	WCP6 LN2 Dewar Rupture Disc	-												
006	RV - 0356	WAMS	WCP6 LN2 Dewar Relief Valve	-												
006	RD - 0357	WAMS	WCP6 LN2 Dewar Rupture Disc	-												
006	RV - 0357	WAMS	WCP6 LN2 Dewar Relief Valve	-												
006	RV - 0358	WAMS	WCP6 LN2 Dewar Relief Valve	-												
016	PSV - 0360	WAMS	Class 100 Air Pressure Safety Valve	-												
016	PCV - 0361	WAMS	Class 100 Air Seal Gas Pressure Control Valve	-												
016	PI - 0361	WAMS	Class 100 Air Seal Gas Pressure Indicator	-												
006	RV - 0362	WAMS	WCP6 LN2 Dewar Pressure Control Relief Valve	-												
006	PCV - 0363	WAMS	WCP6 LN2 Dewar Vent Pressure Control Valve	-												
006	PI - 0372	WAMS	WCP6 LN2 Dewar Pressure Control Indicator	-												
006	PCV - 0373	WAMS	WCP6 LN2 Dewar Pressure Control Valve	-												
006	RV - 0382	WAMS	WCP6 LN2 Dewar Pressure Control Relief Valve	-												
006	RV - 0383	WAMS	WCP6 80K Cryopump Discharge Relief Valve	-												
016	PCV - 0384	WAMS	Class 100 Air Pressure Control Valve	-												
016	PI - 0384	WAMS	Class 100 Air Pressure Indicator	-												

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DWG	P&ID INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
006	RV - 0390	WACS	WCP6LN2 Dewar Relief Valve	-												
006	LIC - 0400	WAES	WCP7 80K Cryopump Level Control Loop Output	AO				1								
006	LT - 0400	WAES	WCP7 80K Cryopump Level Transmitter	AI			1						069	0	100	% Level
006	LV - 0400	WAES	WCP7 80K Cryopump Level Control Valve	-									062			
006	LY - 0400	WACS	WCP7 80K Cryopump Level Control Loop Output	AO				1								
006	XV - 0400	WAMS	WCP7 80K Cryopump Level Control Valve Solenoid	DO		1										
006	ZSC - 0400	WAES	WCP7 80K Cryopump Level Control Valve Closed	DI	1								026			
006	PI - 0401	WAES	WCP7 80K Cryopump Discharge Pressure Indication	-												
006	PT - 0401	WAES	WCP7 80K Cryopump Discharge Pressure Transmitter	AI			1						090	0	25	PSIG
006	TE - 0402	WAES	WCP7 80K Cryopump Discharge Thermocouple	T/C					1							
006	TI - 0402	WAES	WCP7 80K Cryopump Discharge Temperature Indication	-												
006	JC - 0403	WACS	*WCP7 80K Cryopump Regen SCR Controller*	AI			1									
006	TIC - 0403	WAES	WCP7 80K Cryopump Regen Loop Temperature Control	-												
006	TSH - 0403	WAES	WCP7 80K Cryopump Regen Loop HI Temperature	-												
006	TY - 0403	WAES	WCP7 80K Cryopump Regen Loop Temperature Control Loop Output	AO				1								
006	TE - 0403A	WAES	WCP7 80K Cryopump Regen Loop Thermocouple	T/C-T					1				091	-320	700	Deg F
006	TE - 0403B	WAES	WCP7 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	TE - 0403C	WAES	WCP7 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	FE - 0404	WAES	WCP7 80K Cryopump Regen Loop Pitot Tube Flow Element	-									079	0	12,000	SCFH
006	FI - 0404	WAES	WCP7 80K Cryopump Regen Loop Flow Indicator	-									088	0	12,000	SCFH
006	LT - 0405	WAES	WCP7 LN2 Dewar Level Transmitter	AI			1						089	0	100	% Level
006	PI - 0405	WAES	WCP7 LN2 Dewar Pressure Indicator	-												
006	LI - 0405A	WAES	WCP7 LN2 Dewar Level Indicator	-												
006	LI - 0405B	WAES	WCP7 LN2 Dewar Level Indication	-												
006	RD - 0406	WAES	WCP7 LN2 Dewar Rupture Disc	-												
006	RV - 0406	WAES	WCP7 LN2 Dewar Relief Valve	-												
006	RD - 0407	WAES	*WCP7 LN2 Dewar Rupture Disc*	-												
006	RV - 0407	WAES	WCP7 LN2 Dewar Relief Valve	-												
006	RV - 0408	WAES	WCP7 LN2 Dewar Relief Valve	-												
010	EV - 0409	WAES	WCP7 80K Cryopump Outlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag WVG17	554617	005			
010	HS - 0409	WAES	WCP7 80K Cryopump Outlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0409	WAES	WGV17 25 L/S Ion Pump Current Indication	AI			1						004			
010	SC - 0409	WAES	WCP7 80K Cryopump Outlet Isolation Valve Controller	-												
010	XA - 0409	WAES	WCP7 80K Cryopump Outlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0409	WAES	WGV17 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
010	ZSC - 0409	WAES	WCP7 80K Cryopump Outlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG17	554617	005			
010	ZSO - 0409	WAES	WCP7 80K Cryopump Outlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG17	554617	005			
002	PC - 0410	WACS	WBSC10 Pressure Control Valve Controller	-									061			
002	PCV - 0410	WACS	WBSC10 Pressure Control Valve	-									061			
002	PY - 0410	WACS	WBSC10 Pressure Control Loop Output	AO				1								
002	PE - 0410A	WACS	WBSC10 Pirani Gauge Tube	-									007			
002	PI - 0410A	WACS	WBSC10 Lo Vacuum Pressure Indication	-												
002	PT - 0410A	WACS	WBSC10 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
002	PE - 0410B	WACS	WBSC10 Ion Gauge Tube	-									007			
002	PI - 0410B	WACS	WBSC10 HI Vacuum Pressure Indication	-												
002	PT - 0410B	WACS	WBSC10 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
002	II - 0411	WACS	WBSC10 75 L/S Ion Pump Current Indication	AI			1						004			
002	XIC - 0411	WACS	WBSC10 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
010	EV - 0419	WAES	WCP7 80K Cryopump Inlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag WVG18	554617	005			
010	HS - 0419	WAES	WCP7 80K Cryopump Inlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0419	WAES	WGV18 25 L/S Ion Pump Current Indication	AI			1						004			
010	SC - 0419	WAES	WCP7 80K Cryopump Inlet Isolation Valve Controller	-												

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DWG	PI&D INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
010	XA - 0419	WAES	WCP7 80K Cryopump Inlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0419	WAES	WGV18 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
010	ZSC - 0419	WAES	WCP7 80K Cryopump Inlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG18	554617	005			
010	ZSO - 0419	WAES	WCP7 80K Cryopump Inlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG18	554617	005			
010	HV - 0420	WAES	WCP7 80K Cryopump Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
010	ZSC - 0420	WAES	WCP7 80K Cryopump Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
010	ZSO - 0420	WAES	WCP7 80K Cryopump Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
010	HV - 0421	WAES	Left End Beam Tube 10" Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
010	ZSC - 0421	WAES	Left End Beam Tube Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
010	ZSO - 0421	WAES	Left End Beam Tube Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
010	XIC - 0422	WAES	WIP11 2500 L/S Ion Pump Controller	-						Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
010	EI - 0422A	WAES	WIP11-1 2500 L/S Ion Pump Voltage Indication	AI			1						004			
010	HS - 0422A	WAES	WIP11-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
010	II - 0422A	WAES	WIP11-1 2500 L/S Ion Pump Current Indication	AI			1						004			
010	XA - 0422A	WAES	WIP11-1 2500 L/S Ion Pump Fault Alarm	DI	1											
010	EI - 0422B	WAES	WIP11-2 2500 L/S Ion Pump Voltage Indication	AI			1						004			
010	HS - 0422B	WAES	WIP11-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
010	II - 0422B	WAES	WIP11-2 2500 L/S Ion Pump Current Indication	AI			1						004			
010	XA - 0422B	WAES	WIP11-2 2500 L/S Ion Pump Fault Alarm	DI	1											
010	HS - 0422C	WAES	WIP11-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
010	HS - 0422D	WAES	WIP11-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
010	PE - 0423A	WAES	WCP7 Pirani Gauge Tube	-									007			
010	PI - 0423A	WAES	WCP7 Low Vacuum Pressure Indication	-												
010	PT - 0423A	WAES	WCP7 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
010	PE - 0423B	WAES	WCP7 Ion Gauge Tube	-									007			
010	PI - 0423B	WAES	WCP7 HI Vacuum Pressure Indication	-												
010	PT - 0423B	WAES	WCP7 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
010	PE - 0424A	WAES	Left End Beam Tube Pirani Gauge Tube	-									007			
010	PI - 0424A	WAES	Left End Beam Tube Lo Vacuum Pressure Indication	-												
010	PT - 0424A	WAES	Left End Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
010	PE - 0424B	WAES	Left End Beam Tube Ion Gauge Tube	-									007			
010	PI - 0424B	WAES	Left End Beam Tube HI Vacuum Pressure Indication	-												
010	PT - 0424B	WAES	Left End Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
010	PSV - 0425	WAES	Class 100 Air Pressure Safety Valve	-												
010	PCV - 0426	WAES	Class 100 Air Seal Gas Pressure Control Valve	-												
010	PI - 0426	WAES	Class 100 Air Seal Gas Pressure Indicator	-												
010	PCV - 0427	WAES	Class 100 Air Pressure Control Valve	-												
010	PI - 0427	WAES	Class 100 Air Pressure Indicator	-												
006	RV - 0436	WACS	WCP7 LN2 Dewar Relief Valve	-												
006	RV - 0462	WAES	WCP7 LN2 Dewar Pressure Control Relief Valve	-												
006	PCV - 0463	WAES	WCP7 LN2 Dewar Vent Pressure Control Valve	-												
006	PI - 0472	WAES	WCP7 LN2 Dewar Pressure Control Indicator	-												
006	PCV - 0473	WAES	WCP7 LN2 Dewar Pressure Control Valve	-												
006	RV - 0482	WAES	WCP7 LN2 Dewar Pressure Control Relief Valve	-												
006	RV - 0483	WAES	WCP7 80K Cryopump Discharge Relief Valve	-												
006	LIC - 0500	WAES	WCP8 80K Cryopump Level Control Loop Output	AO				1								
006	LT - 0500	WAES	WCP8 80K Cryopump Level Transmitter	AI			1						089	0	100	% Level
006	LV - 0500	WAES	WCP8 80K Cryopump Level Control Valve	-									062			
006	LY - 0500	WACS	WCP8 80K Cryopump Level Control Loop Output	AO				1								
006	XV - 0500	WAMS	WCP8 80K Cryopump Level Control Valve Solenoid	DO		1										
006	ZSC - 0500	WAES	WCP8 80K Cryopump Level Control Valve Closed	DI	1								026			
006	PI - 0501	WAES	WCP8 80K Cryopump Discharge Pressure Indication	-												

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DWG	PI&D INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
006	PT - 0501	WAES	WCP8 80K Cryopump Discharge Pressure Transmitter	AI			1						090	0	25	PSIG
006	TE - 0502	WAES	WCP8 80K Cryopump Discharge Thermocouple	T/C					1							
006	TI - 0502	WAES	WCP8 80K Cryopump Discharge Temperature Indication	-												
006	JC - 0503	WACS	WCP8 80K Cryopump Regen SCR Controller	AI			1									
006	TIC - 0503	WAES	WCP8 80K Cryopump Regen Loop Temperature Control	-												
006	TSH - 0503	WAES	WCP8 80K Cryopump Regen Loop HI Temperature	-												
006	TY - 0503	WAES	WCP8 80K Cryopump Regen Loop Temperature Control Loop Output	AO				1								
006	TE - 0503A	WAES	WCP8 80K Cryopump Regen Loop Thermocouple	T/C-T					1				091	-320	700	Deg F
006	TE - 0503B	WAES	WCP8 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	TE - 0503C	WAES	WCP8 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	FE - 0504	WAES	WCP8 80K Cryopump Regen Loop Pitot Tube Flow Element	-									079	0	12,000	SCFH
006	FI - 0504	WAES	WCP8 80K Cryopump Regen Loop Flow Indicator	-									088	0	12,000	SCFH
006	LT - 0505	WAES	WCP8 LN2 Dewar Level Transmitter	AI			1						089	0	100	% Level
006	PI - 0505	WAES	WCP8 LN2 Dewar Pressure Indicator	-												
006	LI - 0505A	WAES	WCP8 LN2 Dewar Level Indicator	-												
006	LI - 0505B	WAES	WCP8 LN2 Dewar Level Indication	-												
006	RD - 0506	WAES	WCP8 LN2 Dewar Rupture Disc	-												
006	RV - 0506	WAES	WCP8 LN2 Dewar Relief Valve	-												
006	RD - 0507	WAES	WCP8 LN2 Dewar Rupture Disc	-												
006	RV - 0507	WAES	WCP8 LN2 Dewar Relief Valve	-												
006	RV - 0508	WAES	WCP8 LN2 Dewar Relief Valve	-												
017	EV - 0509	WAES	WCP8 80K Cryopump Outlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag WVG19	554617	005			
017	HS - 0509	WAES	WCP8 80K Cryopump Outlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0509	WAES	WGV19 25 L/S Ion Pump Current Indication	AI			1						004			
017	SC - 0509	WAES	WCP8 80K Cryopump Outlet Isolation Valve Controller	-												
017	XA - 0509	WAES	WCP8 80K Cryopump Outlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0509	WAES	WGV19 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
017	ZSC - 0509	WAES	WCP8 80K Cryopump Outlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG19	554617	005			
017	ZSO - 0509	WAES	WCP8 80K Cryopump Outlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG19	554617	005			
002	PC - 0510	WACS	WBSC9 Pressure Control Valve Controller	-									061			
002	PCV - 0510	WACS	WBSC9 Pressure Control Valve	-									061			
002	PY - 0510	WACS	WBSC9 Pressure Control Loop Output	AO				1								
002	PE - 0510A	WACS	WBSC9 Pirani Gauge Tube	-									007			
002	PI - 0510A	WACS	WBSC9 Lo Vacuum Pressure Indication	-												
002	PT - 0510A	WACS	WBSC9 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
002	PE - 0510B	WACS	WBSC9 Ion Gauge Tube	-									007			
002	PI - 0510B	WACS	WBSC9 HI Vacuum Pressure Indication	-												
002	PT - 0510B	WACS	WBSC9 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
002	II - 0511	WACS	WBSC9 75 L/S Ion Pump Current Indication	AI			1						004			
002	XIC - 0511	WACS	WBSC9 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
017	EV - 0519	WAES	WCP8 80K Cryopump Inlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag WVG20	554617	005			
017	HS - 0519	WAES	WCP8 80K Cryopump Inlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0519	WAES	WGV20 25 L/S Ion Pump Current Indication	AI			1						004			
017	SC - 0519	WAES	WCP8 80K Cryopump Inlet Isolation Valve Controller	-												
017	XA - 0519	WAES	WCP8 80K Cryopump Inlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0519	WAES	WGV20 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
017	ZSC - 0519	WAES	WCP8 80K Cryopump Inlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG20	554617	005			
017	ZSO - 0519	WAES	WCP8 80K Cryopump Inlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag WVG20	554617	005			
017	HV - 0520	WAES	WCP8 80K Cryopump Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
017	ZSC - 0520	WAES	WCP8 80K Cryopump Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
017	ZSO - 0520	WAES	WCP8 80K Cryopump Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
017	HV - 0521	WAES	Right End Beam Tube 10" Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			

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V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
017	ZSC - 0521	WAES	Right End Beam Tube Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
017	ZSO - 0521	WAES	Right End Beam Tube Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
017	XIC - 0522	WAES	WIP12 2500 L/S Ion Pump Controller	-						Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
017	EI - 0522A	WAES	WIP12-1 2500 L/S Ion Pump Voltage Indication	AI			1						004			
017	HS - 0522A	WAES	WIP12-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
017	II - 0522A	WAES	WIP12-1 2500 L/S Ion Pump Current Indication	AI			1						004			
017	XA - 0522A	WAES	WIP12-1 2500 L/S Ion Pump Fault Alarm	DI	1											
017	EI - 0522B	WAES	WIP12-2 2500 L/S Ion Pump Voltage Indication	AI			1						004			
017	HS - 0522B	WAES	WIP12-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
017	II - 0522B	WAES	WIP12-2 2500 L/S Ion Pump Current Indication	AI			1						004			
017	XA - 0522B	WAES	WIP12-2 2500 L/S Ion Pump Fault Alarm	DI	1											
017	HS - 0522C	WAES	WIP12-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
017	HS - 0522D	WAES	WIP12-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
017	PE - 0523A	WAES	Right End Beam Tube Pirani Gauge Tube	-									007			
017	PI - 0523A	WAES	Right End Beam Tube Lo Vacuum Pressure Indication	-												
017	PT - 0523A	WAES	Right End Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
017	PE - 0523B	WAES	Right End Beam Tube Ion Gauge Tube	-									007			
017	PI - 0523B	WAES	Right End Beam Tube HI Vacuum Pressure Indication	-												
017	PT - 0523B	WAES	Right End Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
017	PE - 0524A	WAES	WCP8 Pirani Gauge Tube	-									007			
017	PI - 0524A	WAES	WCP8 Lo Vacuum Pressure Indication	-												
017	PT - 0524A	WAES	WCP8 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
017	PE - 0524B	WAES	WCP8 Ion Gauge Tube	-									007			
017	PI - 0524B	WAES	WCP8 HI Vacuum Pressure Indication	-												
017	PT - 0524B	WAES	WCP8 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
017	PSV - 0525	WAES	Class 100 Air Pressure Safety Valve	-												
017	PCV - 0526	WAES	Class 100 Air Seal Gas Pressure Control Valve	-												
017	PI - 0526	WAES	Class 100 Air Seal Gas Pressure Indicator	-												
017	PCV - 0527	WAES	Class 100 Air Pressure Control Valve	-												
017	PI - 0527	WAES	Class 100 Air Pressure Indicator	-												
006	RV - 0536	WACS	WCP8 LN2 Dewar Relief Valve	-												
006	RV - 0562	WAES	WCP8 LN2 Dewar Pressure Control Relief Valve	-												
006	PCV - 0563	WAES	WCP8 LN2 Dewar Vent Pressure Control Valve	-												
006	PI - 0572	WAES	WCP8 LN2 Dewar Pressure Control Indicator	-												
006	PCV - 0573	WAES	WCP8 LN2 Dewar Pressure Control Valve	-												
006	RV - 0582	WAES	WCP8 LN2 Dewar Pressure Control Relief Valve	-												
006	RV - 0583	WAES	WCP8 80K Cryopump Discharge Relief Valve	-												
006	LIC - 0600	LACS	LCP1 80K Cryopump Level Control Loop Output	AO				1								
006	LT - 0600	LACS	LCP1 80K Cryopump Level Transmitter	AI			1						069	0	100	% Level
006	LV - 0600	LACS	LCP1 80K Cryopump Level Control Valve	-									062			
006	LY - 0600	LACS	LCP1 80K Cryopump Level Control Loop Output	AO				1								
006	XV - 0600	LACS	LCP1 80K Cryopump Level Control Valve Solenoid	DO		1										
006	ZSC - 0600	LACS	LCP1 80K Cryopump Level Control Valve Closed	DI	1								026			
006	PI - 0601	LACS	LCP1 80K Cryopump Discharge Pressure Indication	-												
006	PT - 0601	LACS	LCP1 80K Cryopump Discharge Pressure Transmitter	AI			1						090	0	25	PSIG
006	TE - 0602	LACS	LCP1 80K Cryopump Discharge Thermocouple	T/C					1							
006	TI - 0602	LACS	LCP1 80K Cryopump Discharge Temperature Indication	-												
006	JC - 0603	LACS	LCP1 80K Cryopump Regen SCR Controller	AI			1									
006	TIC - 0603	LACS	LCP1 80K Cryopump Regen Loop Temperature Control	-												
006	TSH - 0603	LACS	LCP1 80K Cryopump Regen Loop HI Temperature	-												
006	TY - 0603	LACS	LCP1 80K Cryopump Regen Loop Temperature Control Loop Output	AO				1								
006	TE - 0603A	LACS	LCP1 80K Cryopump Regen Loop Thermocouple	T/C-T					1				091	-320	700	Deg F

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V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
006	TE - 0603B	LACS	LCP1 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	TE - 0603C	LACS	LCP1 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	FE - 0604	LACS	LCP1 80K Cryopump Regen Loop Pitot Tube Flow Element	-									079	0	12,000	SCFH
006	FI - 0604	LACS	LCP1 80K Cryopump Regen Loop Flow Indicator	-									088	0	12,000	SCFH
006	LT - 0605	LACS	LCP1 LN2 Dewar Level Transmitter	AI			1						089	0	100	% Level
006	PI - 0605	LACS	LCP1 LN2 Dewar Pressure Indicator	-												
006	LI - 0605A	LACS	LCP1 LN2 Dewar Level Indicator	-												
006	LI - 0605B	LACS	LCP1 LN2 Dewar Level Indication	-												
006	RD - 0606	LACS	LCP1 LN2 Dewar Rupture Disc	-												
006	RV - 0606	LACS	LCP1 LN2 Dewar Relief Valve	-												
006	RD - 0607	LACS	LCP1 LN2 Dewar Rupture Disc	-												
006	RV - 0607	LACS	LCP1 LN2 Dewar Relief Valve	-												
006	RV - 0608	LACS	LCP1 LN2 Dewar Relief Valve	-												
023	HV - 0609	LACS	Vertex Beam Tube 10" Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
023	ZSC - 0609	LACS	Vertex Beam Tube 10" Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
023	ZSO - 0609	LACS	Vertex Beam Tube 10" Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
003	II - 0611	LACS	LBSC1 75 L/S Ion Pump Current Indication	AI			1						004			
003	XIC - 0611	LACS	LBSC1 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
006	RV - 0612	LACS	LCP1 LN2 Dewar Pressure Control Relief Valve	-												
006	PCV - 0613	LACS	LCP1 LN2 Dewar Vent Pressure Control Valve	-												
022	PE - 0614A	LACS	LCP1 Pirani Gauge Tube	-									007			
022	PI - 0614A	LACS	LCP1 Lo Vacuum Pressure Indication	-												
022	PT - 0614A	LACS	LCP1 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
022	PE - 0614B	LACS	LCP1 Ion Gauge Tube	-									007			
022	PI - 0614B	LACS	LCP1 Hi Vacuum Pressure Indication	-												
022	PT - 0614B	LACS	LCP1 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
004	II - 0615	LACS	LHAM1 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0615	LACS	LHAM1 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
004	II - 0617	LACS	LHAM2 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0617	LACS	LHAM2 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
023	EV - 0619	LACS	Vertex Section Isolation Valve	-						GNB Corp	122CM, Gate Valve, Electric, Tag LVG1	554617	005			
023	HS - 0619	LACS	Vertex Section Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0619	LACS	LGV1 25 L/S Ion Pump Current Indication	AI			1						004			
023	SC - 0619	LACS	Vertex Section Isolation Valve Controller	-												
023	XA - 0619	LACS	Vertex Section Isolation Valve Common Alarm	DI	1											
005	XIC - 0619	LACS	LGV1 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
023	ZSC - 0619	LACS	Vertex Section Isolation Valve Closed	DI	1					GNB Corp	122CM, Gate Valve, Electric, Tag LVG1	554617	005			
023	ZSO - 0619	LACS	Vertex Section Isolation Valve Open	DI	1					GNB Corp	122CM, Gate Valve, Electric, Tag LVG1	554617	005			
002	PC - 0620	LACS	LBSC2 Pressure Control Valve Controller	-									061			
002	PCV - 0620	LACS	LBSC2 Pressure Control Valve	-									061			
002	PY - 0620	LACS	LBSC2 Pressure Control Loop Output	AO				1								
002	PE - 0620A	LACS	LBSC2 Pirani Gauge Tube	-									007			
002	PI - 0620A	LACS	LBSC2 Lo Vacuum Pressure Indication	-												
002	PT - 0620A	LACS	LBSC2 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
002	PE - 0620B	LACS	LBSC2 Ion Gauge Tube	-									007			
002	PI - 0620B	LACS	LBSC2 Hi Vacuum Pressure Indication	-												
002	PT - 0620B	LACS	LBSC2 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
002	II - 0621	LACS	LBSC2 75 L/S Ion Pump Current Indication	AI			1						004			
002	XIC - 0621	LACS	LBSC2 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
006	PI - 0622	LACS	LCP1 LN2 Dewar Pressure Control Indicator	-												
006	PCV - 0623	LACS	LCP1 LN2 Dewar Pressure Control Valve	-												
022	PE - 0624A	LACS	Left Manifold Beam Tube Pirani Gauge Tube	-									007			

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DWG	PI&D INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
022	PI - 0624A	LACS	Left Manifold Beam Tube Lo Vacuum Pressure Indication	-												
022	PT - 0624A	LACS	Left Manifold Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
022	PE - 0624B	LACS	Left Manifold Beam Tube Ion Gauge Tube	-									007			
022	PI - 0624B	LACS	Left Manifold Beam Tube HI Vacuum Pressure Indication	-												
022	PT - 0624B	LACS	Left Manifold Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
004	II - 0625	LACS	LHAM3 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0625	LACS	LHAM3 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
004	II - 0627	LACS	LHAM4 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0627	LACS	LHAM4 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
023	EV - 0629	LACS	Vertex Section Isolation Valve	-						GNB Corp	122CM, Gate Valve, Electric, Tag LVG2	554617	005			
023	HS - 0629	LACS	Vertex Section Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0629	LACS	LGV2 25 L/S Ion Pump Current Indication	AI			1						004			
023	SC - 0629	LACS	Vertex Section Isolation Valve Controller	-												
023	XA - 0629	LACS	Vertex Section Isolation Valve Common Alarm	DI	1											
005	XIC - 0629	LACS	LGV2 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
023	ZSC - 0629	LACS	Vertex Section Isolation Valve Closed	DI	1					GNB Corp	122CM, Gate Valve, Electric, Tag LVG2	554617	005			
023	ZSO - 0629	LACS	Vertex Section Isolation Valve Open	DI	1					GNB Corp	122CM, Gate Valve, Electric, Tag LVG2	554617	005			
003	II - 0631	LACS	LBSC3 75 L/S Ion Pump Current Indication	AI			1						004			
003	XIC - 0631	LACS	LBSC3 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
006	RV - 0632	LACS	LCP1 LN2 Dewar Pressure Control Relief Valve	-												
006	RV - 0633	LACS	LCP1 80K Cryopump Discharge Relief Valve	-												
024	PE - 0634A	LACS	LCP2 Pirani Gauge Tube	-									007			
024	PI - 0634A	LACS	LCP2 Lo Vacuum Pressure Indication	-												
024	PT - 0634A	LACS	LCP2 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
024	PE - 0634B	LACS	LCP2 Ion Gauge Tube	-									007			
024	PI - 0634B	LACS	LCP2 HI Vacuum Pressure Indication	-												
024	PT - 0634B	LACS	LCP2 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
004	II - 0635	LACS	LHAM5 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0635	LACS	LHAM5 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
006	RV - 0636	WACS	LCP1 LN2 Dewar Relief Valve	-												
004	II - 0637	LACS	LHAM6 75 L/S Ion Pump Current Indication	AI			1						004			
004	XIC - 0637	LACS	LHAM6 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
006	RV - 0642	LACS	LCP2 LN2 Dewar Pressure Control Relief Valve	-												
006	PCV - 0643	LACS	LCP2 LN2 Dewar Vent Pressure Control Valve	-												
024	PE - 0644A	LACS	Right Manifold Beam Tube Pirani Gauge Tube	-									007			
024	PI - 0644A	LACS	Right Manifold Beam Tube Lo Vacuum Pressure Indication	-												
024	PT - 0644A	LACS	Right Manifold Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
024	PE - 0644B	LACS	Right Manifold Beam Tube Ion Gauge Tube	-									007			
024	PI - 0644B	LACS	Right Manifold Beam Tube HI Vacuum Pressure Indication	-												
024	PT - 0644B	LACS	Right Manifold Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
023	HV - 0645	LACS	Vertex Beam Tube 6" Pumpout Port Valve	-						Varian Vacu Products	6" SST Gate Valve	555029	006			
023	ZSC - 0645	LACS	Vertex Beam Tube 6" Pumpout Port Valve Closed	DI	1					Varian Vacu Products	6" SST Gate Valve	555029	006			
023	ZSO - 0645	LACS	Vertex Beam Tube 6" Pumpout Port Valve Open	DI	1					Varian Vacu Products	6" SST Gate Valve	555029	006			
022	HV - 0646	LACS	Left Manifold Beam Tube 6" Pumpout Port Valve	-						Varian Vacu Products	6" SST Gate Valve	555029	006			
022	ZSC - 0646	LACS	Left Manifold Beam Tube 6" Pumpout Port Valve Closed	DI	1					Varian Vacu Products	6" SST Gate Valve	555029	006			
022	ZSO - 0646	LACS	Left Manifold Beam Tube 6" Pumpout Port Valve Open	DI	1					Varian Vacu Products	6" SST Gate Valve	555029	006			
022	HV - 0647	LACS	Left Manifold Beam Tube 10" Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
022	ZSC - 0647	LACS	Left Manifold Beam Tube 10" Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
022	ZSO - 0647	LACS	Left Manifold Beam Tube 10" Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
022	HV - 0648	LACS	LCP1 80K Cryopump Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
022	ZSC - 0648	LACS	LCP1 80K Cryopump Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
022	ZSO - 0648	LACS	LCP1 80K Cryopump Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			

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LIGO INSTRUMENT LIST

DWG	PI&D INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-High or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
006	LIC - 0650	LACS	LCP2 80K Cryopump Level Control Loop Output	AO				1								
006	LT - 0650	LACS	LCP2 80K Cryopump Level Transmitter	AI			1						089	0	100	% Level
006	LV - 0650	LACS	LCP2 80K Cryopump Level Control Valve	-									062			
006	LY - 0650	LACS	LCP2 80K Cryopump Level Control Loop Output	AO				1								
006	XV - 0650	LACS	LCP2 80K Cryopump Level Control Valve Solenoid	DO		1										
006	ZSC - 0650	LACS	LCP2 80K Cryopump Level Control Valve Closed	DI	1								026			
006	PI - 0651	LACS	LCP2 80K Cryopump Discharge Pressure Indication	-												
006	PT - 0651	LACS	LCP2 80K Cryopump Discharge Pressure Transmitter	AI			1						090	0	25	PSIG
006	TE - 0652	LACS	LCP2 80K Cryopump Discharge Thermocouple	T/C					1							
006	TI - 0652	LACS	LCP2 80K Cryopump Discharge Temperature Indication	-												
006	JC - 0653	LACS	LCP2 80K Cryopump Regen SCR Controller	AI			1									
006	TIC - 0653	LACS	LCP2 80K Cryopump Regen Loop Temperature Control	-												
006	TSH - 0653	LACS	LCP2 80K Cryopump Regen Loop HI Temperature	-												
006	TY - 0653	LACS	LCP2 80K Cryopump Regen Loop Temperature Control Loop Output	AO				1								
006	TE - 0653A	LACS	LCP2 80K Cryopump Regen Loop Thermocouple	T/C-T					1				091	-320	700	Deg F
006	TE - 0653B	LACS	LCP2 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	TE - 0653C	LACS	LCP2 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	FE - 0654	LACS	LCP2 80K Cryopump Regen Loop Pitot Tube Flow Element	-									079	0	12,000	SCFH
006	FI - 0654	LACS	LCP2 80K Cryopump Regen Loop Flow Indicator	-									088	0	12,000	SCFH
006	LT - 0655	LACS	LCP2 LN2 Dewar Level Transmitter	AI			1						089	0	100	% Level
006	PI - 0655	LACS	LCP2 LN2 Dewar Pressure Indicator	-												
006	LI - 0655A	LACS	LCP2 LN2 Dewar Level Indicator	-												
006	LI - 0655B	LACS	LCP2 LN2 Dewar Level Indication	-												
006	RD - 0656	LACS	LCP2 LN2 Dewar Rupture Disc	-												
006	RV - 0656	LACS	LCP2 LN2 Dewar Relief Valve	-												
006	RD - 0657	LACS	LCP2 LN2 Dewar Rupture Disc	-												
006	RV - 0657	LACS	LCP2 LN2 Dewar Relief Valve	-												
006	RV - 0658	LACS	LCP2 LN2 Dewar Relief Valve	-												
022	HS - 0659	LACS	LCP1 80K Cryopump Outlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0659	LACS	LGV3 25 L/S Ion Pump Current Indication	AI			1						004			
005	XIC - 0659	LACS	LGV3 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
022	XV - 0659	LACS	LCP1 80K Cryopump Outlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG3	554617	005			
022	XY - 0659	LACS	LCP1 80K Cryopump Outlet Isolation Valve Solenoid	-						GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG3	554617	005			
022	ZSC - 0659	LACS	LCP1 80K Cryopump Outlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG3	554617	005			
022	ZSO - 0659	LACS	LCP1 80K Cryopump Outlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG3	554617	005			
023	XIC - 0661	LACS	LIP1 2500 L/S Ion Pump Controller	-						Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
023	EI - 0661A	LACS	LIP1-1 2500 L/S Ion Pump Voltage Indication	AI			1						004			
023	HS - 0661A	LACS	LIP1-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
023	II - 0661A	LACS	LIP1-1 2500 L/S Ion Pump Current Indication	AI			1						004			
023	XA - 0661A	LACS	LIP1-1 2500 L/S Ion Pump Fault Alarm	DI	1											
023	EI - 0661B	LACS	LIP1-2 2500 L/S Ion Pump Voltage Indication	AI			1						004			
023	HS - 0661B	LACS	LIP1-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
023	II - 0661B	LACS	LIP1-2 2500 L/S Ion Pump Current Indication	AI			1						004			
023	XA - 0661B	LACS	LIP1-2 2500 L/S Ion Pump Fault Alarm	DI	1											
023	HS - 0661C	LACS	LIP1-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
023	HS - 0661D	LACS	LIP1-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
023	XIC - 0662	LACS	LIP2 2500 L/S Ion Pump Controller	-						Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
023	EI - 0662A	LACS	LIP2-1 2500 L/S Ion Pump Voltage Indication	AI			1						004			
023	HS - 0662A	LACS	LIP2-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
023	II - 0662A	LACS	LIP2-1 2500 L/S Ion Pump Current Indication	AI			1						004			
023	XA - 0662A	LACS	LIP2-1 2500 L/S Ion Pump Fault Alarm	DI	1											
023	EI - 0662B	LACS	LIP2-2 2500 L/S Ion Pump Voltage Indication	AI			1						004			

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DWG	P&ID INFORMATION			I/O BREAKDOWN					EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
023	HS - 0662B	LACS	LIP2-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1						004			
023	II - 0662B	LACS	LIP2-2 2500 L/S Ion Pump Current Indication	AI			1					004			
023	XA - 0662B	LACS	LIP2-2 2500 L/S Ion Pump Fault Alarm	DI	1										
023	HS - 0662C	LACS	LIP2-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1						004			
023	HS - 0662D	LACS	LIP2-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1						004			
023	XIC - 0663	LACS	LIP3 2500 L/S Ion Pump Controller	-					Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
023	EI - 0663A	LACS	LIP3-1 2500 L/S Ion Pump Voltage Indication	AI			1					004			
023	HS - 0663A	LACS	LIP3-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1						004			
023	II - 0663A	LACS	LIP3-1 2500 L/S Ion Pump Current Indication	AI			1					004			
023	XA - 0663A	LACS	LIP3-1 2500 L/S Ion Pump Fault Alarm	DI	1										
023	EI - 0663B	LACS	LIP3-2 2500 L/S Ion Pump Voltage Indication	AI			1					004			
023	HS - 0663B	LACS	LIP3-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1						004			
023	II - 0663B	LACS	LIP3-2 2500 L/S Ion Pump Current Indication	AI			1					004			
023	XA - 0663B	LACS	LIP3-2 2500 L/S Ion Pump Fault Alarm	DI	1										
023	HS - 0663C	LACS	LIP3-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1						004			
023	HS - 0663D	LACS	LIP3-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1						004			
023	XIC - 0664	LACS	LIP4 2500 L/S Ion Pump Controller	-					Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
023	EI - 0664A	LACS	LIP4-1 2500 L/S Ion Pump Voltage Indication	AI			1					004			
023	HS - 0664A	LACS	LIP4-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1						004			
023	II - 0664A	LACS	LIP4-1 2500 L/S Ion Pump Current Indication	AI			1					004			
023	XA - 0664A	LACS	LIP4-1 2500 L/S Ion Pump Fault Alarm	DI	1										
023	EI - 0664B	LACS	LIP4-2 2500 L/S Ion Pump Voltage Indication	AI			1					004			
023	HS - 0664B	LACS	LIP4-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1						004			
023	II - 0664B	LACS	LIP4-2 2500 L/S Ion Pump Current Indication	AI			1					004			
023	XA - 0664B	LACS	LIP4-2 2500 L/S Ion Pump Fault Alarm	DI	1										
023	HS - 0664C	LACS	LIP4-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1						004			
023	HS - 0664D	LACS	LIP4-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1						004			
022	HS - 0669	LACS	LCP1 80K Cryopump Inlet Isolation Valve Open/Close Switch	DO		1						005			
005	II - 0669	LACS	LGV4 25 L/S Ion Pump Current Indication	AI			1					004			
005	XIC - 0669	LACS	LGV4 25 L/S Ion Pump Controller	-					Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
022	XV - 0669	LACS	LCP1 80K Cryopump Inlet Isolation Valve	-					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG4	554617	005			
022	XY - 0669	LACS	LCP1 80K Cryopump Inlet Isolation Valve Solenoid	-					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG4	554617	005			
022	ZSC - 0669	LACS	LCP1 80K Cryopump Inlet Isolation Valve Closed	DI	1				GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG4	554617	005			
022	ZSO - 0669	LACS	LCP1 80K Cryopump Inlet Isolation Valve Open	DI	1				GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG4	554617	005			
024	PE - 0670A	LACS	Right Manifold Beam Tube Pirani Gauge Tube	-								007			
024	PI - 0670A	LACS	Right Manifold Beam Tube Lo Vacuum Pressure Indication	-											
024	PT - 0670A	LACS	Right Manifold Beam Tube Pirani Gauge Transmitter	AI			1						1 x 10-3	1000	TORR
024	PE - 0670B	LACS	Right Manifold Beam Tube Ion Gauge Tube	-								007			
024	PI - 0670B	LACS	Right Manifold Beam Tube Hi Vacuum Pressure Indication	-											
024	PT - 0670B	LACS	Right Manifold Beam Tube Ion Gauge Transmitter	AI			1						3 x 10-11	1 x 10-2	TORR
006	PI - 0672	LACS	LCP2 LN2 Dewar Pressure Control Indicator	-											
006	PCV - 0673	LACS	LCP2 LN2 Dewar Pressure Control Valve	-											
026	PSV - 0675	LAES	Class 100 Air Pressure Safety Valve	-											
024	HV - 0676	LACS	Right Manifold Beam Tube 6" Pumpout Port Valve	-					Varian Vacu Products	6" SST Gate Valve	555029	006			
024	ZSC - 0676	LACS	Right Manifold Beam Tube 6" Pumpout Port Valve Closed	DI	1				Varian Vacu Products	6" SST Gate Valve	555029	006			
024	ZSO - 0676	LACS	Right Manifold Beam Tube 6" Pumpout Port Valve Open	DI	1				Varian Vacu Products	6" SST Gate Valve	555029	006			
024	HV - 0677	LACS	Right Manifold Beam Tube 10" Pumpout Port Valve	-					Varian Vacu Products	10" SST Gate Valve	555029	006			
024	ZSC - 0677	LACS	Right Manifold Beam Tube 10" Pumpout Port Valve Closed	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			
024	ZSO - 0677	LACS	Right Manifold Beam Tube 10" Pumpout Port Valve Open	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			
024	HV - 0678	LACS	LCP2 80K Cryopump Pumpout Port Valve	-					Varian Vacu Products	10" SST Gate Valve	555029	006			
024	ZSC - 0678	LACS	LCP2 80K Cryopump Pumpout Port Valve Closed	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			
024	ZSO - 0678	LACS	LCP2 80K Cryopump Pumpout Port Valve Open	DI	1				Varian Vacu Products	10" SST Gate Valve	555029	006			

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DWG	PI&D INFORMATION			I/O BREAKDOWN					EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
024	HS - 0679	LACS	LCP2 80K Cryopump Outlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0679	LACS	LGV5 25 L/S Ion Pump Current Indication	AI			1						004			
005	XIC - 0679	LACS	LGV5 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
024	XV - 0679	LACS	LCP2 80K Cryopump Outlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG5	554617	005			
024	XY - 0679	LACS	LCP2 80K Cryopump Outlet Isolation Valve Solenoid	-						GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG5	554617	005			
024	ZSC - 0679	LACS	LCP2 80K Cryopump Outlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG5	554617	005			
024	ZSO - 0679	LACS	LCP2 80K Cryopump Outlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG5	554617	005			
022	PE - 0680A	LACS	Left Manifold Beam Tube Pirani Gauge Tube	-									007			
022	PI - 0680A	LACS	Left Manifold Beam Tube Lo Vacuum Pressure Indication	-												
022	PT - 0680A	LACS	Left Manifold Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
022	PE - 0680B	LACS	Left Manifold Beam Tube Ion Gauge Tube	-									007			
022	PI - 0680B	LACS	Left Manifold Beam Tube Hi Vacuum Pressure Indication	-												
022	PT - 0680B	LACS	Left Manifold Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
006	RV - 0682	LACS	LCP2 LN2 Dewar Pressure Control Relief Valve	-												
006	RV - 0683	LACS	LCP2 80K Cryopump Discharge Relief Valve	-												
026	PCV - 0684	LAES	Class 100 Air Seal Gas Pressure Control Valve	-												
026	PI - 0684	LAES	Class 100 Air Seal Gas Pressure Indicator	-												
022	II - 0686	LACS	75 L/S Ion Pump Current Indication Left Beam Manifold	AI			1						004			
022	XIC - 0686	LACS	75 L/S Ion Pump Controller Left Beam Manifold	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
024	II - 0688	LACS	75 L/S Ion Pump Current Indication Right Beam Manifold	AI			1						004			
024	XIC - 0688	LACS	75 L/S Ion Pump Controller Right Beam Manifold	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
024	HS - 0689	LACS	LCP2 80K Cryopump Inlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0689	LACS	LGV6 25 L/S Ion Pump Current Indication	AI			1						004			
005	XIC - 0689	LACS	LGV6 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
024	XV - 0689	LACS	LCP2 80K Cryopump Inlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG6	554617	005			
024	XY - 0689	LACS	LCP2 80K Cryopump Inlet Isolation Valve Solenoid	-						GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG6	554617	005			
024	*ZSC - 0689*	*LACS*	*LCP2 80K Cryopump Inlet Isolation Valve Closed*	DI	1					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG6	554617	005			
024	ZSO - 0689	LACS	LCP2 80K Cryopump Inlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Pnewmatic, Tag LVG6	554617	005			
006	RV - 0690	WACS	LCP2 LN2 Dewar Relief Valve	-												
026	PCV - 0696	LAES	Class 100 Air Pressure Control Valve	-												
026	PI - 0696	LAES	Class 100 Air Pressure Indicator	-												
006	LIC - 0700	LAES	LCP3 80K Cryopump Level Control Loop Output	AO				1								
006	LT - 0700	LAES	LCP3 80K Cryopump Level Control Transmitter	AI			1						089	0	100	% Level
006	LV - 0700	LAES	LCP3 80K Cryopump Level Control Valve	-									062			
006	LY - 0700	LACS	LCP3 80K Cryopump Level Control Loop Output	AO				1								
006	XV - 0700	LAES	LCP3 80K Cryopump Level Control Valve Solenoid	DO		1										
006	ZSC - 0700	LAES	LCP3 80K Cryopump Level Control Valve Closed	DI	1								026			
006	PI - 0701	LAES	LCP3 80K Cryopump Discharge Pressure Indication	-												
006	PT - 0701	LAES	LCP3 80K Cryopump Discharge Pressure Transmitter	AI			1						090	0	25	PSIG
006	TE - 0702	LAES	LCP3 80K Cryopump Discharge Thermocouple	T/C					1							
006	TI - 0702	LAES	LCP3 80K Cryopump Discharge Temperature Indication	-												
006	*JC - 0703*	*LACS*	*LCP3 80K Cryopump Regen SCR Controller*	AI			1									
006	TIC - 0703	LAES	LCP3 80K Cryopump Regen Loop Temperature Control	-												
006	TSH - 0703	LAES	LCP3 80K Cryopump Regen Loop HI Temperature	-												
006	TY - 0703	LAES	LCP3 80K Cryopump Regen Loop Temperature Control Loop Output	AO				1								
006	TE - 0703A	LAES	LCP3 80K Cryopump Regen Loop Thermocouple	T/C-T					1				091	-320	700	Deg F
006	TE - 0703B	LAES	LCP3 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	TE - 0703C	LAES	LCP3 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	FE - 0704	LAES	LCP3 80K Cryopump Regen Loop Pitot Tube Flow Element	-									079	0	12,000	SCFH
006	FI - 0704	LAES	LCP3 80K Cryopump Regen Loop Flow Indicator	-									088	0	12,000	SCFH
006	LT - 0705	LAES	LCP3 LN2 Dewar Level Transmitter	-									089	0	100	% Level
006	PI - 0705	LAES	LCP3 LN2 Dewar Pressure Indicator	-												

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DWG	PI&D INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
006	LI - 0705A	LAES	LCP3 LN2 Dewar Level Indicator	-												
006	LI - 0705B	LAES	LCP3 LN2 Dewar Level Indication	-												
006	RD - 0706	LAES	LCP3 LN2 Dewar Rupture Disc	-												
006	RV - 0706	LAES	LCP3 LN2 Dewar Relief Valve	-												
006	RD - 0707	LAES	LCP3 LN2 Dewar Rupture Disc	-												
006	RV - 0707	LAES	LCP3 LN2 Dewar Relief Valve	-												
006	RV - 0708	LAES	LCP3 LN2 Dewar Relief Valve	-												
020	EV - 0709	LAES	LCP3 80K Cryopump Outlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag LVG9	554617	005			
020	HS - 0709	LAES	LCP3 80K Cryopump Outlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0709	LAES	LGV9 25 L/S Ion Pump Current Indication	AI			1						004			
020	SC - 0709	LAES	LCP3 80K Cryopump Outlet Isolation Valve Controller	-												
020	XA - 0709	LAES	LCP3 80K Cryopump Outlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0709	LAES	LGV9 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
020	ZSC - 0709	LAES	LCP3 80K Cryopump Outlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag LVG9	554617	005			
020	ZSO - 0709	LAES	LCP3 80K Cryopump Outlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag LVG9	554617	005			
002	PC - 0710	LAES	LBSC5 Pressure Control Valve Controller	-									061			
002	PCV - 0710	LAES	LBSC5 Pressure Control Valve	-									061			
002	PY - 0710	LAES	LBSC5 Pressure Control Loop Output	AO				1								
002	PE - 0710A	LAES	LBSC5 Pirani Gauge Tube	-									007			
002	PI - 0710A	LAES	LBSC5 Lo Vacuum Pressure Indication	-												
002	PT - 0710A	LAES	LBSC5 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
002	PE - 0710B	LAES	LBSC5 Ion Gauge Tube	-									007			
002	PI - 0710B	LAES	LBSC5 HI Vacuum Pressure Indication	-												
002	PT - 0710B	LAES	LBSC5 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
002	II - 0711	LAES	LBSC5 75 L/S Ion Pump Current Indication	AI			1						004			
002	XIC - 0711	LAES	LBSC5 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
020	EV - 0719	LAES	LCP3 80K Cryopump Inlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag LVG10	554617	005			
020	HS - 0719	LAES	LCP3 80K Cryopump Inlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0719	LAES	LGV10 25 L/S Ion Pump Current Indication	AI			1						004			
020	SC - 0719	LAES	LCP3 80K Cryopump Inlet Isolation Valve Controller	-												
020	XA - 0719	LAES	LCP3 80K Cryopump Inlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0719	LAES	LGV10 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
020	ZSC - 0719	LAES	LCP3 80K Cryopump Inlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag LVG10	554617	005			
020	ZSO - 0719	LAES	LCP3 80K Cryopump Inlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag LVG10	554617	005			
020	HV - 0720	LAES	LCP3 80K Cryopump Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
020	ZSC - 0720	LAES	LCP3 80K Cryopump Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
020	ZSO - 0720	LAES	LCP3 80K Cryopump Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
020	HV - 0721	LAES	Left End Beam Tube 10" Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
020	ZSC - 0721	LAES	Left End Beam Tube Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
020	ZSO - 0721	LAES	Left End Beam Tube Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
020	XIC - 0722	LAES	LIP5 2500 L/S Ion Pump Controller	-						Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
020	EI - 0722A	LAES	LIP5-1 2500 L/S Ion Pump Voltage Indication	AI			1						004			
020	HS - 0722A	LAES	LIP5-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
020	II - 0722A	LAES	LIP5-1 2500 L/S Ion Pump Current Indication	AI			1						004			
020	XA - 0722A	LAES	LIP5-1 2500 L/S Ion Pump Fault Alarm	DI	1											
020	EI - 0722B	LAES	LIP5-2 2500 L/S Ion Pump Voltage Indication	AI			1						004			
020	HS - 0722B	LAES	LIP5-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
020	II - 0722B	LAES	LIP5-2 2500 L/S Ion Pump Current Indication	AI			1						004			
020	XA - 0722B	LAES	LIP5-2 2500 L/S Ion Pump Fault Alarm	DI	1											
020	HS - 0722C	LAES	LIP5-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
020	HS - 0722D	LAES	LIP5-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
020	PE - 0723A	LAES	Left End Beam Tube Pirani Gauge Tube	-									007			

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LIGO INSTRUMENT LIST

DWG	PI&D INFORMATION			I/O BREAKDOWN					EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
020	PI - 0723A	LAES	Left End Beam Tube Lo Vacuum Pressure Indication	-												
020	PT - 0723A	LAES	Left End Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
020	PE - 0723B	LAES	Left End Beam Tube Ion Gauge Tube	-									007			
020	PI - 0723B	LAES	Left End Beam Tube HI Vacuum Pressure Indication	-												
020	PT - 0723B	LAES	Left End Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
020	PE - 0724A	LAES	LCP3 Pirani Gauge Tube	-									007			
020	PI - 0724A	LAES	LCP3 Lo Vacuum Pressure Indication	-												
020	PT - 0724A	LAES	LCP3 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
020	PE - 0724B	LAES	LCP3 Ion Gauge Tube	-									007			
020	PI - 0724B	LAES	LCP3 HI Vacuum Pressure Indication	-												
020	PT - 0724B	LAES	LCP3 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
020	PSV - 0725	LAES	Class 100 Air Pressure Safety Valve	-												
020	PCV - 0726	LAES	Class 100 Air Seal Gas Pressure Control Valve	-												
020	PI - 0726	LAES	Class 100 Air Seal Gas Pressure Indicator	-												
020	PCV - 0727	LAES	Class 100 Air Pressure Control Valve	-												
020	PI - 0727	LAES	Class 100 Air Pressure Indicator	-												
006	RV - 0736	WACS	LCP3 LN2 Dewar Relief Valve	-												
021	EV - 0750	LAMJ	Left Mid Joint Isolation Valve	-						GNB Corp	122CM, Gate Valve, Electric, Tag LVG7	554617	005			
021	HS - 0750	LAMJ	Left Mid Joint Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0750	LAMJ	LGV7 25 L/S Ion Pump Current Indication	AI			1						004			
021	SC - 0750	LAMJ	Left Mid Joint Isolation Valve Controller	-												
021	XA - 0750	LAMJ	Left Mid Joint Isolation Valve Common Alarm	DI	1											
005	XIC - 0750	LAMJ	LGV7 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
021	ZSC - 0750	LAMJ	Left Mid Joint Isolation Valve Closed	DI	1					GNB Corp	122CM, Gate Valve, Electric, Tag LVG7	554617	005			
021	ZSO - 0750	LAMJ	Left Mid Joint Isolation Valve Open	DI	1					GNB Corp	122CM, Gate Valve, Electric, Tag LVG7	554617	005			
021	PE - 0751A	LAMJ	Left Mid Joint Beam Tube Pirani Gauge Tube	-									007			
021	PI - 0751A	LAMJ	Left Mid Joint Beam Tube Lo Vacuum Pressure Indication	-												
021	PT - 0751A	LAMJ	Left Mid Joint Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
021	PE - 0751B	LAMJ	Left Mid Joint Beam Tube Ion Gauge Tube	-									007			
021	PI - 0751B	LAMJ	Left Mid Joint Beam Tube HI Vacuum Pressure Indication	-												
021	PT - 0751B	LAMJ	Left Mid Joint Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
021	PE - 0752A	LAMJ	Left Mid Joint Beam Tube Pirani Gauge Tube	-									007			
021	PI - 0752A	LAMJ	Left Mid Joint Beam Tube Lo Vacuum Pressure Indication	-												
021	PT - 0752A	LAMJ	Left Mid Joint Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
021	PE - 0752B	LAMJ	Left Mid Joint Beam Tube Ion Gauge Tube	-									007			
021	PI - 0752B	LAMJ	Left Mid Joint Beam Tube HI Vacuum Pressure Indication	-												
021	PT - 0752B	LAMJ	Left Mid Joint Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
006	RV - 0762	LAES	LCP3 LN2 Dewar Pressure Control Relief Valve	-												
006	PCV - 0763	LAES	LCP3 LN2 Dewar Vent Pressure Control Valve	-												
006	PI - 0772	LAES	LCP3 LN2 Dewar Pressure Control Indicator	-												
006	PCV - 0773	LAES	LCP3 LN2 Dewar Pressure Control Valve	-												
006	RV - 0782	LAES	LCP3 LN2 Dewar Pressure Control Relief Valve	-												
006	RV - 0783	LAES	LCP3 80K Cryopump Discharge Relief Valve	-												
006	LIC - 0800	LAES	LCP4 80K Cryopump Level Control Loop Output	AO				1								
006	LT - 0800	LAES	LCP4 80K Cryopump Level Transmitter	AI			1						089	0	100	% Level
006	LV - 0800	LAES	LCP4 80K Cryopump Level Control Valve	-									062			
006	LY - 0800	LACS	LCP4 80K Cryopump Level Control Loop Output	AO				1								
006	XV - 0800	LAES	LCP4 80K Cryopump Level Control Valve Solenoid	DO		1										
006	ZSC - 0800	LAES	LCP4 80K Cryopump Level Control Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag LVG11	554617	005			
006	PI - 0801	LAES	LCP4 80K Cryopump Discharge Pressure Indication	-												
006	PT - 0801	LAES	LCP4 80K Cryopump Discharge Pressure Transmitter	AI			1						090	0	25	PSIG
006	TE - 0802	LAES	LCP4 80K Cryopump Discharge Thermocouple	T/C					1							

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LIGO INSTRUMENT LIST

DWG	P&ID INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
006	TI - 0802	LAES	LCP4 80K Cryopump Discharge Temperature Indication	-												
006	JC - 0803	LACS	LCP4 80K Cryopump Regen SCR Controller	AI			1									
006	TIC - 0803	LAES	LCP4 80K Cryopump Regen Loop Temperature Control	-												
006	TSH - 0803	LAES	LCP4 80K Cryopump Regen Loop HI Temperature	-												
006	TY - 0803	LAES	LCP4 80K Cryopump Regen Loop Temperature Control Loop Output	AO				1								
006	TE - 0803A	LAES	LCP4 80K Cryopump Regen Loop Thermocouple	T/C-T					1				091	-320	700	Deg F
006	TE - 0803B	LAES	LCP4 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	TE - 0803C	LAES	LCP4 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	FE - 0804	LAES	LCP4 80K Cryopump Regen Loop Pitot Tube Flow Element	-									079	0	12,000	SCFH
006	FI - 0804	LAES	LCP4 80K Cryopump Regen Loop Flow Indicator	-									088	0	12,000	SCFH
006	LT - 0805	LAES	LCP4 LN2 Dewar Level Transmitter	AI			1						089	0	100	% Level
006	PI - 0805	LAES	LCP4 LN2 Dewar Pressure Indicator	-												
006	LI - 0805A	LAES	LCP4 LN2 Dewar Level Indicator	-												
006	LI - 0805B	LAES	LCP4 LN2 Dewar Level Indication	-												
006	RD - 0806	LAES	LCP4 LN2 Dewar Rupture Disc	-												
006	RV - 0806	LAES	LCP4 LN2 Dewar Relief Valve	-												
006	RD - 0807	LAES	LCP4 LN2 Dewar Rupture Disc	-												
006	RV - 0807	LAES	LCP4 LN2 Dewar Relief Valve	-												
006	RV - 0808	LAES	LCP4 LN2 Dewar Relief Valve	-												
025	EV - 0809	LAES	LCP4 80K Cryopump Outlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag LVG11	554617	005			
025	HS - 0809	LAES	LCP4 80K Cryopump Outlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0809	LAES	LGV11 25 L/S Ion Pump Current Indication	AI			1						004			
025	SC - 0809	LAES	LCP4 80K Cryopump Outlet Isolation Valve Controller	-												
025	XA - 0809	LAES	LCP4 80K Cryopump Outlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0809	LAES	LGV11 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
025	ZSC - 0809	LAES	LCP4 80K Cryopump Outlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag LVG12	554617	005			
025	ZSO - 0809	LAES	LCP4 80K Cryopump Outlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag LVG11	554617	005			
002	PC - 0810	LAES	LBSC4 Pressure Control Valve Controller	-									061			
002	PCV - 0810	LAES	LBSC4 Pressure Control Valve	-									061			
002	PY - 0810	LAES	LBSC4 Pressure Control Loop Output	AO				1								
002	PE - 0810A	LAES	LBSC4 Pirani Gauge Tube	-									007			
002	PI - 0810A	LAES	LBSC4 Lo Vacuum Pressure Indication	-												
002	PT - 0810A	LAES	LBSC4 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
002	PE - 0810B	LAES	LBSC4 Ion Gauge Tube	-									007			
002	PI - 0810B	LAES	LBSC4 HI Vacuum Pressure Indication	-												
002	PT - 0810B	LAES	LBSC4 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
002	II - 0811	LAES	LBSC4 75 L/S Ion Pump Current Indication	AI			1						004			
002	XIC - 0811	LAES	LBSC4 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
025	EV - 0819	LAES	LCP4 80K Cryopump Inlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag LVG12	554617	005			
025	HS - 0819	LAES	LCP4 80K Cryopump Inlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0819	LAES	LGV12 25 L/S Ion Pump Current Indication	AI			1						004			
025	SC - 0819	LAES	LCP4 80K Cryopump Inlet Isolation Valve Controller	-												
025	XA - 0819	LAES	LCP4 80K Cryopump Inlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0819	LAES	LGV12 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
025	ZSC - 0819	LAES	LCP4 80K Cryopump Inlet Isolation Valve Closed	DI	1								005			
025	ZSO - 0819	LAES	LCP4 80K Cryopump Inlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag LVG12	554617	005			
025	HV - 0820	LAES	LCP4 80K Cryopump 10" Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
025	ZSC - 0820	LAES	LCP4 80K Cryopump Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
025	ZSO - 0820	LAES	LCP4 80K Cryopump Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
025	HV - 0821	LAES	Right End Beam Tube 10" Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
025	ZSC - 0821	LAES	Right End Beam Tube Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
025	ZSO - 0821	LAES	Right End Beam Tube Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			

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LIGO INSTRUMENT LIST

DWG	PI&D INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
025	XIC - 0822	LAES	LIP6 2500 L/S Ion Pump Controller	-						Varian Vacu Products	2500 L/S Noble Diode Ion Pump Controller	554936	004			
025	EI - 0822A	LAES	LIP6-1 2500 L/S Ion Pump Voltage Indication	AI			1						004			
025	HS - 0822A	LAES	LIP6-1 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
025	II - 0822A	LAES	LIP6-1 2500 L/S Ion Pump Current Indication	AI			1						004			
025	XA - 0822A	LAES	LIP6-1 2500 L/S Ion Pump Fault Alarm	DI	1											
025	EI - 0822B	LAES	LIP6-2 2500 L/S Ion Pump Voltage Indication	AI			1						004			
025	HS - 0822B	LAES	LIP6-1 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
025	II - 0822B	LAES	LIP6-2 2500 L/S Ion Pump Current Indication	AI			1						004			
025	XA - 0822B	LAES	LIP6-2 2500 L/S Ion Pump Fault Alarm	DI	1											
025	HS - 0822C	LAES	LIP6-2 2500 L/S Ion Pump Remote High Voltage Start Switch	DO		1							004			
025	HS - 0822D	LAES	LIP6-2 2500 L/S Ion Pump Remote High Voltage Stop Switch	DO		1							004			
025	PE - 0823A	LAES	Right End Beam Tube Pirani Gauge Tube	-									007			
025	PI - 0823A	LAES	Right End Beam Tube Lo Vacuum Pressure Indication	-												
025	PT - 0823A	LAES	Right End Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
025	PE - 0823B	LAES	Right End Beam Tube Ion Gauge Tube	-									007			
025	PI - 0823B	LAES	Right End Beam Tube HI Vacuum Pressure Indication	-												
025	PT - 0823B	LAES	Right End Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
025	PE - 0824A	LAES	CLP4 Pirani Gauge Tube	-									007			
025	PI - 0824A	LAES	CLP4 Lo Vacuum Pressure Indication	-												
025	PT - 0824A	LAES	CLP4 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
025	PE - 0824B	LAES	CLP4 Ion Gauge Tube	-									007			
025	PI - 0824B	LAES	CLP4 HI Vacuum Pressure Indication	-												
025	PT - 0824B	LAES	CLP4 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
025	PSV - 0825	LAES	Class 100 Air Pressure Safety Valve	-												
025	PCV - 0826	LAES	Class 100 Air Seal Gas Pressure Control Valve	-												
025	PI - 0826	LAES	Class 100 Air Seal Gas Pressure Indicator	-												
025	PCV - 0827	LAES	Class 100 Air Pressure Control Valve	-												
025	PI - 0827	LAES	Class 100 Air Pressure Indicator	-												
006	RV - 0836	WACS	LCP4 LN2 Dewar Relief Valve	-												
021	EV - 0850	LAMJ	Right Mid Joint Isolation Valve	-						GNB Corp	122CM, Gate Valve, Electric, Tag LVG8	554617	005			
021	HS - 0850	LAMJ	Right Mid Joint Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0850	LAMJ	LGV8 25 L/S Ion Pump Current Indication	AI			1						004			
021	SC - 0850	LAMJ	Right Mid Joint Isolation Valve Controller	-												
021	XA - 0850	LAMJ	Right Mid Joint Isolation Valve Common Alarm	DI	1											
005	XIC - 0850	LAMJ	LGV8 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
021	ZSC - 0850	LAMJ	Right Mid Joint Isolation Valve Closed	DI	1					GNB Corp	122CM, Gate Valve, Electric, Tag LVG8	554617	005			
021	ZSO - 0850	LAMJ	Right Mid Joint Isolation Valve Open	DI	1					GNB Corp	122CM, Gate Valve, Electric, Tag LVG8	554617	005			
021	PE - 0851A	LAMJ	Right Mid Joint Beam Tube Pirani Gauge Tube	-									007			
021	PI - 0851A	LAMJ	Right Mid Joint Beam Tube Lo Vacuum Pressure Indication	-												
021	PT - 0851A	LAMJ	Right Mid Joint Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
021	PE - 0851B	LAMJ	Right Mid Joint Beam Tube Ion Gauge Tube	-									007			
021	PI - 0851B	LAMJ	Right Mid Joint Beam Tube HI Vacuum Pressure Indication	-												
021	PT - 0851B	LAMJ	Right Mid Joint Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
021	PE - 0852A	LAMJ	Right Mid Joint Beam Tube Pirani Gauge Tube	-									007			
021	PI - 0852A	LAMJ	Right Mid Joint Beam Tube Lo Vacuum Pressure Indication	-												
021	PT - 0852A	LAMJ	Right Mid Joint Beam Tube Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
021	PE - 0852B	LAMJ	Right Mid Joint Beam Tube Ion Gauge Tube	-									007			
021	PI - 0852B	LAMJ	Right Mid Joint Beam Tube HI Vacuum Pressure Indication	-												
021	PT - 0852B	LAMJ	Right Mid Joint Beam Tube Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
006	RV - 0862	LAES	LCP4 LN2 Dewar Pressure Control Relief Valve	-												
006	PCV - 0863	LAES	LCP4 LN2 Dewar Vent Pressure Control Valve	-												
006	PI - 0872	LAES	LCP4 LN2 Dewar Pressure Control Indicator	-												

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DWG	PI&D INFORMATION			I/O BREAKDOWN						EQUIPMENT INFORMATION			SPEC	SETTINGS (low-to-high or off-on)		
V049-0-	TAG #	AREA	SERVICE DESCRIPTION	TYPE	DI	DO	AI	AO	T/C	MANUFACTURER	MODEL No.	P. O. #	V049-2-	LOW / OFF	HIGH / ON	UNITS
006	PCV - 0873	LAES	LCP4 LN2 Dewar Pressure Control Valve	-												
006	RV - 0882	LAES	LCP4 LN2 Dewar Pressure Control Relief Valve	-												
006	RV - 0883	LAES	LCP4 80K Cryopump Discharge Relief Valve	-												

Title: **SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK**

PRELIMINARY
NOT for CONSTRUCTION

SPECIFICATION

FOR

ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY Daniel J. Parenti, Jr. 4/29/96
WA PE Reg 32541 (exp 5/12/98)
LA PE Reg E-26566 (exp 3/31/98)

ELECTRICAL Fabi Bark

QUALITY ASSURANCE C.R. Bardwell

TECHNICAL DIRECTOR D. A. Williams

PROJECT MANAGER Rachel Bayly

REV LTR	BY—DATE	APPD—DATE	DESCRIPTION OF ACTION
0	DP 4/29/96	RES 4/29/96	Released for Review & Comments per DCN 0149

PROCESS SYSTEMS INTERNATIONAL, INC				SPECIFICATION	
INITIAL APPROVALS	PREPARED BY / DATE		APPROVED BY / DATE	Number	Rev
	D. Parenti, Jr.	4/29/96	RES 4/29/96	A V049-2-022	0

CONTENTS

GENERAL REQUIREMENTS

1 CONSTRUCTION DOCUMENTS

1.1 Process Systems International General Provisions

1.2 General Construction Specification V049-2-021

1.3 Attachments to the Specification (see Table of Contents).

2 SCOPE OF WORK

2.1 Provide labor, tools, materials, and equipment necessary for a complete installation of the Work as specified and as indicated on Drawings.

2.2 Receive, store, and handle equipment furnished by others and required to be installed under this Contract.

2.3 Through the PSI's representative, coordinate Work activities provided under this Contract with work provided by others.

2.4 SUMMARY OF ELECTRICAL WORK

2.4.1 Work as indicated on the Drawings takes place at two sites. The Washington site consists of one corner station, two mid stations, and two end stations and the Louisiana site one corner station and two end stations.

- Provide power, instrument, and control wiring installed in conduit or cable tray; receptacles and outlets; and equipment connections as indicated.
- Panelboards and below grade conduits are provided by others unless otherwise indicated.

2.4.2 Install gages, switches, electronic transmitters, and other instruments that are not already skid mounted; control cabinets; and other equipment furnished by others (see ATTACHMENT B: *FURNISHED ELECTRICAL EQUIPMENT LIST*).

2.4.3 Provide instrument air/gas tubing between pneumatically operated devices and supply lines and connections as indicated. Provide process tubing between electronic transmitters and process points and connections as indicated.

2.4.4 Field Tests

- Test power wiring for grounds and shorts.
- Test motors for correct shaft rotation.
- Test instrument and control wiring for point-to-point continuity, grounds, and shorts.
- Check instrument gas and process tubing for leaks.
- Field Calibrations by PSI

3 INTENT

3.1 Intent of the Drawings and Specification is to assist and guide the Contractor and to establish minimum requirements.

3.2 Drawings indicate arrangement and approximate location of equipment. When necessary to deviate from the arrangement indicated to meet structural conditions or to clear other work, inform PSI's representative of proposed deviation before proceeding.

3.3 Comply with specific, detailed requirements indicated in lieu of generally stated requirements.

3.4 Portions of these Drawings and Specification are abbreviated and may include incomplete statements. Deduce the omitted words or phrases such as *the Contractor shall*, *shall be*, *as indicated on the drawings*, *in accordance with details*, *a*, *the*, and *all*.

3.5 Drawings and Specification do not undertake to indicate every item necessary to produce a complete installation of the Work indicated or specified.

4 DEFINITIONS (ALSO SEE THE GENERAL CONDITIONS & THE NEC)

By Others	Work not under this Contract.
Contractor	Company doing electrical and instrumentation work as defined in the Contract Documents.
PSI	Process Systems International, Inc
Indicated	Shown or noted.
Install	Place, secure, and connect.
Labeled	Equipment marked with an identifying symbol authorized by a nationally recognized testing company such as UL, FM, ETL indicating sample of product has been tested and determined it complies with their safety standards.
Owner	US Government
Owner's Representative	Persons designated by Owner
Permitted	As by code, Contract Documents, or PSI.
Provide	Furnish and install.
Required	As by code, Contract Documents, or prevailing conditions.
Submittal	Information required to show that the proposed equipment complies with project requirements.
Use	Provide material or equipment referenced.
Work	Material and equipment and their installation and other requirements as established in the Contract Documents.
Wire (Verb)	Connect to equipment indicated and provide wiring required for connection.
Wiring	Conductors, raceways, and accessories as required for a complete installation.

5 CODES, STANDARDS, AND PERMITS

5.1 Comply with authorities having legal jurisdiction and applicable parts of the latest (unless otherwise required) publications by the following jurisdictions and organizations:

- Applicable federal, state, and local codes.
- Federal Occupational Safety and Health Act (OSHA)
- American National Standards Institute, Inc. (ANSI)
- National Fire Protection Association (NFPA)
- Institute of Electrical and Electronics Engineers (IEEE)
- National Electrical Manufacturers Association (NEMA)
- Insulated Cable Engineers Association (ICEA)
- Underwriter's Laboratories (UL), Factory Mutual Engineering Corp (FM), Electrical Testing Laboratories, Inc (ETL), or other nationally recognized testing companies' equipment and installation safety standards

5.2 The Drawings and Specification do not undertake to repeat requirements written in the above codes, ordinances, and standards.

5.3 Arrange and pay for necessary permits, licenses, inspections, and certificates applicable to the performance of the Work. At conclusion of the Project, deliver certificates of inspection to the PSI's representative.

6 LABELED EQUIPMENT

Provide labeled equipment and assemblies where recognized national testing company safety standards exist.

7 INSTALLATION RESTRICTIONS

7.1 Do not cut structural members without written acknowledgment from the Owner obtained via the PSI's representative.

7.2 Do not weld supports and equipment to building steel without written acknowledgment from the Owner obtained via the PSI's representative.

7.3 Arrange equipment to allow accessibility to installations likely to need inspection, calibration, repair, and maintenance.

8 SPECIFIED EQUIPMENT AND SUBSTITUTIONS

8.1 The manufacturer of the equipment specified is used as the basis of the design and to establish quality required for this project. Unless no substitutions is stated, other manufacturers of equivalent equipment may also be proposed by the Contractor.

8.2 The description following a catalog number is basically to identify the product, but the description may also call for accessories, options, and modifications which are beyond the cataloged product.

8.3 Submit proposed substitutions to the electrical engineer for acceptance via PSI's representative. With submittal, provide details of necessary changes to accommodate substitutions. Submit samples if requested.

9 PROPOSED EQUIPMENT SUBMITTALS

Before delivering equipment to the job site and installing it, complete the submittal process as follows:

9.1 Equipment List: As soon as practicable, submit for review a list of equipment proposed for installation with each item identified by Specification paragraph number or where applicable by Drawing number. Include manufacturer's name with catalog or model number for each item.

9.2 Product Data: Where required by specification of the product, submit catalog data sheets or other published materials showing appearances, electrical ratings, performance characteristics, dimensions, installation methods, and space requirements of proposed equipment.

9.3 Shop Drawings: Where required by specification of the product, submit shop drawings, drawn to scale, indicating physical size and arrangement, construction details, provisions for conduits, access requirements for installation and maintenance, finishes, and materials used in fabrication. Supplement shop drawings with wiring diagrams and information as previously described under product data.

9.4 Mark submittals to clearly identify proposed equipment including accessories, options, and features and to exclude parts not applicable to the Project.

9.5 If proposed equipment deviates from the Specification or Drawings, indicate those differences and provide sufficient data to justify acceptance.

9.6 Provide products of one manufacturer for each classification of equipment.

9.7 Stamp submittals indicating that they have been checked and that they comply with Project requirements including physical restrictions before submitting.

9.8 Submittals reviews by PSI does not relieve the contractor from the responsibility of complying with the Specification and Drawings.

9.9 Unless otherwise required, provide two copies of submittals and deliver to PSI's project manger. Where practicable submit all product data and shop drawings at one time. Arrange submittal in three-ring binders with loose-leaf dividers separating categories of equipment.

9.10 At the job site, maintain the latest equipment submittals showing the action taken by PSI's project manager. Make these submittals available to Owner's and PSI's representatives.

10 TEMPORARY POWER

10.1 The Owner will provide electrical power, without charge. Make connections to the Owner's system where permitted.

10.2 Provide transformers, wiring, panelboards, distribution boxes, extension cords, and accessories as project needs require.

10.3 When temporary power is no longer required, remove that portion provided under this Contract.

11 RECORD DRAWINGS

11.1 At the site, maintain a set of prints marking them to accurately reflect the actual installation including changes in sizes, locations, dimensions, and circuiting as the work progresses.

11.2 On a daily basis, trace over the prints with a highlighter (transparent marker) to indicate work installed. Make these prints available to Owner's and PSI's representatives.

11.3 At completion of project, deliver marked prints to PSI's project manager.

EQUIPMENT AND INSTALLATION

12 CABLE TRAY SYSTEMS

Where indicated, provide cable trays as follows:

12.1 MANUFACTURERS: PW Industries, B-Line, or MP Husky.

12.2 TRAYS: NEMA VE1; channel and latter type trays as indicated; latter tray with rungs on 12 inch centers less unless otherwise indicated.

12.3 MATERIAL: 6063-T6 aluminum or 5052-H32 steel with ASTM's hot dip galvanized after fabrication standards.

12.4 LOAD AND SPAN: rated for 50 pounds per linear foot or more and span to suit tray supports.

12.5 ACCESSORIES:

12.5.1 expansion fittings in accordance with manufacturer's recommendations to accommodate building expansion joints and thermal expansion of tray to in ambient temperature range of 0°C to 50°C

12.5.2 bonding jumpers

12.5.3 end plates where applicable

12.5.4 drop-out fittings where conduit is not required

12.5.5 divider strips (barriers) where indicated with curved fittings and hold-down clips

12.5.6 other fittings to best suit each application

12.6 SUBMITTALS

12.6.1 Provide product data of each cable tray component.

12.6.2 Provide shop drawings of fabricated support brackets.

12.6.3 Provide dimensioned diagrams indicating where expansion joints are proposed.

12.7 INSTALLATION

12.7.1 Support horizontal and vertical trays by each rail using hold-down clamps to prevent lateral or vertical displacement. Provide support brackets, channels/struts, $^3/_8$ inch or larger hanger rods, and fittings to best suit installation (see *SUPPORTS*, Article 22, p.13).

12.7.2 Ensure that trays are effectively bonded to electrical equipment served by wiring in cable tray.

- Where applicable, bond tray to building steel with #2 AWG copper conductor at two locations.
- Bonding jumpers at expansion and adjustable fittings.

12.7.3 At approximate 20-foot intervals, identify power, instrument, and control cable trays with vinyl, self-adhesive signs with one inch high lettering or, similarly, with stencil and paint.

12.7.4 At approximate 10-foot intervals, identify channel tray with high voltage, ion pump wiring with *DANGER—HIGH VOLTAGE—DO NOT TOUCH.*

13 CONDUIT SYSTEMS
(ELECTRICAL RACEWAY OF CIRCULAR CROSS SECTION)

13.1 RIGID METAL CONDUIT (RMC, also RGS): Provide galvanized steel RMC conforming to ANSI C80.1 and UL 6 standards unless otherwise specified.

13.2 INTERMEDIATE METAL CONDUIT (IMC): At indoor locations, galvanized IMC conforming to UL 1242 standard may be provided in lieu of RMC unless otherwise required.

13.3 ELECTRICAL METALLIC TUBING (EMT): At indoor locations, EMT conforming to ANSI C80.3 and UL 797 standards may be provided in lieu of RMC or IMC unless otherwise required.

13.4 FLEXIBLE METAL CONDUIT (FMC): At connections to motors, transformers, and other vibrating equipment and instruments, provide thermoplastic covered, liquidtight FMC conforming to UL 360 standard and fittings to best suit application.

13.5 ACCESSORIES:

13.5.1 Provide fittings to best suit each application.

13.5.2 Provide expansion fittings as required in accordance with manufacturer's recommendations to accommodate building expansion joints indoors and thermal expansion of conduit in ambient temperature range of 0°C to 50°C.

13.6 INSTALLATION:

13.6.1 Restrictions: Where practicable, keep instrument wiring at least 12 inches away from other wiring and minimize paralleling instrument wiring with power or control wiring.

13.6.2 Arrangement: Make raceway offsets and bends symmetrically and uniformly.

13.6.3 Supports:

- Fasten conduits to building with one-hole malleable iron conduit clamps with screw or bolt.
- Where applicable and where two, three, or more

conduits are routed together, provide trapeze hangers made of 3/8 inch minimum hanger rods and channels/struts with conduit clamps.

- Support 11/2 inch or larger suspended conduits with 3/8 inch minimum hanger rods with conduit clamp.
- Provide supports as specified under *SUPPORTS*, Article 22, p.13.

13.6.4 Pull boxes: Provide pull boxes required for proper conductor installation in addition to boxes indicated.

13.6.5 Terminating conduits:

- Attach RMC and IMC to equipment by threading into integral cast hub, compression fitting, or double locknuts with bushing.
- Attach EMT with either set-screw or compression type fittings and connectors with integral insulating liners.

13.6.6 Flexible conduit connections:

- Connect to motors, transformers, and other vibrating equipment with 18 to 30 inches of FMC.
- At equipment mounted on vibrating isolators, provide 90° bend in the FMC connection.
- Connect to instruments with 18 to 30 inches of FMC.

13.6.7 Grounding: Where grounding conductor or bonding is applicable at locknut installations, provide threaded bushings with insulating liner and grounding lug.

13.6.8 Close openings: Keep conduits closed when not accessing them to prevent rain, dirt, and debris from entering.

14 BOXES, CONDUIT BODIES, AND WIREWAYS

14.1 PULL AND SPLICE BOXES:

14.1.1 Where indicated and as required to install wiring without damaging insulation or stretching conductors, provide sheet steel, galvanized or finished with gray baked enamel boxes with screw-on covers unless otherwise required.

14.1.2 Where applicable, provide sheet steel, galvanized or finished with gray baked enamel box barriers to maintain separation of wiring systems.

14.2 OUTLET AND JUNCTION BOXES

14.2.1 Provide cast-metal boxes with threaded hubs unless otherwise specified.

14.2.2 At outdoor locations, provide covers with gaskets.

14.2.3 At indoor locations, sheet-metal boxes may be provided in lieu of cast-metal boxes and conduit bodies unless otherwise required.

14.3 CONDUIT BODIES:

14.3.1 Where applicable, cast-metal conduit bodies with threaded hubs may be used in lieu of boxes unless otherwise required.

14.3.2 At outdoor locations, provide covers with gaskets.

14.4 WIREWAYS AND AUXILIARY GUTTERS:

14.4.1 Where required, provide sheet steel, galvanized or finished with gray baked enamel wireways and gutters with screw-on covers unless otherwise required.

14.4.2 Where applicable, provide sheet steel, galvanized or finished with gray baked enamel box barriers to maintain separation of wiring systems.

14.5 ACCESSORIES: Provide fittings to best suit each application.

14.6 INSTALLATION:

14.6.1 General requirements:

- Arrange boxes neatly and symmetrically to adjacent components and architectural features.
- Identify wire and cables by tag numbers within box with indelible felt tipped marker pen or as specified under wiring systems.
- Provide supports as specified under *SUPPORTS*, Article 22, p.13.
- When not accessing, close equipment to prevent rain, dirt, and debris from entering.

14.6.2 Wireway and gutters: Bond each section of wireways and gutters with #12 or larger conductor.

14.6.3 Pull and splice boxes: Provide supports to prevent conductors from resting on removable bottom covers.

14.6.4 Outlet and junction boxes: Rigidly fasten boxes directly to structure, to support channels/struts, or in framed constructions to bar hangers.

15 WIRE AND CABLE

15.1 POWER WIRE (up through 600 volts):

15.1.1 Provide #12 AWG or larger single; stranded copper; type THHN, THHN-THWN, THWN, or XHHW conductors rated 90°C, 600 volts unless otherwise specified.

Use colored coded insulation in sizes up to #8 AWG, except up to #6 AWG for grounding conductors, and black insulated conductors in larger sizes (see *WIRING IDENTIFICATION*, Article 16).

15.2 CONTROL WIRE (discrete signals):

15.2.1 120 VAC: Provide #14 AWG or larger, stranded copper, type THHN-THWN, multiconductor cable rated 90°C, 600 volts unless otherwise indicated.

15.2.2 24 VDC: Provide #18 AWG or larger, stranded copper, multiconductor cables rated 90°C and 300 volts unless otherwise indicated.

15.3 INSTRUMENT WIRE (analog signals):

15.3.1 4-20mA: Provide #18 AWG or larger, stranded copper, individually shielded twisted pairs, single or multipair cables rated 90°C, 300 volts unless otherwise indicated.

15.3.2 Thermocouple: Provide #16 AWG single pair and #20 AWG multipair ANSI type (as indicated), solid thermocouple extension cable shielded, rated 105°C, 300 volts.

15.4 TRAY CABLE: In addition to above, provide cable tray installations with cable labeled for cable tray use.

15.5 SUBMITTALS: Provide product data of each wire and cable.

15.6 INSTALLATION:

15.6.1 Where practicable, keep instrument wiring at least 12 inches away from other wiring and minimize paralleling instrument wiring with power or control wiring

15.6.2 Without splices, install wiring in conduit or cable tray unless otherwise indicated.

15.6.3 Install simultaneously conductors and multiconductor cables to occupy same conduit .

15.6.4 Where necessary, use labeled pulling lubricant that is approved by the cable manufacturer.

15.6.5 Use woven cable grips.

15.6.6 Be cautious not to exceed manufacturer's recommended pulling tension and cable bending radius.

15.6.7 After installation, seal cables exposed to weather or other harmful environments until cable is terminated.

15.6.8 Provide sufficient wire length at each end of pull to permit grouping and training the wires and cables. Where applicable, use self-locking nylon wire ties; cut off loose ends. Take care not to exceed manufacturer's wire bending radii. Do not allow wiring to bear against edges of enclosures. Replace wiring cut too short to meet installation requirements.

15.7 See *TESTING*, Article 23, p.14.

16 WIRING IDENTIFICATION

16.1 POWER WIRE:

16.1.1 Color code single conductors as follows:

Line	208/120V	480/277V
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
N	White	Gray
G	Green	Green

16.1.2 Where applicable, color code conductors using one-inch wide colored plastic adhesive tape wrapped with two full turns.

16.1.3 Identify each conductor end with panel designation and circuit number or with applicable identification to suit other type of circuits. Use printed, adhesive wire marker strips.

16.2 INSTRUMENT AND CONTROL WIRE:

16.2.1 Tag each end of single conductors and cable pairs with schematic wire number unless otherwise directed.

16.2.2 Tag each spare cable end with unique identification.

16.2.3 Use printed sleeve markers.

16.3 SUBMITTALS: Provide product data of printed sleeve markers.

17 WIRING TERMINATIONS

17.1 POWER WIRE:

17.1.1 Splices:

- #10 AWG and smaller conductors, provide insulated spring connectors.
- #8 AWG and larger conductors, provide either compression (crimp) connectors using matching installing tool or mechanical screw type connectors. Cover splices with insulating material made for connector where available; otherwise, cover with at least three layers of electrical, vinyl tape to attain insulation rating equivalent to that of the conductor.

17.1.2 Terminations:

- #10 AWG and smaller conductors to buses, enclosures, and similar applications, provide compression (crimp) terminals.
- #8 AWG and larger conductors, provide either compression (crimp) connectors using matching installing tool or mechanical screw type connectors.
- Where more than one conductor requires termination and terminals are not provided as part of the equipment, provide screw or pressure type insulated terminal blocks.

17.1.3 Motor Leads: To connect to motor leads, use split-bolts connectors. Cover splices with insulating material made for connector where available; otherwise, cover with at least three layers of electrical, vinyl tape to attain insulation rating equivalent to that of the conductor.

17.1.4 Where applicable, tighten screw type hardware in accordance with manufacturer's published torque values. If not available, comply with UL 486A standards.

17.2 INSTRUMENT AND CONTROL WIRE:

17.2.1 At instrument end of cable, strip and cutoff shielding back to edge of overall jacket. Then wrap two full turns of electrical plastic tape or placed heat shrinkable insulating sleeve half on conductors and half on overall jacket . At other end of cable, secure shielding to junction box terminal. (Shielding connects only to a single ground reference point at the electrical source.)

17.2.2 Coil, insulate, and label ends of spare conductors.

17.2.3 Remove insulation from ends of conductors using mechanical or electric heat type stripper.

18 WIRING DEVICES

Provide devices as indicted on the Drawings.

19 GROUNDING

19.1 EQUIPMENT GROUNDING: Bond each end of equipment grounding conductors to the grounding bushing, the grounding bus, grounding lug, or the enclosure, respectively.

19.2 GROUNDING CONNECTIONS:

19.2.1 Use mechanical connectors to make grounding connections.

Completely remove paint, dirt, and corrosion down to bare metal at connection areas, and coat surfaces with anti-oxidant electrical joint compound.

20 INSTRUMENT AIR/GAS AND PROCESS TUBING

Where indicated, provide the following:

20.1 INSTRUMENT AIR/GAS TUBING: Provide $^1/_4$ inch, type L, or larger copper tubing, brass compression connectors, and copper clips.

20.2 PROCESS TUBING: Provide $^1/_4$ inch, 0.035 WT, or larger 304 stainless steel, seamless tubing, stainless steel compression connectors, and stainless steel clips

20.3 INSTALLATIONS: Arrange tubing neatly and symmetrically to adjacent components. Use bending tools to make bends in tubing.

20.4 SUBMITTALS: Provide product data of tubing and accessories.

21 EQUIPMENT FURNISHED BY OTHERS
(SEE — **ATTACHMENT *B: FURNISHED ELECTRICAL EQUIPMENT LIST*)**

21.1 Receive, store (in clean, dry location), and handle equipment furnished by others and required to be installed under this Contract.

21.2 Rig large, heavy equipment in place and bolt free standing equipment to floor as specified under *SUPPORTS*, Article 22, p.13.

21.3 Make power, instrument, and control wiring and tubing connections as indicated.

21.4 Where practicable, keep instrumentation wiring 12 inches away from other wiring and minimize paralleling instrument wiring with power or control wiring.

21.5 Where necessary, cut holes to accommodate conduit, cable, and tubing connections.

22 SUPPORTS

22.1 Where applicable, provide steel channels/struts with galvanized or painted finish.

22.2 Fasten equipment and supports with corrosion resistant hardware.

22.3 Provide support systems of suitable strength to hold intended equipment in place.

22.4 Fabricate supports from structural steel or steel channels/struts rigidly welded or bolted. Paint cut ends of supports with rust inhibitor matching existing finish.

22.5 Secure free-standing equipment to concrete pad or floor with at least four $^5/_8$ inch or larger bolts. Provide drilled concrete anchors where applicable.

22.6 Secure surface-mounted panels and cabinets with at least four $^1/_2$ inch or larger bolts.

23 TESTING

23.1 No equipment shall be energized without consent of PSI's representative.

23.2 It is the Contractor's responsibility to conduct tests without damage to equipment.

23.3 POWER WIRE TESTING (up through 600 volts):

23.3.1 Test each new conductor installed and existing conductor reconnected to ground using 1000-volt megger.

23.3.2 Provide written test report listing resistance by feeder and branch circuit.

23.3.3 Replace conductors measuring less than 25 megohm and retest.

23.4 CONTROL AND INSTRUMENT WIRE TESTING:

23.4.1 Check point-to-point continuity of each conductor to ensure that wiring is intact and terminated at the proper place at both ends. After wiring has been terminated,

1. lift one conductor at a time off of its terminal at both ends;
2. establish an isolated return path (not ground, but may be one of the cable conductors);
3. check conductor continuity;
4. reconnect wire to terminals, or if defective, correct, recheck, and reconnect;
5. with highlighter, mark wiring diagram or schedule to indicate that wire and connection has been verified; and
6. proceed to next conductor.

23.4.2 Using highlighter, indicate on terminal wiring diagrams or schedules that each wire and connection has been verified. Make these sheets available to Owner's and PSI's representatives.

23.4.3 Replace defective wiring and retest.

23.5 MOTORS TESTING:

23.5.1 Before connecting, measure motor winding resistance and ground resistance.

23.5.2 PSI will test each three-phase motor for proper rotary direction. Where necessary, correct circuit connections at motor box.

23.6 RECEPTACLES TESTING: Test polarity and grounding of each receptacle device used with equipment furnished under this Work. Report deficiencies to PSI's representative.

23.7 INSTRUMENT GAS AND PROCESS TUBING TESTING:

23.7.1 Check tubing and connectors for leaks.

23.7.2 Check gas operated valves for proper opening and closing or positioning of pneumatically operated device.

23.7.3 Make repairs as necessary and retest.

23.8 VALVES TESTING:

23.8.1 Valve cycling to verify proper operation of limit switches, pneumatic operators, and positioning operators is by PSI.

23.8.2 At defective installation, make electrical and pneumatic repairs as necessary and retest.

23.9 SCHEDULING, NOTIFYING, AND WITNESSING TESTING: Provide the PSI's representative with at least three days notification of scheduled testing. With the notification, include a list of proposed tests and the expected time to perform these tests.

24 CALIBRATING—BY PSI

—END—

ATTACHMENT "A"

DRAWING LISTS

Washington Site only

DRAWING	DESCRIPTION
V049-3-002	OVERALL SITE PLAN
V049-3-101	INSTRUMENT PLAN—VERTEX SECTION
V049-3-102	INSTRUMENT PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-103	INSTRUMENT PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-104	INSTRUMENT PLAN—DIAGONAL SECTION
V049-3-106	CABLE TRAY PLAN—VERTEX SECTION
V049-3-107	CABLE TRAY PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-108	CABLE TRAY PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-109	CABLE TRAY PLAN—DIAGONAL SECTION
V049-3-111	INSTRUMENT/ELECTRICAL PLAN—VERTEX SECTION
V049-3-112	INSTRUMENT/ELECTRICAL PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-113	INSTRUMENT/ELECTRICAL PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-114	INSTRUMENT/ELECTRICAL PLAN—DIAGONAL SECTION
V049-3-116	POWER PLAN—VERTEX SECTION
V049-3-117	POWER PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-118	POWER PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-119	POWER PLAN—DIAGONAL SECTION
V049-3-123	CDS INTERFACE DIAGRAM—CORNER STATION (4 SHEETS)
V049-3-124	CONDUIT STUB-UP PLAN—CORNER STATION (2 SHEETS)
V049-3-125	VACUUM CART INTERFACE PLAN—CORNER STATION (3 SHEETS)
V049-3-126	CONDUIT SCHEDULE—CORNER STATION
V049-3-127	DATA HIGHWAY PLAN— VERTEX STATION
V049-3-128	DATA HIGHWAY PLAN— LEFT BEAM MANIFOLD STATION
V049-3-129	DATA HIGHWAY PLAN— RIGHT BEAM MANIFOLD STATION
V049-3-130	DATA HIGHWAY PLAN— DIAGONAL STATION

Washington Site only

DRAWING	DESCRIPTION
V049-3-131	DATA HIGHWAY INTERCONNECT DIAGRAM— CORNER STATION
V049-3-201	INSTRUMENT PLAN—LEFT MID STATION
V049-3-202	CABLE TRAY PLAN—LEFT MID STATION
V049-3-203	INSTRUMENT/ELECTRICAL PLAN—LEFT MID STATION
V049-3-204	POWER PLAN—LEFT MID STATION
V049-3-206	VACUUM CART INTERFACE PLAN—LEFT MID STATION (2 SHEETS)
V049-3-208	CDS INTERFACE DIAGRAM—LEFT MID STATION
V049-3-209	CONDUIT SCHEDULE—LEFT MID STATION
V049-3-301	INSTRUMENT PLAN—RIGHT MID STATION
V049-3-302	CABLE TRAY PLAN—RIGHT MID STATION
V049-3-303	INSTRUMENT/ELECTRICAL PLAN—RIGHT MID STATION
V049-3-304	POWER PLAN—RIGHT MID STATION
V049-3-305	CONDUIT STUB-UP PLAN—RIGHT MID STATION
V049-3-306	VACUUM CART INTERFACE PLAN—RIGHT MID STATION (2 SHEETS)
V049-3-308	CDS INTERFACE DIAGRAM—RIGHT MID STATION
V049-3-309	CONDUIT SCHEDULE—RIGHT MID STATION
V049-3-308	CDS INTERFACE DIAGRAM—RIGHT MID STATION (2 SHEETS)
V049-3-401	INSTRUMENT PLAN—LEFT END STATION
V049-3-402	CABLE TRAY PLAN—LEFT END STATION
V049-3-403	INSTRUMENT/ELECTRICAL PLAN—LEFT END STATION
V049-3-404	POWER PLAN—LEFT END STATION
V049-3-406	VACUUM CART INTERFACE PLAN—LEFT END STATION (2 SHEETS)
V049-3-408	CDS INTERFACE DIAGRAM—LEFT END STATION
V049-3-409	CONDUIT SCHEDULE—LEFT END STATION
V049-3-408	CDS INTERFACE DIAGRAM—LEFT END STATION
V049-3-501	INSTRUMENT PLAN—RIGHT END STATION
V049-3-502	CABLE TRAY PLAN—RIGHT END STATION

ATTACHMENT "A"

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Washington Site only

DRAWING	DESCRIPTION
V049-3-503	INSTRUMENT/ELECTRICAL PLAN—RIGHT END STATION
V049-3-504	POWER PLAN—RIGHT END STATION
V049-3-505	CONDUIT STUB-UP PLAN—RIGHT END STATION
V049-3-506	VACUUM CART INTERFACE PLAN—RIGHT END STATION (2 SHEETS)
V049-3-508	CDS INTERFACE DIAGRAM—RIGHT END STATION
V049-3-509	CONDUIT SCHEDULE—RIGHT END STATION

Louisiana Site only

DRAWING	DESCRIPTION
V049-3-003	OVERALL SITE PLAN
V049-3-601	INSTRUMENT PLAN—VERTEX SECTION
V049-3-602	INSTRUMENT PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-603	INSTRUMENT PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-606	CABLE TRAY PLAN—VERTEX SECTION
V049-3-607	CABLE TRAY PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-608	CABLE TRAY PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-611	INSTRUMENT/ELECTRICAL PLAN—VERTEX SECTION
V049-3-612	INSTRUMENT/ELECTRICAL PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-613	INSTRUMENT/ELECTRICAL PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-616	POWER PLAN—VERTEX SECTION
V049-3-617	POWER PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-618	POWER PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-623	CDS INTERFACE DIAGRAM—CORNER STATION (4 SHEETS)
V049-3-624	CONDUIT STUB-UP PLAN—CORNER STATION (2 SHEETS)
V049-3-625	VACUUM CART INTERFACE PLAN—CORNER STATION (3 SHEETS)
V049-3-626	CONDUIT SCHEDULE—CORNER STATION
V049-3-627	DATA HIGHWAY PLAN—VERTEX STATION
V049-3-628	DATA HIGHWAY PLAN— LEFT BEAM MANIFOLD STATION
V049-3-629	DATA HIGHWAY PLAN— RIGHT BEAM MANIFOLD STATION
V049-3-630	DATA HIGHWAY PLAN— DIAGONAL STATION
V049-3-631	DATA HIGHWAY INTERCONNECT DIAGRAM— CORNER STATION
V049-3-701	INSTRUMENT PLAN—LEFT END STATION
V049-3-702	CABLE TRAY PLAN—LEFT END STATION
V049-3-703	INSTRUMENT/ELECTRICAL PLAN—LEFT END STATION
V049-3-704	POWER PLAN—LEFT END STATION

ATTACHMENT "A"

Number A V049-2-022 | Rev Φ

Louisiana Site only

DRAWING	DESCRIPTION
V049-3-706	VACUUM CART INTERFACE PLAN—LEFT END STATION (2 SHEETS)
V049-3-708	CDS INTERFACE DIAGRAM—LEFT END STATION
V049-3-709	CONDUIT SCHEDULE—LEFT END STATION
V049-3-801	INSTRUMENT PLAN—RIGHT END STATION
V049-3-802	CABLE TRAY PLAN—RIGHT END STATION
V049-3-803	INSTRUMENT/ELECTRICAL PLAN—RIGHT END STATION
V049-3-804	POWER PLAN—RIGHT END STATION
V049-3-805	CONDUIT STUB-UP PLAN—RIGHT END STATION
V049-3-806	VACUUM CART INTERFACE PLAN—RIGHT END STATION (2 SHEETS)
V049-3-808	CDS INTERFACE DIAGRAM—RIGHT END STATION
V049-3-809	CONDUIT SCHEDULE—RIGHT END STATION

Washington & Louisiana Sites

DRAWING	DESCRIPTION
V049-3-001	GENERAL NOTES & LEGEND
V049-3-006	ELECTRICAL INSTALLATION DETAILS
V049-3-007	ELECTRICAL INSTALLATION DETAILS
V049-3-008	ELECTRICAL INSTALLATION DETAILS

REFERENCE DRAWING LIST*

DRAWING	DESCRIPTION
V049-3-004	ION CONTROLLER CABINET (2 SHEETS)
V049-3-121	PNL-100A & 100B ASSEMBLY
V049-3-122	PNL-100A & 100B WIRING DIAGRAM
V049-3-207	PNL-200 WIRING DIAGRAM
V049-3-307	PNL-300 WIRING DIAGRAM
V049-3-407	PNL-400 WIRING DIAGRAM
V049-3-507	PNL-500 WIRING DIAGRAM
V049-3-622	PNL-600A & 600B WIRING DIAGRAM
V049-3-707	PNL-700 WIRING DIAGRAM
V049-3-807	PNL-800 WIRING DIAGRAM

* Reference drawings, used by others to fabricate equipment, are furnished to supplement installation details and indicate wiring terminations.

ATTACHMENT "A"

Number	Rev
A V049-2-022	4

ATTACHMENT "B"

FURNISHED ELECTRICAL EQUIPMENT LIST

Washington Site only

ITEM	INSTRUMENT TAG/EQUIPMENT DESIGNATION	V INDICATES VACUUM ENVIRONMENT LOCATION	DESCRIPTION (INDICATED ON DRAWING/SHEET)
1	FI-104	—	CRYOPUMP WCP1 FLOW INDICATOR (V049-3-102)
2	FI-154	—	CRYOPUMP WCP2 FLOW INDICATOR (V049-3-103)
3	FI-204	—	CRYOPUMP WCP3 FLOW INDICATOR (V049-3-201)
4	FI-254	—	CRYOPUMP WCP4 FLOW INDICATOR (V049-3-201)
5	FI-304	—	CRYOPUMP WCP5 FLOW INDICATOR (V049-3-301)
6	FI-354	—	CRYOPUMP WCP6 FLOW INDICATOR (V049-3-301)
7	FI-404	—	CRYOPUMP WCP7 FLOW INDICATOR (V049-3-401)
8	FI-504	—	CRYOPUMP WCP8 FLOW INDICATOR (V049-3-501)
9	LT-100	—	CRYOPUMP WCP1 LEVEL TRANSMITTER* (V049-3-102)
10	LT-105	—	CRYOPUMP WCP1 DEWAR LEVEL TRANSMITTER* (V049-3-102)
11	LT-150	—	CRYOPUMP WCP2 LEVEL TRANSMITTER* (V049-3-103)
12	LT-155	—	CRYOPUMP WCP2 DEWAR LEVEL TRANSMITTER* (V049-3-103)
13	LT-200	—	CRYOPUMP WCP3 LEVEL TRANSMITTER* (V049-3-201)
14	LT-205	—	CRYOPUMP WCP3 DEWAR LEVEL TRANSMITTER* (V049-3-201)
15	LT-250	—	CRYOPUMP WCP4 LEVEL TRANSMITTER* (V049-3-201)
16	LT-255	—	CRYOPUMP WCP4 DEWAR LEVEL TRANSMITTER* (V049-3-201)
17	LT-300	—	CRYOPUMP WCP5 LEVEL TRANSMITTER* (V049-3-301)
18	LT-305	—	CRYOPUMP WCP5 DEWAR LEVEL TRANSMITTER* (V049-3-301)
19	LT-350	—	CRYOPUMP WCP6 LEVEL TRANSMITTER* (V049-3-301)
20	LT-355	—	CRYOPUMP WCP6 DEWAR LEVEL TRANSMITTER* (V049-3-301)
21	LT-400	—	CRYOPUMP WCP7 LEVEL TRANSMITTER* (V049-3-401)
22	LT-405	—	CRYOPUMP WCP7 DEWAR LEVEL TRANSMITTER* (V049-3-401)

* Furnished with accessories.

Washington Site only

ITEM	INSTRUMENT TAG/EQUIPMENT DESIGNATION	V INDICATES VACUUM ENVIRONMENT LOCATION	DESCRIPTION (INDICATED ON DRAWING/SHEET)
23	LT-500	—	CRYOPUMP WCP8 LEVEL TRANSMITTER* (V049-3-501)
24	LT-505	—	CRYOPUMP WCP8 DEWAR LEVEL TRANSMITTER* (V049-3-501)
25	PNL-100A	—	CORNER STATION ION CONTROLLER PANEL (V049-3-116)
26	PNL-100B	—	CORNER STATION ION CONTROLLER PANEL (V049-3-116)
27	PNL-200	—	LEFT MID STATION ION CONTROLLER PANEL (V049-3-204)
28	PNL-300	—	RIGHT MID STATION ION CONTROLLER PANEL (V049-3-304)
29	PNL-400	—	LEFT END STATION ION CONTROLLER PANEL (V049-3-404)
30	PNL-500	—	RIGHT END STATION ION CONTROLLER PANEL (V049-3-504)
31	PT-101	—	CRYOPUMP WCP1 PRESSURE TRANSMITTER* (V049-3-102)
32	PT-151	—	CRYOPUMP WCP2 PRESSURE TRANSMITTER* (V049-3-103)
33	PT-201	—	CRYOPUMP WCP3 PRESSURE TRANSMITTER* (V049-3-201)
34	PT-251	—	CRYOPUMP WCP4 PRESSURE TRANSMITTER* (V049-3-201)
35	PT-301	—	CRYOPUMP WCP5 PRESSURE TRANSMITTER* (V049-3-301)
36	PT-351	—	CRYOPUMP WCP6 PRESSURE TRANSMITTER* (V049-3-301)
37	PT-401	—	CRYOPUMP WCP7 PRESSURE TRANSMITTER* (V049-3-401)
38	PT-501	—	CRYOPUMP WCP8 PRESSURE TRANSMITTER* (V049-3-501)
39	TE-103A	—	CRYOPUMP WCP1 THERMOCOUPLE (V049-3-102)
40	TE-153A	—	CRYOPUMP WCP2 THERMOCOUPLE (V049-3-103)
41	TE-203A	—	CRYOPUMP WCP3 THERMOCOUPLE (V049-3-201)
42	TE-253A	—	CRYOPUMP WCP4 THERMOCOUPLE (V049-3-201)
43	TE-303A	—	CRYOPUMP WCP5 THERMOCOUPLE (V049-3-301)
44	TE-353A	—	CRYOPUMP WCP6 THERMOCOUPLE (V049-3-301)
45	TE-403A	—	CRYOPUMP WCP7 THERMOCOUPLE (V049-3-401)
46	TE-503A	—	CRYOPUMP WCP8 THERMOCOUPLE (V049-3-501)

* Furnished with accessories

ATTACHMENT "B"

Number	Rev
A V049-2-022	

Louisiana Site only

ITEM	INSTRUMENT TAG/EQUIPMENT DESIGNATION	V INDICATES VACUUM ENVIRONMENT LOCATION	DESCRIPTION (INDICATED ON DRAWING/SHEET)
1	FI-604	—	CRYOPUMP LCP1 FLOW INDICATOR (V049-3-602)
2	FI-654	—	CRYOPUMP LCP2 FLOW INDICATOR (V049-3-603)
3	FI-704	—	CRYOPUMP LCP3 FLOW INDICATOR (V049-3-701)
4	FI-754	—	CRYOPUMP LCP4 FLOW INDICATOR (V049-3-801)
5	LT-600	—	CRYOPUMP LCP1 LEVEL TRANSMITTER* (V049-3-602)
6	LT-605	—	CRYOPUMP LCP1 DEWAR LEVEL TRANSMITTER* (V049-3-602)
7	LT-650	—	CRYOPUMP LCP2 LEVEL TRANSMITTER* (V049-3-603)
8	LT-655	—	CRYOPUMP LCP2 DEWAR LEVEL TRANSMITTER (V049-3-603)
9	LT-700	—	CRYOPUMP LCP3 LEVEL TRANSMITTER* (V049-3-701)
10	LT-705	—	CRYOPUMP LCP3 DEWAR LEVEL TRANSMITTER* (V049-3-701)
11	LT-800	—	CRYOPUMP LCP4 LEVEL TRANSMITTER* (V049-3-801)
12	LT-805	—	CRYOPUMP LCP4 DEWAR LEVEL TRANSMITTER* (V049-3-801)
13	PNL-600A	—	CORNER STATION ION CONTROLLER PANEL (V049-3-616)
14	PNL-600B	—	CORNER STATION ION CONTROLLER PANEL (V049-3-616)
15	PNL-700	—	LEFT END STATION ION CONTROLLER PANEL (V049-3-704)
16	PNL-800	—	RIGHT END STATION ION CONTROLLER PANEL (V049-3-804)
17	PT-601	—	CRYOPUMP LCP1 PRESSURE TRANSMITTER* (V049-3-602
18	PT-651	—	CRYOPUMP LCP2 PRESSURE TRANSMITTER* (V049-3-603)
19	PT-701	—	CRYOPUMP LCP3 PRESSURE TRANSMITTER* (V049-3-701)
20	PT-851	—	CRYOPUMP LCP4 PRESSURE TRANSMITTER* (V049-3-801)
21	TE-603A	—	CRYOPUMP LCP1 THERMOCOUPLE (V049-3-602)
22	TE-653A	—	CRYOPUMP LCP2 THERMOCOUPLE (V049-3-603)
23	TE-703A	—	CRYOPUMP LCP3 THERMOCOUPLE (V049-3-701)
24	TE-803A	—	CRYOPUMP LCP4 THERMOCOUPLE (V049-3-801)

*Furnished with accessories.

ATTACHMENT "B"

Number A V049-2-022 Rev Φ

ATTACHMENT "C"

SUBMITTAL LIST

Submit for review the proposed equipment submittals and reports as required under the Specification and listed below:

1. Equipment substitutions (Article 8.3, page 6)

   Submit proposed substitutions to the electrical engineer for acceptance via PSI's representative. With submittal, provide details of necessary changes to accommodate substitutions. Submit samples if requested.

2. List of proposed equipment (Article 9.1, page 6)

   As soon as practicable, submit for review a list of equipment proposed for installation with each item identified by Specification paragraph number or where applicable by Drawing number. Include manufacturer's name with catalog or model number for each item.

3. Cable tray (Article 12.6, page 7)

   Provide product data of each cable tray component.
   Provide shop drawings of fabricated support brackets.
   Provide dimensioned diagrams indicating where expansion joints are proposed.

4. Wire and cable (Article 15.5, page 11)

   Provide product data of each wire and cable.

5. Wiring identification (Article 16.3, page 12)

   Provide product data of printed sleeve markers.

6. Instrument air/gas and process tubing (Article 20.4, page 13)

   Provide product data of tubing and accessories.

7. Testing (Article 23.3.2, page 14)

   Provide written test report listing resistance by feeder and branch circuit.

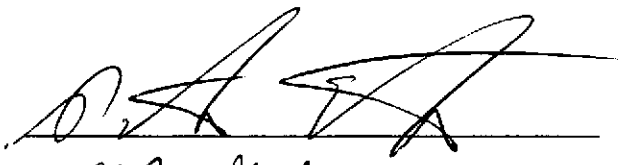
SPECIFICATION FOR

BAKEOUT SYSTEM PERSONNEL COMPUTERS

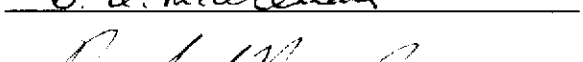
FOR

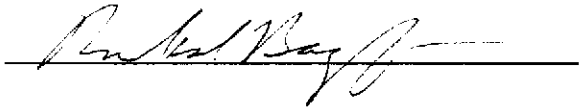
LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: 

QUALITY ASSURANCE: 

TECHNICAL DIRECTOR: 

PROJECT MANAGER: 

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
Ø	APS 1/26/96	DMW	Issued for Purchase DEO #051

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number A V049-2-049	Rev. 0
	APS 1/26/96	DMW 1-26		

Title **SPECIFICATION FOR BAKEOUT SYSTEM PERSONNEL COMPUTERS**

1. Gateway 2000 Personnel Computers with the following :

- Intel 120 Pentium Processor
- 16 MB EDO DRAM
- 256L pipelined burst SRAM cache
- 1.2 GB 11ms EIDE Western Digital HD
- PCI Enhanced IDE interface
- PCI local-bus graphics with 2MB DRAM
- 6X CD-ROM with EIDE interface
- 3.5" 1.44 MB DD
- 17" CrystalScan Monitor
- Slots: (2) 16-bit ISA, (3) 32-bit PCI, (1) PCI/ISA
- Desktop Case
- 104+ Keyboard (NO ANYKEY)
- Microsoft Mouse
- Microsoft NT Workstation 3.51
- Microsoft Office Pro 95
- Gateway Gold Premium Service(3 year on-site)

Number

Rev.

SPECIFICATION

Number A V049-2-049 Rev. Ø

Title: SPECIFICATION FOR BAKEOUT SYSTEM THERMOCOUPLE MEASUREMENT SYSTEM

SPECIFICATION FOR

BAKEOUT SYSTEM THERMOCOUPLE MEASUREMENT SYSTEM

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: [signature]

QUALITY ASSURANCE: [signature]

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: RICHARD BAGLEY

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	PDS 3/12/96	D. McW	Issued for Purchase DEO #0090
0	PDS 1/26/96	D. McW	Issued for Purchase DEO #051

Title	SPECIFICATION FOR BAKEOUT SYSTEM THERMOCOUPLE MEASUREMENT SYSTEM

1. I/O Tech Thermocouple Measurement System As Follows :

   a) (1) TEMPSCAN-1000A
   Hi speed thermocouple measurement Main Chassis

   b) (1) EXP/11A
   10 slot expansion chassis for Tempscan/1000A, includes rackmount kit and CA-35-1 master/slave cable

   c) (6) TEMPTC-32A
   32 Channel T/C Scanning Module for Non-Grounded T/C's

NOTE: 2 year warranty standard

Number

Rev.

SPECIFICATION

Number		Rev.
A	V049-2-050	1

SPECIFICATION FOR

BAKEOUT SYSTEM T/C MEASUREMENT PLC INTERFACE

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: [signature]

QUALITY ASSURANCE: [signature]

TECHNICAL DIRECTOR: [signature]

PROJECT MANAGER: RICHARD BACKUS

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
Ø	PDS 1/26/96	D. McW	ISSUED FOR PURCHASE DEO #0051

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE: PDS 1/26/96	APPROVED DATE: D. McW 1-26-96	Number A V049-2-051	Rev. Ø

Allen-Bradley Plc Interface Modules As Follows :

1. 1771-DMC
   Control Co-Processor Main Module with 256 KBYTE

2. 1771-DRS1
   1 Mega Byte Memory Expansion

Title: SPECIFICATION FOR BAKEOUT PLC/T/C SYSTEM INTERFACE SOFTWARE FUNCTIONALITY BAKEOUT CONTROL SYSTEM

SPECIFICATION FOR

BAKEOUT PLC-T/C SYSTEM INTERFACE SOFTWARE FUNCTIONALITY BAKEOUT CONTROL SYSTEM

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

Job No. V59049

CONTROL:

ELECTRICAL:

PROJECT: D. A. Mueller

PROJECT MANAGER:

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
2	PPS 11/16/96	D Mueller 9-12-96	Issued for Design DFO # 0125
1	PPS 3/12/96	D. Mueller 3/29/96	Issued for Design DFO # 0085
0	PPS 2/21/96	D Mueller 2-21-96	Issued for Design DFO# 069

PROCESS SYSTEMS INTERNATIONAL, INC. | **SPECIFICATION**

INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number	Rev.
	PPS	8/21/96	D. Mueller	2-21-96	V049-2-053	2

SPECIFICATION TABLE OF CONTENTS

1.0 BAKEOUT CO-PROCESSOR T/C SOFTWARE FUNCTIONALITY

The Control Co-Processor software shall request T/C information from the TempScan1000A unit via RS-232 (9600 baud) every X seconds (derived from system variable SP_133). The Co-Processor shall receive this T/C information (192 values), range check-it and send the T/C information, T/C range alarming information and system alarm information/heartbeat to the Bakeout PLC.

The Control Co-Processor Module (Allen-Bradley #1771-DMC) is directly wired to the Bakeout PLC (Allen-Bradley #1785-L30B PLC 5/30) Co-Processor expansion port and shall utilize PLC-5 interface routines called in the C-Code software to directly access any registers in the Bakeout PLC. The PLC-5 interface routines are contained with-in the development software (Allen-Bradley #1771-PCB)

1.1 T/C Value Transfer, Range Checking, Clamping And Alarming

The TempScan1000A shall process a total of 192 T/C values. Expansion capabilities of adding an additional 32 are available (TI-077A/B through TI-092A/B).

1.1.1 Blanket Control T/C's

152 T/C's will be Blanket Control T/C's tagged TI-001A through TI-076A and TI-001B through TI-076B. See Attach-A for a listing.

Each Blanket Control T/C value shall be range checked to verify that it is a correct Type-J T/C value. The T/C range shall be defined as follows (See Attach-A for more details):

a) Blanket Control T/C low range SP_130L (Variable range of 0 to 1200 Deg C)

b) Blanket Control T/C hi range SP_130H (Variable range of 0 to 1200 Deg C)

NOTE: The low and hi range variables are verified by the Co-Processor passing the variable values into indication points.

The low range SP_130L has a verification of SP_130LI.

The hi range SP_130H has a verification of SP_130HI.

Each Blanket Control T/C has a range check alarm point of TA-001A through TA-076A and TA-001B through TA-076B The following shall occur for each Blanket Control T/C range check alarm :

a) T/C falls with-in the low and hi-range the Alarm is OK (bit set to 0)

b) T/C falls out of the low and hi range the Alarm is active (bit set to 1)

This range check is performed each time new T/C information is received from the TempScan1000A and prior to sending T/C values to the Bakeout PLC. See Attach-A for a listing of alarms.

All Blanket Control T/C values transferred to the Bakeout PLC shall be clamped from -32768 to 32767, a valid PLC-5 Integer value.

1.1.2 Auxiliary Systems Control T/C's

32 T/C's will be Auxiliary Systems Control T/C's tagged TI-093A through TI-108A and TI-093B through TI-108B. See Attach-A for a listing.

Each Auxiliary Systems Control T/C value shall be range checked to verify that it is a correct Type-J T/C value. The T/C range shall be defined as follows (See Attach-A for more details):

a) Aux. Sys. Cont. T/C low range SP_130L (Variable range of 0 to 1200 Deg C)

b) Aux. Sys. Cont. T/C hi range SP_130H (Variable range of 0 to 1200 Deg C)

NOTE: The low and hi range Variable are verified by the Co-Processor passing the variable values into indication points.

The low range variable SP_130L has a verification of SP_130LI.

The hi range variable SP_130H has a verification of SP_130HI.

Each Auxiliary Systems Control T/C has a range check alarm point of TA-093A through TA-108A and TA-093B through TA-108B. The following shall occur for each control T/C range check alarm:

a) T/C falls with-in the low and hi-range the Alarm is OK (bit set to 0)

b) T/C falls out of the low and hi-range the Alarm is active (bit set to 1)

This range check is performed each time new T/C information is received from the TempScan1000A and prior to sending T/C values to the Bakeout PLC. See Attach-A for a listing of alarms.

All Auxiliary Systems Control T/C values transferred to the Bakeout PLC shall be clamped from -32768 to 32767, a valid PLC-5 Integer value.

1.1.3 Gauge Control T/C's

8 T/C's will be Auxiliary Systems Control T/C's tagged TI-109A through TI-112A and TI-109B through TI-112B. See Attach-A for a listing.

Each Gauge Control T/C value shall be range checked to verify that it is a correct Type-J T/C value. The T/C range shall be defined as follows (See Attach-A for more details):

a) Gauge Cont. T/C low range SP_131L (Variable range of 0 to 1200 Deg C)

b) Gauge Cont. T/C hi range SP_131H (Variable range of 0 to 1200 Deg C)

NOTE: The low and hi range Set Points are verified by the Co-Processor passing the variable values into indication points.

The low range variable SP_131L has a verification of SP_131LI.

The hi range variable SP_131H has a verification of SP_131HI.

Each Auxiliary Systems Control T/C has a range check alarm point of TA-109A through TA-112A and TA-109B through TA-112B. The following shall occur for each control T/C range check alarm:

a) T/C falls with-in the low and hi-range the Alarm is OK (bit set to 0)

b) T/C falls out of the low and hi-range the Alarm is active (bit set to 1)

This range check is performed each time new T/C information is received from the TempScan1000A and prior to sending T/C values to the Bakeout PLC. See Attach-A for a listing of alarms.

All Auxiliary Systems Control T/C values transferred to the Bakeout PLC shall be clamped from -32768 to 32767, a valid PLC-5 Integer value.

1.2 System Variables, Flags And Alarms

The data transfer interval between the Co-Processor and PLC shall be a variable (SP_133) set from the PLC. It shall be between 10 and 60 seconds. The data transfer rate between the Co-Processor and the TempScan1000A shall be at least half of variable SP_133 (5 to 30 seconds).

NOTE: The data transfer interval variable is verified by the Co-Processor passing the Set Point value into an indication point.

The data transfer interval variable SP_133 has a verification of SP_133I.

The Co-Processor software shall set the heartbeat flag to a 1 after complete T/C and alarm information has been sent to the Bakeout PLC. This flag will not be set until all information has been passed to the Bakeout PLC. This flag will used by the PLC to process information and be reset to a 0 when complete. This flag will also be used by the PLC as a communication alarm between the Co-Processor and PLC. An alarm will be set in the PLC if the heartbeat flag is not set by the Co-Processor every X seconds.

See Attach-A for details of XI_134.

The Co-Processor software shall check the data integrity of the T/C information received from the TempScan1000A. The following shall occur for the Data Integrity Signal (XI_135):

a) Data Integrity is OK, set XI_135 to 0

b) Data Integrity is BAD, set XI_135 to 1

See Attach-A for details of XI_135. An alarm will be set in the PLC if XI_135 is set.

The Co-Processor software shall check the RS-232 communication between the TempScan1000A and the Co-Processor. The following shall occur for the Communication Signal (XI_136):

a) Communication is OK, set XI_136 to 0

b) Communication is BAD, set XI_136 to 1

See Attach-A for details of XI_136. An alarm will be set in the PLC if XI_136 is set.

2.0 SOFTWARE COMMUNICATION AND PROGRAM FAILURE PROTOCOL

The Co-Processor software shall start-up immediately upon power-up of the Co-Processor module, and continue to operate until power is removed.

The software shall continue to operate in the event of loss of communication to either the TempScan1000A RS-232 network or the Bakeout PLC. If communication to either or both is lost the software shall continue to operate but not communicate to the lost node. When RS-232 communications has been re-established or the Bakeout PLC is back On-Line, the software should detect this and re-establish communications to the node.

2.1 Documentation And Source Code Requirements

Three (3) copies of the Co-Processor software source code shall provided on 3 1/2" DS HD (MS-DOS based) Disks.

Three (3) hard copy print-outs of the source code shall be provided.

The source code shall be fully documented with explanations of functionality and linkages through-out the source code to make the source code fully understandable and easy to follow.

V049-2-053 Attachment-A REV. 2		LIGO BAKEOUT SYSTEM PLC- T/C REGISTER LISTING (under "TAG STAT" ** indicates change in tag information)	RANGE SETTINGS			PLC LOCATION	
			LOW RANGE	HIGH RANGE	UNITS		
SYMBOL NAME	TAG STAT	SERVICE DESCRIPTION	OFF-IND.	ON-IND.		DEVICE	ADDRESS
		ABCDEFGHIJABCDEFGHIJABCDEFGHIJABCDEFGHIJ - 40 CHARS	ABCDEFG	ABCDEFG	ABCDEFG		
TI	001A	HEATER-001 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:001
TI	002A	HEATER-002 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:002
TI	003A	HEATER-003 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:003
TI	004A	HEATER-004 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:004
TI	005A	HEATER-005 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:005
TI	006A	HEATER-006 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:006
TI	007A	HEATER-007 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:007
TI	008A	HEATER-008 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:008
TI	009A	HEATER-009 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:009
TI	010A	HEATER-010 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:010
TI	011A	HEATER-011 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:011
TI	012A	HEATER-012 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:012
TI	013A	HEATER-013 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:013
TI	014A	HEATER-014 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:014
TI	015A	HEATER-015 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:015
TI	016A	HEATER-016 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:016
TI	017A	HEATER-017 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:017
TI	018A	HEATER-018 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:018
TI	019A	HEATER-019 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:019
TI	020A	HEATER-020 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:020
TI	021A	HEATER-021 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:021
TI	022A	HEATER-022 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:022
TI	023A	HEATER-023 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:023
TI	024A	HEATER-024 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:024
TI	025A	HEATER-025 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:025
TI	026A	HEATER-026 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:026
TI	027A	HEATER-027 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:027
TI	028A	HEATER-028 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:028
TI	029A	HEATER-029 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:029
TI	030A	HEATER-030 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:030
TI	031A	HEATER-031 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:031
TI	032A	HEATER-032 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:032
TI	033A	HEATER-033 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:033
TI	034A	HEATER-034 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:034
TI	035A	HEATER-035 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:035
TI	036A	HEATER-036 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:036
TI	037A	HEATER-037 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:037
TI	038A	HEATER-038 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:038
TI	039A	HEATER-039 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:039

V049-2-053 Attachment-A REV. 2		LIGO BAKEOUT SYSTEM PLC- T/C REGISTER LISTING (under "TAG STAT" ** indicates change in tag information)	RANGE SETTINGS			PLC LOCATION	
			LOW RANGE	HIGH RANGE	UNITS	DEVICE	ADDRESS
SYMBOL NAME	TAG STAT	SERVICE DESCRIPTION	OFF-IND.	ON-IND.			
		ABCDEFGHIJABCDEFGHIJABCDEFGHIJABCDEFGHIJ - 40 CHARS	ABCDEFG	ABCDEFG	ABCDEFG		
TI	040A		HEATER-040 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:040
TI	041A		HEATER-041 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:041
TI	042A		HEATER-042 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:042
TI	043A		HEATER-043 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:043
TI	044A		HEATER-044 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:044
TI	045A		HEATER-045 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:045
TI	046A		HEATER-046 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:046
TI	047A		HEATER-047 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:047
TI	048A		HEATER-048 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:048
TI	049A		HEATER-049 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:049
TI	050A		HEATER-050 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:050
TI	051A		HEATER-051 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:051
TI	052A		HEATER-052 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:052
TI	053A		HEATER-053 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:053
TI	054A		HEATER-054 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:054
TI	055A		HEATER-055 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:055
TI	056A		HEATER-056 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:056
TI	057A		HEATER-057 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:057
TI	058A		HEATER-058 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:058
TI	059A		HEATER-059 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:059
TI	060A		HEATER-060 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:060
TI	061A		HEATER-061 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:061
TI	062A		HEATER-062 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:062
TI	063A		HEATER-063 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:063
TI	064A		HEATER-064 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:064
TI	065A		HEATER-065 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:065
TI	066A		HEATER-066 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:066
TI	067A		HEATER-067 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:067
TI	068A		HEATER-068 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:068
TI	069A		HEATER-069 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:069
TI	070A		HEATER-070 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:070
TI	071A		HEATER-071 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:071
TI	072A		HEATER-072 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:072
TI	073A		HEATER-073 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:073
TI	074A		HEATER-074 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:074
TI	075A		HEATER-075 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:075
TI	076A		HEATER-076 CHAMBER BLANKET T/C-A	-32768	32767	Deg C	01	N12:076
TI	093A		HEATER-093 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:093
TI	094A		HEATER-094 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:094

V049-2-053 Attachment-A REV. 2		LIGO BAKEOUT SYSTEM PLC- T/C REGISTER LISTING (under "TAG STAT" ** indicates change in tag information)	RANGE SETTINGS			PLC LOCATION	
			LOW RANGE	HIGH RANGE	UNITS		
SYMBOL NAME	TAG STAT	SERVICE DESCRIPTION	OFF-IND.	ON-IND.		DEVICE	ADDRESS
		ABCDEFGHIJABCDEFGHIJABCDEFGHIJABCDEFGHIJ - 40 CHARS	ABCDEFG	ABCDEFG	ABCDEFG		
TI	095A		HEATER-095 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:095
TI	096A		HEATER-096 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:096
TI	097A		HEATER-097 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:097
TI	098A		HEATER-098 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:098
TI	099A		HEATER-099 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:099
TI	100A		HEATER-100 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:100
TI	101A		HEATER-101 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:101
TI	102A		HEATER-102 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:102
TI	103A		HEATER-103 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:103
TI	104A		HEATER-104 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:104
TI	105A		HEATER-105 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:105
TI	106A		HEATER-106 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:106
TI	107A		HEATER-107 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:107
TI	108A		HEATER-108 AUX. BLANKET T/C-A	-32768	32767	Deg C	01	N12:108
TI	109A		HEATER-109 GAUGE BLANKET T/C-A	-32768	32767	Deg C	01	N12:109
TI	110A		HEATER-110 GAUGE BLANKET T/C-A	-32768	32767	Deg C	01	N12:110
TI	111A		HEATER-111 GAUGE BLANKET T/C-A	-32768	32767	Deg C	01	N12:111
TI	112A		HEATER-112 GAUGE BLANKET T/C-A	-32768	32767	Deg C	01	N12:112
TI	001B		HEATER-001 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:001
TI	002B		HEATER-002 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:002
TI	003B		HEATER-003 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:003
TI	004B		HEATER-004 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:004
TI	005B		HEATER-005 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:005
TI	006B		HEATER-006 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:006
TI	007B		HEATER-007 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:007
TI	008B		HEATER-008 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:008
TI	009B		HEATER-009 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:009
TI	010B		HEATER-010 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:010
TI	011B		HEATER-011 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:011
TI	012B		HEATER-012 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:012
TI	013B		HEATER-013 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:013
TI	014B		HEATER-014 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:014
TI	015B		HEATER-015 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:015
TI	016B		HEATER-016 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:016
TI	017B		HEATER-017 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:017
TI	018B		HEATER-018 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:018
TI	019B		HEATER-019 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:019
TI	020B		HEATER-020 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:020

V049-2-053 Attachment-A REV. 2		LIGO BAKEOUT SYSTEM PLC- T/C REGISTER LISTING (under "TAG STAT" ** indicates change in tag information)	RANGE SETTINGS			PLC LOCATION	
			LOW RANGE	HIGH RANGE	UNITS		
SYMBOL NAME	TAG STAT	SERVICE DESCRIPTION	OFF-IND.	ON-IND.		DEVICE	ADDRESS
		ABCDEFGHIJABCDEFGHIJABCDEFGHIJABCDEFGHIJ - 40 CHARS	ABCDEFG	ABCDEFG	ABCDEFG		
TI	021B	HEATER-021 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:021
TI	022B	HEATER-022 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:022
TI	023B	HEATER-023 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:023
TI	024B	HEATER-024 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:024
TI	025B	HEATER-025 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:025
TI	026B	HEATER-026 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:026
TI	027B	HEATER-027 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:027
TI	028B	HEATER-028 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:028
TI	029B	HEATER-029 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:029
TI	030B	HEATER-030 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:030
TI	031B	HEATER-031 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:031
TI	032B	HEATER-032 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:032
TI	033B	HEATER-033 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:033
TI	034B	HEATER-034 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:034
TI	035B	HEATER-035 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:035
TI	036B	HEATER-036 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:036
TI	037B	HEATER-037 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:037
TI	038B	HEATER-038 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:038
TI	039B	HEATER-039 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:039
TI	040B	HEATER-040 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:040
TI	041B	HEATER-041 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:041
TI	042B	HEATER-042 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:042
TI	043B	HEATER-043 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:043
TI	044B	HEATER-044 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:044
TI	045B	HEATER-045 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:045
TI	046B	HEATER-046 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:046
TI	047B	HEATER-047 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:047
TI	048B	HEATER-048 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:048
TI	049B	HEATER-049 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:049
TI	050B	HEATER-050 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:050
TI	051B	HEATER-051 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:051
TI	052B	HEATER-052 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:052
TI	053B	HEATER-053 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:053
TI	054B	HEATER-054 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:054
TI	055B	HEATER-055 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:055
TI	056B	HEATER-056 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:056
TI	057B	HEATER-057 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:057
TI	058B	HEATER-058 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:058
TI	059B	HEATER-059 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:059

V049-2-053 Attachment-A REV. 2		LIGO BAKEOUT SYSTEM PLC- T/C REGISTER LISTING (under "TAG STAT" ** indicates change in tag information)	RANGE SETTINGS			PLC LOCATION	
			LOW RANGE	HIGH RANGE	UNITS		
SYMBOL NAME	TAG STAT	SERVICE DESCRIPTION	OFF-IND.	ON-IND.		DEVICE	ADDRESS
		ABCDEFGHIJABCDEFGHIJABCDEFGHIJABCDEFGHIJ - 40 CHARS	ABCDEFG	ABCDEFG	ABCDEFG		
TI 060B		HEATER-060 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:060
TI 061B		HEATER-061 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:061
TI 062B		HEATER-062 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:062
TI 063B		HEATER-063 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:063
TI 064B		HEATER-064 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:064
TI 065B		HEATER-065 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:065
TI 066B		HEATER-066 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:066
TI 067B		HEATER-067 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:067
TI 068B		HEATER-068 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:068
TI 069B		HEATER-069 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:069
TI 070B		HEATER-070 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:070
TI 071B		HEATER-071 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:071
TI 072B		HEATER-072 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:072
TI 073B		HEATER-073 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:073
TI 074B		HEATER-074 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:074
TI 075B		HEATER-075 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:075
TI 076B		HEATER-076 CHAMBER BLANKET T/C-B	-32768	32767	Deg C	01	N13:076
TI 093B		HEATER-093 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:093
TI 094B		HEATER-094 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:094
TI 095B		HEATER-095 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:095
TI 096B		HEATER-096 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:096
TI 097B		HEATER-097 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:097
TI 098B		HEATER-098 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:098
TI 099B		HEATER-099 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:099
TI 100B		HEATER-100 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:100
TI 101B		HEATER-101 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:101
TI 102B		HEATER-102 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:102
TI 103B		HEATER-103 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:103
TI 104B		HEATER-104 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:104
TI 105B		HEATER-105 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:105
TI 106B		HEATER-106 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:106
TI 107B		HEATER-107 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:107
TI 108B		HEATER-108 AUX. BLANKET T/C-B	-32768	32767	Deg C	01	N13:108
TI 109B		HEATER-109 GAUGE BLANKET T/C-B	-32768	32767	Deg C	01	N13:109
TI 110B		HEATER-110 GAUGE BLANKET T/C-B	-32768	32767	Deg C	01	N13:110
TI 111B		HEATER-111 GAUGE BLANKET T/C-B	-32768	32767	Deg C	01	N13:111
TI 112B		HEATER-112 GAUGE BLANKET T/C-B	-32768	32767	Deg C	01	N13:112
SP 130H		HEATER 1 THRU 108 T/C-A/B HIGH RANGE SP	0	1200	Deg C	01	N15:000

V049-2-053 Attachment-A REV. 2		LIGO BAKEOUT SYSTEM PLC- T/C REGISTER LISTING (under "TAG STAT" ** indicates change in tag information)	RANGE SETTINGS			PLC LOCATION	
SYMBOL NAME	TAG STAT	SERVICE DESCRIPTION	LOW RANGE OFF-IND.	HIGH RANGE ON-IND.	UNITS	DEVICE	ADDRESS
		ABCDEFGHIJABCDEFGHIJABCDEFGHIJABCDEFGHIJ - 40 CHARS	ABCDEFG	ABCDEFG	ABCDEFG		
SP	130HI	HEATER 1 THRU 108 T/C-A/B HIGH RANGE SP IND.	0	1200	Deg C	01	N15:001
SP	130L	HEATER 1 THRU 108 T/C-A/B LOW RANGE SP	0	1200	Deg C	01	N15:002
SP	130LI	HEATER 1 THRU 108 T/C-A/B LOW RANGE SP IND.	0	1200	Deg C	01	N15:003
SP	131H	HEATER 108 THRU 112 T/C-A/B HIGH RANGE SP	0	1200	Deg C	01	N15:004
SP	131HI	HEATER 108 THRU 112 T/C-A/B HIGH RANGE SP IND.	0	1200	Deg C	01	N15:005
SP	131L	HEATER 108 THRU 112 T/C-A/B LOW RANGE SP	0	1200	Deg C	01	N15:006
SP	131LI	HEATER 108 THRU 112 T/C-B LOW RANGE SP IND.	0	1200	Deg C	01	N15:007
SP	133	DATA TRANSFER TIME INTERVAL SP	10	60	SECS	01	N15:008
SP	133I	DATA TRANSFER TIME INTERVAL SP IND.	10	60	SECS	01	N15:009
XI	134	PLC-COPRO COMMUNICATION HEARTBEAT	HEARTBEAT	---	---	01	N15:010/00
XI	135	OMEGA-COPRO DATA INTEGRITY ALARM	OK	ALARM	---	01	N15:010/01
XI	136	OMEGA-COPRO COMMUNICATION ALARM	OK	ALARM	---	01	N15:010/02
XA	137	COPRO ERROR CODE	0	100	---	01	N15:011
XA	138	COPRO ERROR LOCATION	0	100	---	01	N15:012
TRS	001A	** HEATER-001 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:001/00
TRS	002A	** HEATER-002 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:002/00
TRS	003A	** HEATER-003 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:003/00
TRS	004A	** HEATER-004 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:004/00
TRS	005A	** HEATER-005 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:005/00
TRS	006A	** HEATER-006 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:006/00
TRS	007A	** HEATER-007 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:007/00
TRS	008A	** HEATER-008 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:008/00
TRS	009A	** HEATER-009 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:009/00
TRS	010A	** HEATER-010 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:010/00
TRS	011A	** HEATER-011 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:011/00
TRS	012A	** HEATER-012 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:012/00
TRS	013A	** HEATER-013 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:013/00
TRS	014A	** HEATER-014 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:014/00
TRS	015A	** HEATER-015 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:015/00
TRS	016A	** HEATER-016 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:016/00
TRS	017A	** HEATER-017 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:017/00
TRS	018A	** HEATER-018 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:018/00
TRS	019A	** HEATER-019 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:019/00
TRS	020A	** HEATER-020 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:020/00
TRS	021A	** HEATER-021 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:021/00
TRS	022A	** HEATER-022 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:022/00
TRS	023A	** HEATER-023 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:023/00
TRS	024A	** HEATER-024 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:024/00

V049-2-053 Attachment-A REV. 2		LIGO BAKEOUT SYSTEM PLC- T/C REGISTER LISTING (under "TAG STAT" ** indicates change in tag information)	RANGE SETTINGS			PLC LOCATION	
			LOW RANGE	HIGH RANGE	UNITS		
SYMBOL NAME	TAG STAT	SERVICE DESCRIPTION	OFF-IND.	ON-IND.		DEVICE	ADDRESS
		ABCDEFGHIJABCDEFGHIJABCDEFGHIJABCDEFGHIJ - 40 CHARS	ABCDEFG	ABCDEFG	ABCDEFG		
TRS 025A	**	HEATER-025 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:025/00
TRS 026A	**	HEATER-026 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:026/00
TRS 027A	**	HEATER-027 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:027/00
TRS 028A	**	HEATER-028 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:028/00
TRS 029A	**	HEATER-029 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:029/00
TRS 030A	**	HEATER-030 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:030/00
TRS 031A	**	HEATER-031 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:031/00
TRS 032A	**	HEATER-032 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:032/00
TRS 033A	**	HEATER-033 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:033/00
TRS 034A	**	HEATER-034 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:034/00
TRS 035A	**	HEATER-035 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:035/00
TRS 036A	**	HEATER-036 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:036/00
TRS 037A	**	HEATER-037 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:037/00
TRS 038A	**	HEATER-038 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:038/00
TRS 039A	**	HEATER-039 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:039/00
TRS 040A	**	HEATER-040 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:040/00
TRS 041A	**	HEATER-041 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:041/00
TRS 042A	**	HEATER-042 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:042/00
TRS 043A	**	HEATER-043 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:043/00
TRS 044A	**	HEATER-044 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:044/00
TRS 045A	**	HEATER-045 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:045/00
TRS 046A	**	HEATER-046 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:046/00
TRS 047A	**	HEATER-047 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:047/00
TRS 048A	**	HEATER-048 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:048/00
TRS 049A	**	HEATER-049 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:049/00
TRS 050A	**	HEATER-050 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:050/00
TRS 051A	**	HEATER-051 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:051/00
TRS 052A	**	HEATER-052 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:052/00
TRS 053A	**	HEATER-053 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:053/00
TRS 054A	**	HEATER-054 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:054/00
TRS 055A	**	HEATER-055 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:055/00
TRS 056A	**	HEATER-056 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:056/00
TRS 057A	**	HEATER-057 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:057/00
TRS 058A	**	HEATER-058 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:058/00
TRS 059A	**	HEATER-059 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:059/00
TRS 060A	**	HEATER-060 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:060/00
TRS 061A	**	HEATER-061 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:061/00
TRS 062A	**	HEATER-062 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:062/00
TRS 063A	**	HEATER-063 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:063/00

V049-2-053 Attachment-A REV. 2		LIGO BAKEOUT SYSTEM PLC- T/C REGISTER LISTING (under "TAG STAT" ** indicates change in tag information)	RANGE SETTINGS			PLC LOCATION	
			LOW RANGE	HIGH RANGE	UNITS		
SYMBOL NAME	TAG STAT	SERVICE DESCRIPTION	OFF-IND.	ON-IND.		DEVICE	ADDRESS
		ABCDEFGHIJABCDEFGHIJABCDEFGHIJABCDEFGHIJ - 40 CHARS	ABCDEFG	ABCDEFG	ABCDEFG		
TRS 064A	**	HEATER-064 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:064/00
TRS 065A	**	HEATER-065 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:065/00
TRS 066A	**	HEATER-066 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:066/00
TRS 067A	**	HEATER-067 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:067/00
TRS 068A	**	HEATER-068 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:068/00
TRS 069A	**	HEATER-069 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:069/00
TRS 070A	**	HEATER-070 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:070/00
TRS 071A	**	HEATER-071 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:071/00
TRS 072A	**	HEATER-072 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:072/00
TRS 073A	**	HEATER-073 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:073/00
TRS 074A	**	HEATER-074 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:074/00
TRS 075A	**	HEATER-075 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:075/00
TRS 076A	**	HEATER-076 CHAMBER BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:076/00
TRS 093A	**	HEATER-093 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:093/00
TRS 094A	**	HEATER-094 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:094/00
TRS 095A	**	HEATER-095 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:095/00
TRS 096A	**	HEATER-096 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:096/00
TRS 097A	**	HEATER-097 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:097/00
TRS 098A	**	HEATER-098 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:098/00
TRS 099A	**	HEATER-099 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:099/00
TRS 100A	**	HEATER-100 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:100/00
TRS 101A	**	HEATER-101 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:101/00
TRS 102A	**	HEATER-102 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:102/00
TRS 103A	**	HEATER-103 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:103/00
TRS 104A	**	HEATER-104 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:104/00
TRS 105A	**	HEATER-105 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:105/00
TRS 106A	**	HEATER-106 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:106/00
TRS 107A	**	HEATER-107 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:107/00
TRS 108A	**	HEATER-108 AUX. BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:108/00
TRS 109A	**	HEATER-109 GAUGE BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:109/00
TRS 110A	**	HEATER-110 GAUGE BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:110/00
TRS 111A	**	HEATER-111 GAUGE BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:111/00
TRS 112A	**	HEATER-112 GAUGE BLANKET T/C-A RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:112/00
TRS 001B	**	HEATER-001 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:001/01
TRS 002B	**	HEATER-002 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:002/01
TRS 003B	**	HEATER-003 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:003/01
TRS 004B	**	HEATER-004 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:004/01
TRS 005B	**	HEATER-005 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:005/01

V049-2-053 Attachment-A REV. 2		LIGO BAKEOUT SYSTEM PLC- T/C REGISTER LISTING (under "TAG STAT" ** indicates change in tag information)	RANGE SETTINGS			PLC LOCATION	
			LOW RANGE	HIGH RANGE	UNITS		
SYMBOL NAME	TAG STAT	SERVICE DESCRIPTION	OFF-IND.	ON-IND.		DEVICE	ADDRESS
		ABCDEFGHIJABCDEFGHIJABCDEFGHIJABCDEFGHIJ - 40 CHARS	ABCDEFG	ABCDEFG	ABCDEFG		
TRS 006B	**	HEATER-006 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:006/01
TRS 007B	**	HEATER-007 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:007/01
TRS 008B	**	HEATER-008 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:008/01
TRS 009B	**	HEATER-009 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:009/01
TRS 010B	**	HEATER-010 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:010/01
TRS 011B	**	HEATER-011 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:011/01
TRS 012B	**	HEATER-012 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:012/01
TRS 013B	**	HEATER-013 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:013/01
TRS 014B	**	HEATER-014 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:014/01
TRS 015B	**	HEATER-015 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:015/01
TRS 016B	**	HEATER-016 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:016/01
TRS 017B	**	HEATER-017 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:017/01
TRS 018B	**	HEATER-018 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:018/01
TRS 019B	**	HEATER-019 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:019/01
TRS 020B	**	HEATER-020 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:020/01
TRS 021B	**	HEATER-021 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:021/01
TRS 022B	**	HEATER-022 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:022/01
TRS 023B	**	HEATER-023 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:023/01
TRS 024B	**	HEATER-024 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:024/01
TRS 025B	**	HEATER-025 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:025/01
TRS 026B	**	HEATER-026 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:026/01
TRS 027B	**	HEATER-027 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:027/01
TRS 028B	**	HEATER-028 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:028/01
TRS 029B	**	HEATER-029 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:029/01
TRS 030B	**	HEATER-030 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:030/01
TRS 031B	**	HEATER-031 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:031/01
TRS 032B	**	HEATER-032 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:032/01
TRS 033B	**	HEATER-033 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:033/01
TRS 034B	**	HEATER-034 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:034/01
TRS 035B	**	HEATER-035 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:035/01
TRS 036B	**	HEATER-036 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:036/01
TRS 037B	**	HEATER-037 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:037/01
TRS 038B	**	HEATER-038 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:038/01
TRS 039B	**	HEATER-039 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:039/01
TRS 040B	**	HEATER-040 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:040/01
TRS 041B	**	HEATER-041 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:041/01
TRS 042B	**	HEATER-042 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:042/01
TRS 043B	**	HEATER-043 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:043/01
TRS 044B	**	HEATER-044 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:044/01

V049-2-053 Attachment-A REV. 2		LIGO BAKEOUT SYSTEM PLC- T/C REGISTER LISTING (under "TAG STAT" ** indicates change in tag information)	RANGE SETTINGS			PLC LOCATION	
			LOW RANGE	HIGH RANGE	UNITS	DEVICE	ADDRESS
SYMBOL NAME	TAG STAT	SERVICE DESCRIPTION	OFF-IND.	ON-IND.			
		ABCDEFGHIJABCDEFGHIJABCDEFGHIJABCDEFGHIJ - 40 CHARS	ABCDEFG	ABCDEFG	ABCDEFG		
TRS 045B	**	HEATER-045 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:045/01
TRS 046B	**	HEATER-046 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:046/01
TRS 047B	**	HEATER-047 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:047/01
TRS 048B	**	HEATER-048 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:048/01
TRS 049B	**	HEATER-049 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:049/01
TRS 050B	**	HEATER-050 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:050/01
TRS 051B	**	HEATER-051 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:051/01
TRS 052B	**	HEATER-052 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:052/01
TRS 053B	**	HEATER-053 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:053/01
TRS 054B	**	HEATER-054 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:054/01
TRS 055B	**	HEATER-055 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:055/01
TRS 056B	**	HEATER-056 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:056/01
TRS 057B	**	HEATER-057 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:057/01
TRS 058B	**	HEATER-058 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:058/01
TRS 059B	**	HEATER-059 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:059/01
TRS 060B	**	HEATER-060 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:060/01
TRS 061B	**	HEATER-061 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:061/01
TRS 062B	**	HEATER-062 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:062/01
TRS 063B	**	HEATER-063 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:063/01
TRS 064B	**	HEATER-064 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:064/01
TRS 065B	**	HEATER-065 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:065/01
TRS 066B	**	HEATER-066 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:066/01
TRS 067B	**	HEATER-067 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:067/01
TRS 068B	**	HEATER-068 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:068/01
TRS 069B	**	HEATER-069 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:069/01
TRS 070B	**	HEATER-070 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:070/01
TRS 071B	**	HEATER-071 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:071/01
TRS 072B	**	HEATER-072 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:072/01
TRS 073B	**	HEATER-073 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:073/01
TRS 074B	**	HEATER-074 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:074/01
TRS 075B	**	HEATER-075 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:075/01
TRS 076B	**	HEATER-076 CHAMBER BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:076/01
TRS 093B	**	HEATER-093 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:093/01
TRS 094B	**	HEATER-094 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:094/01
TRS 095B	**	HEATER-095 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:095/01
TRS 096B	**	HEATER-096 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:096/01
TRS 097B	**	HEATER-097 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:097/01
TRS 098B	**	HEATER-098 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:098/01
TRS 099B	**	HEATER-099 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:099/01

V049-2-053 Attachment-A REV. 2		LIGO BAKEOUT SYSTEM PLC- T/C REGISTER LISTING (under "TAG STAT" ** indicates change in tag information)	RANGE SETTINGS			PLC LOCATION	
			LOW RANGE	HIGH RANGE	UNITS		
SYMBOL NAME	TAG STAT	SERVICE DESCRIPTION	OFF-IND.	ON-IND.		DEVICE	ADDRESS
		ABCDEFGHIJABCDEFGHIJABCDEFGHIJABCDEFGHIJ - 40 CHARS	ABCDEFG	ABCDEFG	ABCDEFG		
TRS 100B	**	HEATER-100 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:100/01
TRS 101B	**	HEATER-101 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:101/01
TRS 102B	**	HEATER-102 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:102/01
TRS 103B	**	HEATER-103 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:103/01
TRS 104B	**	HEATER-104 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:104/01
TRS 105B	**	HEATER-105 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:105/01
TRS 106B	**	HEATER-106 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:106/01
TRS 107B	**	HEATER-107 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:107/01
TRS 108B	**	HEATER-108 AUX. BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:108/01
TRS 109B	**	HEATER-109 GAUGE BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:109/01
TRS 110B	**	HEATER-110 GAUGE BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:110/01
TRS 111B	**	HEATER-111 GAUGE BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:111/01
TRS 112B	**	HEATER-112 GAUGE BLANKET T/C-B RANGE STATUS	OK	OUT-OF RANGE	---	01	N23:112/01

Title: SPECIFICATION FOR BAKEOUT SYSTEM PC - ALLEN BRADLEY PLC INTERFACE MODULE FOR LIGO

SPECIFICATION FOR

BAKEOUT SYSTEM PC - ALLEN BRADLEY PLC INTERFACE

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

I/C:

ELECTRICAL:

MANAGER: D A McWilliams

PROJECT MANAGER:

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
Ø	PPS 2/21/96	D M McW 2-21-96	Issued for Purchase DEO # 66

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE PPS 2/21/96	APPROVED DATE D McW 2-21-96	Number **V049-2-057**	Rev. 0

Title	SPECIFICATION FOR BAKEOUT SYSTEM PC - ALLEN BRADLEY PLC INTERFACE MODULE FOR LIGO

PC - Allen Bradley PLC Interface Module as Follows:

1. 1784 - KTX

   DH+, DH-485, REM I/O Interface Module

Number	Rev.

SPECIFICATION	
Number A V049-2-057	Rev.

Title: SPECIFICATION FOR BAKEOUT SYSTEM PC - INTERFACE SOFTWARE FOR LIGO

SPECIFICATION FOR

BAKEOUT SYSTEM PC - INTERFACE SOFTWARE

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

I/C:

ELECTRICAL:

DIRECTOR:

PROJECT MANAGER:

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
Ø			Issued for Purchase DEO# 0069

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number V049-2-058	Rev. Ø
	PPS	2/22/96	BEB	2/24/96		

PC - Interface Software running on Windows NT as follows:

A. Full Function Runtime SCADA node including:

- i. Distributed Networking
- ii. SCADA
- iii. Object Graphics
- iv. Historical Trending/Collection
- v. DDE Client/Server
- vi. Excel Macros
- vii. Batch Blocks

B. ABK I/O driver

C. Cyberlogic NT driver

Title:	SPECIFICATION FOR PITOT TUBE

SPECIFICATION

FOR

PITOT TUBE

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY Thomas Murphy

ELECTRICAL F. Bath

QUALITY ASSURANCE Allan L Bradbrook

TECHNICAL DIRECTOR D. C. McWilliams

PROJECT MANAGER Richard Bayer

REV LTR	BY—DATE	APP.—DATE	DESCRIPTION OF ACTION
O	TM. 5-2-96	F. Bath 5-2-96	RELEASED FOR FDR PER DEO # 156

PROCESS SYSTEMS INTERNATIONAL, INC				SPECIFICATION	
INITIAL APPROVALS	PREPARED BY	DATE	APPROVED BY	DATE	Number / Rev
	T. Murphy	5-2-96	F. Bath	5-2-96	A V049-2-079 / O

TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of instrumentation for the LIGO vacuum system.

The following specifications refer to the Buyer - Process Systems International (PSI), the Owner - California Institute of technology in partnership with Massachusetts Institute of Technology, under a grant from the National Science Foundation, and Vendor/Seller. The Vendor/Seller is the successful system bidder.

The Vendor shall be responsible for updating any and all references to codes and other standards to reflect the requirements of the latest editions in effect on date of purchase order except as noted.

All attachments are incorporated herein by reference and made a part of this specification.

2.0 CODES AND STANDARDS

2.1 Priority of Codes and Standards

1. Codes
2. Standards
3. Data Sheets
4. This Specification

2.2 All conflicts shall be brought to the attention of PSI for a written resolution prior to award of a purchase order. If more than one document applies to a technical requirement, the more stringent requirement shall have precedence.

2.3 The assembly shall comply with applicable parts of latest editions of publications by the following organizations:

American National Standards Institute, Inc. (ANSI)

Code of Federal Regulations (CFR) Title 47, Part 15

Electrical Standards for Industrial Machinery (NFPA 79) unless otherwise indicated

Factory Mutual (FM)

Federal Communications Commission (FCC) Part 15

Institute of Electrical and Electronics Engineers (IEEE)

Insulated Cable Engineers Association (ICEA)

National Electric Code (NFPA 70)

National Electrical Manufacturers Association (NEMA)

Underwriter's Laboratories (UL) or equipment and installation standards by other nationally recognized testing companies

3..0 GENERAL REQUIREMENTS

3.1 The overall process and mechanical requirements for this specific application are given in data sheets attached to this specification.

3.2 The equipment shall be designed for a minimum serviceable life of 20 years.

3.3 Vendor shall specify all bolt torque requirements in the equipment operating and maintenance manual.

3.4 Instrumentation shall be of industrial quality and shall be subject to the acceptance of the Buyer.

3.5 External carbon steel surfaces shall be cleaned and painted. The Vendor's standard is acceptable if it meets specification requirements and is compatible with federal standard 209 class 50,000.

4.0 MARKING

Plates are to be stamped to show the following information:

a. Manufacturer's name, catalog number
b. Serial number
c. Adjustable range
d. Maximum working pressure
e. Set range
f. Output signal
g. Tag number (as listed on attached data sheet)
h. Tags may be permanently attached or attached with a stainless steel wire.

5.0 RESPONSIBILITY

The Seller shall be completely responsible that the equipment and/or material furnished under this specification is of high quality in every respect, with first-class workmanship throughout and entirely suitable for the purpose outlined herein or reasonably inferred therefrom. Therefore, if any requirement of this specification is deemed by the Vendor/Seller to be unacceptable or technically incorrect, he shall specifically delineate his objections and the reasons therefore in his proposal so that they may be resolved before the order is placed. In all respects, the Seller, by accepting the order, shall be deemed to have agreed that conformance with the requirements of the specification will not prejudice in any way the Buyer's right under warranty.

6.0 REQUIRED DOCUMENTATION

Vendor shall furnish documentation in accordance with specific inquiry, requisition and purchase order requirements. All Vendor documents shall bear the purchase order number and PSI's equipment tag number. The following is a list of minimum documentation required:

5.1 MECHANICAL DATA REQUIREMENTS

Outline dimension drawings and weight.

5.2 MANUALS

Five (5) copies of operational/maintenance manuals.

5.3 TEST REPORTS

Calibration report.

7.0 INSPECTION

The responsibility for inspection rests with the manufacturer; however, the Buyer, Owner, Government, and Owner representatives reserve the right to conduct a non-escort inspection of equipment at any time during fabrication to assure that the materials and workmanship are in accordance with this specification. This will include access to fabrication, assembly, cleaning and testing areas for the purpose of monitoring activities.

8.0 PREPARATION FOR SHIPMENT

8.1 Items shall be completely drained and dried.

8.2 Bolted connections shall be made up before shipment.

8.3 Aluminum plate shipping covers shall be attached with bolts to flanged connections, and with suitable attachments to other connections.

8.4 Units shall be completely covered for protection against the ambient and weather conditions expected during transportation. Units shall be adequately protected for unsheltered storage at the sites.

8.5 The Vendor shall have a signed "Release for Shipment" form provided by the Buyer's Quality Assurance representative prior to full or partial shipment of product.

8.6 Shipping crates shall have the Buyer's purchase order number, Vendor's name and list of tag numbers or part numbers on the outside of each crate.

ATTACHMENT "A"
LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: PITOT TUBE	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-079

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: / Date:
MILESTONE SCHEDULE							
VENDOR Q.A. PLAN							
PREP FOR SHIPMENT PROCEDURE							
ASSEMBLY DRAWINGS							
DESIGN REVIEW							
IN-PROCESS INSPECTIONS						Prior to release for fabrication.	
OPERATION & MAINTENANCE MANUALS				5			
SHOP TEST PLAN						Prior to release for fabrication.	
SHOP TEST (WITH REPORT)						Prior to release for shipment.	

ATTACHMENT B

INSTRUMENT DATA SHEET **LIGO**

FLOW ELEMENTS (PITOT TUBE) **V049-2-079, Rev 0**

TAG NUMBER		FE-104	FE-154	FE-204	FE-254
FLOW SHEET NO.		V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER		1127	1130	242	245
SERVICE		NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID		GAS	GAS	GAS	GAS
OPERATING PRESSURE	PSIG	10	10	10	10
OPERATING TEMPERATURE	°F	-(15) to 96	-(15) to 96	-(15) to 96	-(15) to 96
SP. GR. (MW)		0.9672	0.9672	0.9672	0.9672
BASE PRESSURE	PSIA	14.7	14.7	14.7	14.7
BASE TEMPERATURE	° F	70	70	70	70
FULL SCALE FLOW	SCFH	12000	12000	12000	12000
NORMAL FLOW	SCFH	10600	10600	5300	5300
MIN FLOW	SCFH	2650	2650	2650	2650
LINE SIZE / SCHEDULE		1 1/2" SCH 10S	1 1/2" SCH 10S	1 1/2" SCH 10S	1 1/2" SCH 10S
INSIDE DIAMETER OF LINE	INCHES	1.61	1.61	1.61	1.61
MATERIAL		304 SSTL	304 SSTL	304 SSTL	304 SSTL
PRESSURE TAPS TYPE / SIZE		1/4" MALE NPT	1/4" MALE NPT	1/4" MALE NPT	1/4" MALE NPT
ELEMENT TYPE		IN-LINE	IN-LINE	IN-LINE	IN-LINE
PROCESS CONNECTION		BUTT WELD	BUTT WELD	BUTT WELD	BUTT WELD
ORIENTATION		HORIZONTAL	HORIZONTAL	HORIZONTAL	HORIZONTAL
INACCURACY		2% FULL SCALE	2% FULL SCALE	2% FULL SCALE	2% FULL SCALE
CALCULATIONS REQD.		YES	YES	YES	YES
MANUFACTURER					
MODEL					

	APPROVED	DATE	NOTES
INSTRUMENT ENGINEER			
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT B

INSTRUMENT DATA SHEET **LIGO**

FLOW ELEMENTS (PITOT TUBE) **V049-2-079, Rev 0**

TAG NUMBER		FE-304	FE-354	FE-404	FE-504
FLOW SHEET NO.		V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER		342	345	432	532
SERVICE		NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID		GAS	GAS	GAS	GAS
OPERATING PRESSURE	PSIG	10	10	10	10
OPERATING TEMPERATURE	°F	-(15) to 96	-(15) to 96	-(15) to 96	-(15) to 96
SP. GR. (MW)		0.9672	0.9672	0.9672	0.9672
BASE PRESSURE	PSIA	14.7	14.7	14.7	14.7
BASE TEMPERATURE	° F	70	70	70	70
FULL SCALE FLOW	SCFH	12000	12000	12000	12000
NORMAL FLOW	SCFH	5300	5300	5300	5300
MIN FLOW	SCFH	2650	2650	2650	2650
LINE SIZE / SCHEDULE		1 1/2" SCH 10S	1 1/2" SCH 10S	1 1/2" SCH 10S	1 1/2" SCH 10S
INSIDE DIAMETER OF LINE	INCHES	1.61	1.61	1.61	1.61
MATERIAL		304 SSTL	304 SSTL	304 SSTL	304 SSTL
PRESSURE TAPS TYPE / SIZE		1/4" MALE NPT	1/4" MALE NPT	1/4" MALE NPT	1/4" MALE NPT
ELEMENT TYPE		IN-LINE	IN-LINE	IN-LINE	IN-LINE
PROCESS CONNECTION		BUTT WELD	BUTT WELD	BUTT WELD	BUTT WELD
ORIENTATION		HORIZONTAL	HORIZONTAL	HORIZONTAL	HORIZONTAL
INACCURACY		2% FULL SCALE	2% FULL SCALE	2% FULL SCALE	2% FULL SCALE
CERTIFIED CALCULATIONS REQD.		YES	YES	YES	YES
MANUFACTURER					
MODEL					

	APPROVED	DATE	NOTES
INSTRUMENT ENGINEER			
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT B

INSTRUMENT DATA SHEET **LIGO**

FLOW ELEMENTS (PITOT TUBE) **V049-2-079, Rev 0**

TAG NUMBER		FE-604	FE-654	FE-704	FE-804
FLOW SHEET NO.		V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER		692	695	733	833
SERVICE		NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID		GAS	GAS	GAS	GAS
OPERATING PRESSURE	PSIG	10	10	10	10
OPERATING TEMPERATURE	°F	-(15) to 96	-(15) to 96	-(15) to 96	-(15) to 96
SP. GR. (MW)		0.9672	0.9672	0.9672	0.9672
BASE PRESSURE	PSIA	14.7	14.7	14.7	14.7
BASE TEMPERATURE	° F	70	70	70	70
FULL SCALE FLOW	SCFH	12000	12000	12000	12000
NORMAL FLOW	SCFH	10600	10600	5300	5300
MIN FLOW	SCFH	5300	5300	5300	5300
LINE SIZE / SCHEDULE		1 1/2" SCH 10S	1 1/2" SCH 10S	1 1/2" SCH 10S	1 1/2" SCH 10S
INSIDE DIAMETER OF LINE	INCHES	1.61	1.61	1.61	1.61
MATERIAL		304 SSTL	304 SSTL	304 SSTL	304 SSTL
PRESSURE TAPS TYPE / SIZE		1/4" MALE NPT	1/4" MALE NPT	1/4" MALE NPT	1/4" MALE NPT
ELEMENT TYPE		IN-LINE	IN-LINE	IN-LINE	IN-LINE
PROCESS CONNECTION		BUTT WELD	BUTT WELD	BUTT WELD	BUTT WELD
ORIENTATION		HORIZONTAL	HORIZONTAL	HORIZONTAL	HORIZONTAL
INACCURACY		2% FULL SCALE	2% FULL SCALE	2% FULL SCALE	2% FULL SCALE
CERTIFIED CALCULATIONS REQD.		YES	YES	YES	YES
MANUFACTURER					
MODEL					

	APPROVED	DATE	NOTES
INSTRUMENT ENGINEER			
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

Title:	SPECIFICATION FOR DIFFERENTIAL PRESSURE GAUGES

SPECIFICATION

FOR

DIFFERENTIAL PRESSURE GAUGES

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY Thomas Murphy

ELECTRICAL F. Bark

QUALITY ASSURANCE Allan R Bridbrook

TECHNICAL DIRECTOR D. O. McWilliams

PROJECT MANAGER Richard Bagley

REV LTR	BY—DATE	APP.—DATE	DESCRIPTION OF ACTION
0	T.M. 5-2-96	F. Bark 5-2-96	RELEASED FOR FDR PER DEO # 156

PROCESS SYSTEMS INTERNATIONAL, INC			SPECIFICATION	
INITIAL APPROVALS	PREPARED BY / DATE	APPROVED BY / DATE	Number	Rev
	T. Murphy 5-2-96	F. Bark 5-2-96	A V049-2-088	O

TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of instrumentation for the LIGO vacuum system.

The following specifications refer to the Buyer - Process Systems International (PSI), the Owner - California Institute of technology in partnership with Massachusetts Institute of Technology, under a grant from the National Science Foundation, and Vendor/Seller. The Vendor/Seller is the successful system bidder.

The Vendor shall be responsible for updating any and all references to codes and other standards to reflect the requirements of the latest editions in effect on date of purchase order except as noted.

All attachments are incorporated herein by reference and made a part of this specification.

2.0 CODES AND STANDARDS

2.1 Priority of Codes and Standards

1. Codes
2. Standards
3. Data Sheets
4. This Specification

2.2 All conflicts shall be brought to the attention of PSI for a written resolution prior to award of a purchase order. If more than one document applies to a technical requirement, the more stringent requirement shall have precedence.

2.3 The assembly shall comply with applicable parts of latest editions of publications by the following organizations:

American National Standards Institute, Inc. (ANSI)

Code of Federal Regulations (CFR) Title 47, Part 15

Electrical Standards for Industrial Machinery (NFPA 79) unless otherwise indicated

Factory Mutual (FM)

Federal Communications Commission (FCC) Part 15

Institute of Electrical and Electronics Engineers (IEEE)

Insulated Cable Engineers Association (ICEA)

National Electric Code (NFPA 70)

National Electrical Manufacturers Association (NEMA)

Underwriter's Laboratories (UL) or equipment and installation standards by other nationally recognized testing companies

3..0 GENERAL REQUIREMENTS

3.1 The overall process and mechanical requirements for this specific application are given in data sheets attached to this specification.

3.2 The equipment shall be designed for a minimum serviceable life of 20 years.

3.3 Vendor shall specify all bolt torque requirements in the equipment operating and maintenance manual.

3.4 Instrumentation shall be of industrial quality and shall be subject to the acceptance of the Buyer.

3.5 External carbon steel surfaces shall be cleaned and painted. The Vendor's standard is acceptable if it meets specification requirements and is compatible with federal standard 209 class 50,000.

4.0 MARKING

Plates are to be stamped to show the following information:

a. Manufacturer's name, catalog number
b. Serial number
c. Adjustable range
d. Maximum working pressure
e. Set range
f. Output signal
g. Tag number (as listed on attached data sheet)
h. Tags may be permanently attached or attached with a stainless steel wire.

5.0 RESPONSIBILITY

The Seller shall be completely responsible that the equipment and/or material furnished under this specification is of high quality in every respect, with first-class workmanship throughout and entirely suitable for the purpose outlined herein or reasonably inferred therefrom. Therefore, if any requirement of this specification is deemed by the Vendor/Seller to be unacceptable or technically incorrect, he shall specifically delineate his objections and the reasons therefore in his proposal so that they may be resolved before the order is placed. In all respects, the Seller, by accepting the order, shall be deemed to have agreed that conformance with the requirements of the specification will not prejudice in any way the Buyer's right under warranty.

6.0 REQUIRED DOCUMENTATION

Vendor shall furnish documentation in accordance with specific inquiry, requisition and purchase order requirements. All Vendor documents shall bear the purchase order number and PSI's equipment tag number. The following is a list of minimum documentation required:

5.1 MECHANICAL DATA REQUIREMENTS

Outline dimension drawings and weight.

5.2 MANUALS

Five (5) copies of operational/maintenance manuals.

5.3 TEST REPORTS

Calibration report.

7.0 INSPECTION

The responsibility for inspection rests with the manufacturer; however, the Buyer, Owner, Government, and Owner representatives reserve the right to conduct a non-escort inspection of equipment at any time during fabrication to assure that the materials and workmanship are in accordance with this specification. This will include access to fabrication, assembly, cleaning and testing areas for the purpose of monitoring activities.

8.0 PREPARATION FOR SHIPMENT

8.1 Items shall be completely drained and dried.

8.2 Bolted connections shall be made up before shipment.

8.3 Aluminum plate shipping covers shall be attached with bolts to flanged connections, and with suitable attachments to other connections.

8.4 Units shall be completely covered for protection against the ambient and weather conditions expected during transportation. Units shall be adequately protected for unsheltered storage at the sites.

8.5 The Vendor shall have a signed "Release for Shipment" form provided by the Buyer's Quality Assurance representative prior to full or partial shipment of product.

8.6 Shipping crates shall have the Buyer's purchase order number, Vendor's name and list of tag numbers or part numbers on the outside of each crate.

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: DIFFERENTIAL PRESSURE GAUGE	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-088

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks: / Inspector: / Date:
MILESTONE SCHEDULE						
VENDOR Q.A. PLAN						
PREP FOR SHIPMENT PROCEDURE						
ASSEMBLY DRAWINGS						
DESIGN REVIEW						
IN-PROCESS INSPECTIONS						Prior to release for fabrication.
OPERATION & MAINTENANCE MANUALS				5		
SHOP TEST PLAN						Prior to release for fabrication.
SHOP TEST (WITH REPORT)						Prior to release for shipment.

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

DIFFERENTIAL PRESSURE GAUGES **V049-2-088, Rev O**

TAG NUMBER	FI-104	FI-154	FI-204	FI-254
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	1127	1130	242	245
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	GAS	GAS	GAS	GAS
PRESSURE PSIG	10	10	10	10
TEMPERATURE DEGREES F	(-5) to 95	(-5) to 95	(-5) to 95	(-5) to 95
MOUNTING	SURFACE	SURFACE	SURFACE	SURFACE
DIAL SIZE	4.5 inches	4.5 inches	4.5 inches	4.5 inches
ELEMENT TYPE	DIAPHRAM	DIAPHRAM	DIAPHRAM	DIAPHRAM
RANGE IN H_2O (PSIG)	0 to 25	0 to 25	0 to 25	0 to 25
BODY MATERIAL	aluminum	aluminum	aluminum	aluminum
BODY PRESSURE RATING PSIG	25	25	25	25
MAXIMUM D.P. RATING IN H_2O	25	25	25	25
ELEMENT MATERIAL	B una-N	B una-N	B una-N	B una-N
ELEMENT FILL	Dry	Dry	Dry	Dry
PROCESS CONNECTIONS SIZE / TYPE	1/4" NPT	1/4" NPT	1/4" NPT	1/4" NPT
SCALE	0 to 12000	0 to 12000	0 to 12000	0 to 12000
LEGEND	SCFH	SCFH	SCFH	SCFH
GUARANTEED ACCURACY	2%	2%	2%	2%
QUANTITY	1	1	1	1
MANUFACTURER				
MODEL				

	BY	DATE	NOTES
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

DIFFERENTIAL PRESSURE GAUGES **V049-2-088** REV 0

TAG NUMBER	FI-304	FI-354	FI-404	FI-504
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	342	345	432	532
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	GAS	GAS	GAS	GAS
PRESSURE PSIG	10	10	10	10
TEMPERATURE DEGREES F	(-5) to 95	(-5) to 95	(-5) to 95	(-5) to 95
MOUNTING	SURFACE	SURFACE	SURFACE	SURFACE
DIAL SIZE	4.5 inches	4.5 inches	4.5 inches	4.5 inches
ELEMENT TYPE	DIAPHRAM	DIAPHRAM	DIAPHRAM	DIAPHRAM
RANGE IN H_2O (PSIG)	0 to 25	0 to 25	0 to 25	0 to 25
BODY MATERIAL	aluminum	aluminum	aluminum	aluminum
BODY PRESSURE RATING PSIG	25	25	25	25
MAXIMUM D.P. RATING IN H_2O	25	25	25	25
ELEMENT MATERIAL	B una-N	B una-N	B una-N	B una-N
ELEMENT FILL	Dry	Dry	Dry	Dry
PROCESS CONNECTIONS SIZE / TYPE	1/4" NPT	1/4" NPT	1/4" NPT	1/4" NPT
SCALE	0 to 12000	0 to 12000	0 to 12000	0 to 12000
LEGEND	SCFH	SCFH	SCFH	SCFH
GUARANTEED ACCURACY	2%	2%	2%	2%
QUANTITY	1	1	1	1
MANUFACTURER				
MODEL				

	BY	DATE	NOTES
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

V0492088\Attach-C.xls

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

DIFFERENTIAL PRESSURE GAUGES **V049-2-088, REV O**

TAG NUMBER	FI-604	FI-654	FI-704	FI-804
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	692	695	733	833
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	GAS	GAS	GAS	GAS
PRESSURE PSIG	10	10	10	10
TEMPERATURE DEGREES F	(-5) to 95	(-5) to 95	(-5) to 95	(-5) to 95
MOUNTING	SURFACE	SURFACE	SURFACE	SURFACE
DIAL SIZE	4.5 inches	4.5 inches	4.5 inches	4.5 inches
ELEMENT TYPE	DIAPHRAM	DIAPHRAM	DIAPHRAM	DIAPHRAM
RANGE IN H_2O (PSIG)	0 to 25	0 to 25	0 to 25	0 to 25
BODY MATERIAL	aluminum	aluminum	aluminum	aluminum
BODY PRESSURE RATING PSIG	25	25	25	25
MAXIMUM D.P. RATING IN H_2O	25	25	25	25
ELEMENT MATERIAL	B una-N	B una-N	B una-N	B una-N
ELEMENT FILL	Dry	Dry	Dry	Dry
PROCESS CONNECTIONS SIZE / TYPE	1/4" NPT	1/4" NPT	1/4" NPT	1/4" NPT
SCALE	0 to 12000	0 to 12000	0 to 12000	0 to 12000
LEGEND	SCFH	SCFH	SCFH	SCFH
GUARANTEED ACCURACY	2%	2%	2%	2%
QUANTITY	1	1	1	1
MANUFACTURER				
MODEL				

	BY	DATE	NOTES
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

SPECIFICATION

FOR

LEVEL TRANSMITTERS

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY Thomas Murphy

ELECTRICAL F. Bark

QUALITY ASSURANCE Alan R. Bradbrook

TECHNICAL DIRECTOR D. C. McWilliams

PROJECT MANAGER Richard Boyle

REV LTR	BY—DATE	APP.—DATE	DESCRIPTION OF ACTION
0	TM 5-2-96	F. Bark 5-2-96	RELEASED FOR FDR PER DEO# 156

PROCESS SYSTEMS INTERNATIONAL, INC				SPECIFICATION	
INITIAL APPROVALS	PREPARED BY T. Murphy	DATE 5-2-96	APPROVED BY F Bark	DATE 5-2-96	Number A V049-2-089	Rev 0

TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of instrumentation for the LIGO vacuum system.

The following specifications refer to the Buyer - Process Systems International (PSI), the Owner - California Institute of technology in partnership with Massachusetts Institute of Technology, under a grant from the National Science Foundation, and Vendor/Seller. The Vendor/Seller is the successful system bidder.

The Vendor shall be responsible for updating any and all references to codes and other standards to reflect the requirements of the latest editions in effect on date of purchase order except as noted.

All attachments are incorporated herein by reference and made a part of this specification.

2.0 CODES AND STANDARDS

2.1 Priority of Codes and Standards

1. Codes
2. Standards
3. Data Sheets
4. This Specification

2.2 All conflicts shall be brought to the attention of PSI for a written resolution prior to award of a purchase order. If more than one document applies to a technical requirement, the more stringent requirement shall have precedence.

2.3 The assembly shall comply with applicable parts of latest editions of publications by the following organizations:

American National Standards Institute, Inc. (ANSI)

Code of Federal Regulations (CFR) Title 47, Part 15

Electrical Standards for Industrial Machinery (NFPA 79) unless otherwise indicated

Factory Mutual (FM)

Federal Communications Commission (FCC) Part 15

Institute of Electrical and Electronics Engineers (IEEE)

Insulated Cable Engineers Association (ICEA)

National Electric Code (NFPA 70)

National Electrical Manufacturers Association (NEMA)

Underwriter's Laboratories (UL) or equipment and installation standards by other nationally recognized testing companies

3..0 GENERAL REQUIREMENTS

3.1 The overall process and mechanical requirements for this specific application are given in data sheets attached to this specification.

3.2 The equipment shall be designed for a minimum serviceable life of 20 years.

3.3 Vendor shall specify all bolt torque requirements in the equipment operating and maintenance manual.

3.4 Instrumentation shall be of industrial quality and shall be subject to the acceptance of the Buyer.

3.5 External carbon steel surfaces shall be cleaned and painted. The Vendor's standard is acceptable if it meets specification requirements and is compatible with federal standard 209 class 50,000.

4.0 MARKING

Plates are to be stamped to show the following information:

a. Manufacturer's name, catalog number
b. Serial number
c. Adjustable range
d. Maximum working pressure
e. Set range
f. Output signal
g. Tag number (as listed on attached data sheet)
h. Tags may be permanently attached or attached with a stainless steel wire.

5.0 RESPONSIBILITY

The Seller shall be completely responsible that the equipment and/or material furnished under this specification is of high quality in every respect, with first-class workmanship throughout and entirely suitable for the purpose outlined herein or reasonably inferred therefrom. Therefore, if any requirement of this specification is deemed by the Vendor/Seller to be unacceptable or technically incorrect, he shall specifically delineate his objections and the reasons therefore in his proposal so that they may be resolved before the order is placed. In all respects, the Seller, by accepting the order, shall be deemed to have agreed that conformance with the requirements of the specification will not prejudice in any way the Buyer's right under warranty.

6.0 REQUIRED DOCUMENTATION

Vendor shall furnish documentation in accordance with specific inquiry, requisition and purchase order requirements. All Vendor documents shall bear the purchase order number and PSI's equipment tag number. The following is a list of minimum documentation required:

5.1 MECHANICAL DATA REQUIREMENTS

Outline dimension drawings and weight.

5.2 MANUALS

Five (5) copies of operational/maintenance manuals.

5.3 TEST REPORTS

Calibration report.

7.0 INSPECTION

The responsibility for inspection rests with the manufacturer; however, the Buyer, Owner, Government, and Owner representatives reserve the right to conduct a non-escort inspection of equipment at any time during fabrication to assure that the materials and workmanship are in accordance with this specification. This will include access to fabrication, assembly, cleaning and testing areas for the purpose of monitoring activities.

8.0 PREPARATION FOR SHIPMENT

8.1 Items shall be completely drained and dried.

8.2 Bolted connections shall be made up before shipment.

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8.5 The Vendor shall have a signed "Release for Shipment" form provided by the Buyer's Quality Assurance representative prior to full or partial shipment of product.

8.6 Shipping crates shall have the Buyer's purchase order number, Vendor's name and list of tag numbers or part numbers on the outside of each crate.

ATTACHMENT "A"
LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: LEVEL TRANSMITTERS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-089

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE							
VENDOR Q.A. PLAN							
PREP FOR SHIPMENT PROCEDURE							
ASSEMBLY DRAWINGS							
DESIGN REVIEW							
IN-PROCESS INSPECTIONS						Prior to release for fabrication.	
OPERATION & MAINTENANCE MANUALS				5			
SHOP TEST PLAN						Prior to release for fabrication.	
SHOP TEST (WITH REPORT)						Prior to release for shipment.	

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

LEVEL TRANSMITTER (DIFFERENTIAL PRESSURE TYPE) **V049-2-089, Rev 0**

TAG NUMBER	LT-100	LT-150	LT-200	LT-250
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	—	—	—	—
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	LIQUID	LIQUID	LIQUID	LIQUID
PRESSURE PSIG	10 to 25	10 to 25	10 to 25	10 to 25
TEMPERATURE DEGREES F	15 to 96	15 to 96	15 to 96	15 to 96
ADJUSTABLE RANGE IN H_2O	0 to 50	0 to 50	0 to 50	0 to 50
CALIBRATED RANGE IN H_2O (PSIG)				
TYPE: CAPACITANCE / OTHER	CAPACITANCE	CAPACITANCE	CAPACITANCE	CAPACITANCE
OUTPUT	4 to 20 mA	4 to 20 mA	4 to 20 mA	4 to 20 mA
READOUT	inches of H2O	inches of H2O	inches of H2O	inches of H2O
ENCLOSURE NEMA RATING REQD.	4	4	4	4
MATERIAL: BODY / CAPSULE	SST / SST	SST / SST	SST / SST	SST / SST
MATERIAL: NUTS & BOLTS	Ni plated CS	Ni plated CS	Ni plated CS	Ni plated CS
PRESSURE RATING PSIG	25	25	25	25
MAXIMUM D.P. RATING IN H2O	100	100	100	100
CAPSULE FILL	*	*	*	*
PROCESS CONNECTIONS	*	*	*	*
MINIMUM ACCURACY REQD.	0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
MOUNTING BRACKET REQD.	NO	NO	NO	NO
CONDUIT CONNECTION SIZE	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
QUANTITY	1	1	1	1
MANUFACTURER				
MODEL				

	BY	DATE	NOTES
ENGINEERING APPROVAL			* vendor to advise
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

LEVEL TRANSMITTER (DIFFERENTIAL PRESSURE TYPE) **V049-2-089, Rev 0**

TAG NUMBER		LT-300		LT-350		LT-400		LT-500
FLOW SHEET NO.		V049-0-006		V049-0-006		V049-0-006		V049-0-006
LINE NUMBER		—		—		—		—
SERVICE		NITROGEN		NITROGEN		NITROGEN		NITROGEN
FLUID		LIQUID		LIQUID		LIQUID		LIQUID
PRESSURE	PSIG	10 to 25		10 to 25		10 to 25		10 to 25
TEMPERATURE	DEGREES F	15 to 96		15 to 96		15 to 96		15 to 96
ADJUSTABLE RANGE	IN H_2O	0 to 50		0 to 50		0 to 50		0 to 50
CALIBRATED RANGE	IN H_2O (PSIG)							
TYPE: CAPACITANCE / OTHER		CAPACITANCE		CAPACITANCE		CAPACITANCE		CAPACITANCE
OUTPUT		4 to 20 mA		4 to 20 mA		4 to 20 mA		4 to 20 mA
READOUT		inches of H2O		inches of H2O		inches of H2O		inches of H2O
ENCLOSURE NEMA RATING REQD.		4		4		4		4
MATERIAL: BODY / CAPSULE		SST	SST	SST	SST	SST	SST	SST SST
MATERIAL: NUTS & BOLTS		Ni plated CS		Ni plated CS		Ni plated CS		Ni plated CS
PRESSURE RATING	PSIG	25		25		25		25
MAXIMUM D.P. RATING	IN H2O	100		100		100		100
CAPSULE FILL		*		*		*		*
PROCESS CONNECTIONS		*		*		*		*
MINIMUM ACCURACY REQD.		0.25%		0.25%		0.25%		0.25%
SMART ELECTRONICS REQD.		NO		NO		NO		NO
MOUNTING BRACKET REQD.		NO		NO		NO		NO
CONDUIT CONNECTION SIZE		1/2" NPT		1/2" NPT		1/2" NPT		1/2" NPT
QUANTITY		1		1		1		1
MANUFACTURER								
MODEL								

	BY	DATE	NOTES
ENGINEERING APPROVAL			* vendor to advise
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

LEVEL TRANSMITTER (DIFFERENTIAL PRESSURE TYPE) **V049-2-089, Rev 0**

TAG NUMBER	LT-600	LT-650	LT-700	LT-800
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	—	—	—	—
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	LIQUID	LIQUID	LIQUID	LIQUID
PRESSURE PSIG	10 to 25	10 to 25	10 to 25	10 to 25
TEMPERATURE DEGREES F	15 to 96	15 to 96	15 to 96	15 to 96
ADJUSTABLE RANGE IN H_2O	0 to 50	0 to 50	0 to 50	0 to 50
CALIBRATED RANGE IN H_2O (PSIG)				
TYPE: CAPACITANCE / OTHER	CAPACITANCE	CAPACITANCE	CAPACITANCE	CAPACITANCE
OUTPUT	4 to 20 mA	4 to 20 mA	4 to 20 mA	4 to 20 mA
READOUT	inches of H2O	inches of H2O	inches of H2O	inches of H2O
ENCLOSURE NEMA RATING REQD.	4	4	4	4
MATERIAL: BODY / CAPSULE	SST / SST	SST / SST	SST / SST	SST / SST
MATERIAL: NUTS & BOLTS	Ni plated CS	Ni plated CS	Ni plated CS	Ni plated CS
PRESSURE RATING PSIG	25	25	25	25
MAXIMUM D.P. RATING IN H2O	100	100	100	100
CAPSULE FILL	*	*	*	*
PROCESS CONNECTIONS	*	*	*	*
MINIMUM ACCURACY REQD.	0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
MOUNTING BRACKET REQD.	NO	NO	NO	NO
CONDUIT CONNECTION SIZE	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
QUANTITY	1	1	1	1
MANUFACTURER				
MODEL				

	BY	DATE	NOTES
ENGINEERING APPROVAL			* vendor to advise
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

LEVEL TRANSMITTER (DIFFERENTIAL PRESSURE TYPE) **V049-2-089, Rev 0**

TAG NUMBER	LT-105	LT-155	LT-205	LT-255
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	—	—	—	—
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	LIQUID	LIQUID	LIQUID	LIQUID
PRESSURE PSIG	10 to 25	10 to 25	10 to 25	10 to 25
TEMPERATURE DEGREES F	(-5) to 96	(-5) to 96	(-5) to 96	(-5) to 96
ADJUSTABLE RANGE IN H_2O	0 to 500	0 to 500	0 to 500	0 to 500
CALIBRATED RANGE IN H_2O (PSIG)				
TYPE: CAPACITANCE / OTHER	CAPACITANCE	CAPACITANCE	CAPACITANCE	CAPACITANCE
OUTPUT	4 to 20 mA	4 to 20 mA	4 to 20 mA	4 to 20 mA
READOUT	inches of H2O	inches of H2O	inches of H2O	inches of H2O
ENCLOSURE NEMA RATING REQD.	4	4	4	4
MATERIAL: BODY / CAPSULE	SST / SST	SST / SST	SST / SST	SST / SST
MATERIAL: NUTS & BOLTS	Ni plated CS	Ni plated CS	Ni plated CS	Ni plated CS
PRESSURE RATING PSIG	25	25	25	25
MAXIMUM D.P. RATING IN H2O	100	100	100	100
CAPSULE FILL	*	*	*	*
PROCESS CONNECTIONS	*	*	*	*
MINIMUM ACCURACY REQD.	0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
MOUNTING BRACKET REQD.	NO	NO	NO	NO
CONDUIT CONNECTION SIZE	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
QUANTITY	1	1	1	1
MANUFACTURER				
MODEL				

	BY	DATE	NOTES
ENGINEERING APPROVAL			* vendor to advise
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

LEVEL TRANSMITTER (DIFFERENTIAL PRESSURE TYPE) **V049-2-089, Rev 0**

TAG NUMBER	LT-305	LT-355	LT-405	LT-505
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	—	—	—	—
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	LIQUID	LIQUID	LIQUID	LIQUID
PRESSURE PSIG	10 to 25	10 to 25	10 to 25	10 to 25
TEMPERATURE DEGREES F	(-5) to 96	(-5) to 96	(-5) to 96	(-5) to 96
ADJUSTABLE RANGE IN H_2O	0 to 500	0 to 500	0 to 500	0 to 500
CALIBRATED RANGE IN H_2O (PSIG)				
TYPE: CAPACITANCE / OTHER	CAPACITANCE	CAPACITANCE	CAPACITANCE	CAPACITANCE
OUTPUT	4 to 20 mA	4 to 20 mA	4 to 20 mA	4 to 20 mA
READOUT	inches of H2O	inches of H2O	inches of H2O	inches of H2O
ENCLOSURE NEMA RATING REQD.	4	4	4	4
MATERIAL: BODY / CAPSULE	SST / SST	SST / SST	SST / SST	SST / SST
MATERIAL: NUTS & BOLTS	Ni plated CS	Ni plated CS	Ni plated CS	Ni plated CS
PRESSURE RATING PSIG	25	25	25	25
MAXIMUM D.P. RATING IN H2O	100	100	100	100
CAPSULE FILL	*	*	*	*
PROCESS CONNECTIONS	*	*	*	*
MINIMUM ACCURACY REQD.	0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
MOUNTING BRACKET REQD.	NO	NO	NO	NO
CONDUIT CONNECTION SIZE	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
QUANTITY	1	1	1	1
MANUFACTURER				
MODEL				

	BY	DATE	NOTES
ENGINEERING APPROVAL			* vendor to advise
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

LEVEL TRANSMITTER (DIFFERENTIAL PRESSURE TYPE) **V049-2-089, Rev 0**

TAG NUMBER	LT-605	LT-655	LT-705	LT-805
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	—	—	—	—
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	LIQUID	LIQUID	LIQUID	LIQUID
PRESSURE PSIG	10 to 25	10 to 25	10 to 25	10 to 25
TEMPERATURE DEGREES F	(-5) to 96	(-5) to 96	(-5) to 96	(-5) to 96
ADJUSTABLE RANGE IN H_2O	0 to 500	0 to 500	0 to 500	0 to 500
CALIBRATED RANGE IN H_2O (PSIG)				
TYPE: CAPACITANCE / OTHER	CAPACITANCE	CAPACITANCE	CAPACITANCE	CAPACITANCE
OUTPUT	4 to 20 mA	4 to 20 mA	4 to 20 mA	4 to 20 mA
READOUT	inches of H2O	inches of H2O	inches of H2O	inches of H2O
ENCLOSURE NEMA RATING REQD.	4	4	4	4
MATERIAL: BODY / CAPSULE	SST / SST	SST / SST	SST / SST	SST / SST
MATERIAL: NUTS & BOLTS	Ni plated CS	Ni plated CS	Ni plated CS	Ni plated CS
PRESSURE RATING PSIG	25	25	25	25
MAXIMUM D.P. RATING IN H2O	100	100	100	100
CAPSULE FILL	*	*	*	*
PROCESS CONNECTIONS	*	*	*	*
MINIMUM ACCURACY REQD.	0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
MOUNTING BRACKET REQD.	NO	NO	NO	NO
CONDUIT CONNECTION SIZE	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
QUANTITY	1	1	1	1
MANUFACTURER				
MODEL				

	BY	DATE	NOTES
ENGINEERING APPROVAL			* vendor to advise
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

Title:	SPECIFICATION FOR PRESSURE TRANSMITTERS

SPECIFICATION

FOR

PRESSURE TRANSMITTERS

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY Thomas Murphy

ELECTRICAL F. Lark

QUALITY ASSURANCE Alan L. Bradbrook

TECHNICAL DIRECTOR D. A. McWilliams

PROJECT MANAGER Rachel Bayless

REV LTR	BY—DATE	APP.—DATE	DESCRIPTION OF ACTION
D	TM. 5-2-96	F. Lark 5-2-96	RELEASED FOR FDR PER DED* 156

PROCESS SYSTEMS INTERNATIONAL, INC				SPECIFICATION	
INITIAL APPROVALS	PREPARED BY	DATE	APPROVED BY	DATE	Number	Rev
	J. Murphy	5-2-96	F. Lark	5-2-96	A V049-2-090	D

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1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of instrumentation for the LIGO vacuum system.

The following specifications refer to the Buyer - Process Systems International (PSI), the Owner - California Institute of technology in partnership with Massachusetts Institute of Technology, under a grant from the National Science Foundation, and Vendor/Seller. The Vendor/Seller is the successful system bidder.

The Vendor shall be responsible for updating any and all references to codes and other standards to reflect the requirements of the latest editions in effect on date of purchase order except as noted.

All attachments are incorporated herein by reference and made a part of this specification.

2.0 CODES AND STANDARDS

2.1 Priority of Codes and Standards

1. Codes
2. Standards
3. Data Sheets
4. This Specification

2.2 All conflicts shall be brought to the attention of PSI for a written resolution prior to award of a purchase order. If more than one document applies to a technical requirement, the more stringent requirement shall have precedence.

2.3 The assembly shall comply with applicable parts of latest editions of publications by the following organizations:

American National Standards Institute, Inc. (ANSI)

Code of Federal Regulations (CFR) Title 47, Part 15

Electrical Standards for Industrial Machinery (NFPA 79) unless otherwise indicated

Factory Mutual (FM)

Federal Communications Commission (FCC) Part 15

Institute of Electrical and Electronics Engineers (IEEE)

Insulated Cable Engineers Association (ICEA)

National Electric Code (NFPA 70)

National Electrical Manufacturers Association (NEMA)

Underwriter's Laboratories (UL) or equipment and installation standards by other nationally recognized testing companies

3..0 GENERAL REQUIREMENTS

3.1 The overall process and mechanical requirements for this specific application are given in data sheets attached to this specification.

3.2 The equipment shall be designed for a minimum serviceable life of 20 years.

3.3 Vendor shall specify all bolt torque requirements in the equipment operating and maintenance manual.

3.4 Instrumentation shall be of industrial quality and shall be subject to the acceptance of the Buyer.

3.5 External carbon steel surfaces shall be cleaned and painted. The Vendor's standard is acceptable if it meets specification requirements and is compatible with federal standard 209 class 50,000.

4.0 MARKING

Plates are to be stamped to show the following information:

a. Manufacturer's name, catalog number
b. Serial number
c. Adjustable range
d. Maximum working pressure
e. Set range
f. Output signal
g. Tag number (as listed on attached data sheet)
h. Tags may be permanently attached or attached with a stainless steel wire.

5.0 RESPONSIBILITY

The Seller shall be completely responsible that the equipment and/or material furnished under this specification is of high quality in every respect, with first-class workmanship throughout and entirely suitable for the purpose outlined herein or reasonably inferred therefrom. Therefore, if any requirement of this specification is deemed by the Vendor/Seller to be unacceptable or technically incorrect, he shall specifically delineate his objections and the reasons therefore in his proposal so that they may be resolved before the order is placed. In all respects, the Seller, by accepting the order, shall be deemed to have agreed that conformance with the requirements of the specification will not prejudice in any way the Buyer's right under warranty.

6.0 REQUIRED DOCUMENTATION

Vendor shall furnish documentation in accordance with specific inquiry, requisition and purchase order requirements. All Vendor documents shall bear the purchase order number and PSI's equipment tag number. The following is a list of minimum documentation required:

5.1 MECHANICAL DATA REQUIREMENTS

Outline dimension drawings and weight.

5.2 MANUALS

Five (5) copies of operational/maintenance manuals.

5.3 TEST REPORTS

Calibration report.

7.0 INSPECTION

The responsibility for inspection rests with the manufacturer; however, the Buyer, Owner, Government, and Owner representatives reserve the right to conduct a non-escort inspection of equipment at any time during fabrication to assure that the materials and workmanship are in accordance with this specification. This will include access to fabrication, assembly, cleaning and testing areas for the purpose of monitoring activities.

8.0 PREPARATION FOR SHIPMENT

8.1 Items shall be completely drained and dried.

8.2 Bolted connections shall be made up before shipment.

8.3 Aluminum plate shipping covers shall be attached with bolts to flanged connections, and with suitable attachments to other connections.

8.4 Units shall be completely covered for protection against the ambient and weather conditions expected during transportation. Units shall be adequately protected for unsheltered storage at the sites.

8.5 The Vendor shall have a signed "Release for Shipment" form provided by the Buyer's Quality Assurance representative prior to full or partial shipment of product.

8.6 Shipping crates shall have the Buyer's purchase order number, Vendor's name and list of tag numbers or part numbers on the outside of each crate.

ATTACHMENT "A"
LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: PRESSURE TRANSMITTERS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-090

TESTING INSPECTION AND DOCUMENTATION RECORD						Remarks:	Inspector: Date:
MILESTONE SCHEDULE							
VENDOR Q.A. PLAN							
PREP FOR SHIPMENT PROCEDURE							
ASSEMBLY DRAWINGS							
DESIGN REVIEW							
IN-PROCESS INSPECTIONS						Prior to release for fabrication.	
OPERATION & MAINTENANCE MANUALS				5			
SHOP TEST PLAN						Prior to release for fabrication.	
SHOP TEST (WITH REPORT)						Prior to release for shipment.	

ATTACHMENT B

INSTRUMENT DATA SHEET **LIGO**

PRESSURE TRANSMITTERS **V049-2-090 Rev. 0**

TAG NUMBER	PT-101	PT-151	PT-201	PT-251
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	—	—	—	—
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	GAS	GAS	GAS	GAS
PRESSURE PSIG	0 to 25	0 to 25	0 to 25	0 to 25
TEMPERATURE DEGREES F	15 to 96	15 to 96	15 to 96	15 to 96
ADJUSTABLE RANGE PSIG	0 to 25	0 to 25	0 to 25	0 to 25
CALIBRATED RANGE PSIG	0 to 25	0 to 25	0 to 25	0 to 25
OUTPUT	4 to 20 mA	4 to 20 mA	4 to 20 mA	4 to 20 mA
READOUT	PSIG	PSIG	PSIG	PSIG
ENCLOSURE NEMA RATING REQD.	1	1	1	1
MATERIAL: PROCESS WETTED PARTS	SST	SST	SST	SST
MATERIAL: ELECTRONICS HOUSING	ALUMINUM	ALUMINUM	ALUMINUM	ALUMINUM
MATERIAL: NUTS & BOLTS	CS	CS	CS	CS
PRESSURE RATING PSIG	25	25	25	25
CAPSULE FILL	*	*	*	*
PROCESS CONNECTIONS	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
MINIMUM ACCURACY REQD.	.25%	.25%	.25%	.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
MOUNTING BRACKET REQD.	NO	NO	NO	NO
CONDUIT CONNECTION SIZE	1/2"	1/2"	1/2"	1/2"
MANUFACTURER				
MODEL				

	APPROVED	DATE	NOTES
INSTRUMENT ENGINEER			* VENDOR TO ADVISE
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

INSTRUMENT DATA SHEET
PRESSURE TRANSMITTERS

LIGO
V049-2-090 Rev. 0

TAG NUMBER	PT-301	PT-351	PT-401	PT-501
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	—	—	—	—
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	GAS	GAS	GAS	GAS
PRESSURE PSIG	0 to 25	0 to 25	0 to 25	0 to 25
TEMPERATURE DEGREES F	15 to 96	15 to 96	15 to 96	15 to 96
ADJUSTABLE RANGE PSIG	0 to 25	0 to 25	0 to 25	0 to 25
CALIBRATED RANGE PSIG	0 to 25	0 to 25	0 to 25	0 to 25
OUTPUT	4 to 20 mA	4 to 20 mA	4 to 20 mA	4 to 20 mA
READOUT	PSIG	PSIG	PSIG	PSIG
ENCLOSURE NEMA RATING REQD.	1	1	1	1
MATERIAL: PROCESS WETTED PARTS	SST	SST	SST	SST
MATERIAL: ELECTRONICS HOUSING	ALUMINUM	ALUMINUM	ALUMINUM	ALUMINUM
MATERIAL: NUTS & BOLTS	CS	CS	CS	CS
PRESSURE RATING PSIG	25	25	25	25
CAPSULE FILL	*	*	*	*
PROCESS CONNECTIONS	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
MINIMUM ACCURACY REQD.	.25%	.25%	.25%	.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
MOUNTING BRACKET REQD.	NO	NO	NO	NO
CONDUIT CONNECTION SIZE	1/2"	1/2"	1/2"	1/2"
MANUFACTURER				
MODEL				

	APPROVED	DATE	NOTES
INSTRUMENT ENGINEER			* VENDOR TO ADVISE
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT B

INSTRUMENT DATA SHEET
PRESSURE TRANSMITTERS

LIGO
V049-2-090 Rev. 0

TAG NUMBER	PT-601	PT-651	PT-701	PT-801
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	—	—	—	—
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	GAS	GAS	GAS	GAS
PRESSURE PSIG	0 to 25	0 to 25	0 to 25	0 to 25
TEMPERATURE DEGREES F	15 to 96	15 to 96	15 to 96	15 to 96
ADJUSTABLE RANGE PSIG	0 to 25	0 to 25	0 to 25	0 to 25
CALIBRATED RANGE PSIG	0 to 25	0 to 25	0 to 25	0 to 25
OUTPUT	4 to 20 mA	4 to 20 mA	4 to 20 mA	4 to 20 mA
READOUT	PSIG	PSIG	PSIG	PSIG
ENCLOSURE NEMA RATING REQD.	1	1	1	1
MATERIAL: PROCESS WETTED PARTS	SST	SST	SST	SST
MATERIAL: ELECTRONICS HOUSING	ALUMINUM	ALUMINUM	ALUMINUM	ALUMINUM
MATERIAL: NUTS & BOLTS	CS	CS	CS	CS
PRESSURE RATING PSIG	25	25	25	25
CAPSULE FILL	*	*	*	*
PROCESS CONNECTIONS	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
MINIMUM ACCURACY REQD.	.25%	.25%	.25%	.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
MOUNTING BRACKET REQD.	NO	NO	NO	NO
CONDUIT CONNECTION SIZE	1/2"	1/2"	1/2"	1/2"
MANUFACTURER				
MODEL				

	APPROVED	DATE	NOTES
INSTRUMENT ENGINEER			* VENDOR TO ADVISE
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

Title: **SPECIFICATION FOR TEMPERATURE ELEMENTS**

SPECIFICATION

FOR

TEMPERATURE ELEMENTS

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY Thomas Murphy

ELECTRICAL [signature]

QUALITY ASSURANCE [signature]

TECHNICAL DIRECTOR [signature]

PROJECT MANAGER [signature]

0	T.M. 5-2-96	F. Bach 5-2-96	RELEASED FOR FDR PER DEO# 156
REV LTR	BY—DATE	APP.—DATE	DESCRIPTION OF ACTION

PROCESS SYSTEMS INTERNATIONAL, INC			SPECIFICATION	
INITIAL APPROVALS	PREPARED BY T. Murphy DATE 5-2-96	APPROVED BY F Bach DATE 5-2-96	Number A V049-2-091	Rev 0

V0492091.DOC

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1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, shipment and delivery of instrumentation for the LIGO vacuum system.

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d. Maximum working pressure
e. Set range
f. Output signal
g. Tag number (as listed on attached data sheet)
h. Tags may be permanently attached or attached with a stainless steel wire.

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8.5 The Vendor shall have a signed "Release for Shipment" form provided by the Buyer's Quality Assurance representative prior to full or partial shipment of product.

8.6 Shipping crates shall have the Buyer's purchase order number, Vendor's name and list of tag numbers or part numbers on the outside of each crate.

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: TEMPERATURE ELEMENTS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-091

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE							
VENDOR Q.A. PLAN							
PREP FOR SHIPMENT PROCEDURE							
ASSEMBLY DRAWINGS							
DESIGN REVIEW							
IN-PROCESS INSPECTIONS						Prior to release for fabrication.	
OPERATION & MAINTENANCE MANUALS				5			
SHOP TEST PLAN						Prior to release for fabrication.	
SHOP TEST (WITH REPORT)						Prior to release for shipment.	

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

TEMPERATURE ELEMENTS **V049-2-091, Rev 0**

TAG NAME	TE-103A	TE-153A	TE-203A	TE-253A
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	189	191	328	239
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	GAS	GAS	GAS	GAS
PRESSURE PSIG	25	25	25	25
TEMPERATURE DEGREES F	-5 to 375	-5 to 375	-5 to 375	-5 to 375
T / C OR 100 OHM PLATN. R.T.D. / TYPE	T/C T	T/C T	T/C T	T/C T
ALPHA COEFFICIENT IF R.T.D.	N/A	N/A	N/A	N/A
SINGLE OR DUAL ELEMENT	SINGLE	SINGLE	SINGLE	SINGLE
SPRING LOADED ELEMENT	YES	YES	YES	YES
ELEMENT LENGHT	*	*	*	*
SHEATH MATERIAL	304 SST	304 SST	304 SST	304 SST
SHEATH DIAMETER: NOMINAL	1/4"	1/4"	1/4"	1/4"
GROUNDED / UNGROUNDED / EXPOSED	GROUNDED	GROUNDED	GROUNDED	GROUNDED
CONNECTION HEAD				
CONNECTION HEAD MATERIAL	CAST AL	CAST AL	CAST AL	CAST AL
CONNECTION HEAD NEMA RATING REQ	4	4	4	YES
EXPLOSION PROOF HEAD	NO	NO	NO	NO
CONDUIT CONN. SIZE ON HEAD	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
THERMOWELL				
WELL MATERIAL	304SST	304SST	304SST	304SST
WELL CONSTRUCTION TYPE	TAPERED	TAPERED	TAPERED	TAPERED
PROCESS CONNECTION	3/4" SW	3/4" SW	3/4" SW	3/4" SW
BORE	0.260"	0.260"	0.260"	0.260"
"U" LENGTH SEE PAGE 4	2 1/2"	2 1/2"	2 1/2"	2 1/2"
"T" LENGHT SEE PAGE 4	1 3/4"	1 3/4"	1 3/4"	1 3/4"
"N" LENGHT SEE PAGE 4	2"	2"	2"	2"
MANUFACTURER				
ELEMENT MODEL #				

	BY	DATE	NOTES
ENGINEERING APPROVAL			* VENDOR TO ADVISE
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

TEMPERATURE ELEMENTS **V049-2-091, Rev 0**

TAG NAME	TE-303A	TE-353A	TE-403A	TE-503A
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	338	339	429	529
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	GAS	GAS	GAS	GAS
PRESSURE PSIG	25	25	25	25
TEMPERATURE DEGREES F	-5 to 375	-5 to 375	-5 to 375	-5 to 375
T / C OR 100 OHM PLATN. R.T.D. / TYPE	T/C T	T/C T	T/C T	T/C T
ALPHA COEFFICIENT IF R.T.D.	N/A	N/A	N/A	N/A
SINGLE OR DUAL ELEMENT	SINGLE	SINGLE	SINGLE	SINGLE
SPRING LOADED ELEMENT	YES	YES	YES	YES
ELEMENT LENGHT	*	*	*	*
SHEATH MATERIAL	304 SST	304 SST	304 SST	304 SST
SHEATH DIAMETER: NOMINAL	1/4"	1/4"	1/4"	1/4"
GROUNDED / UNGROUNDED / EXPOSED	GROUNDED	GROUNDED	GROUNDED	GROUNDED
CONNECTION HEAD				
CONNECTION HEAD MATERIAL	CAST AL	CAST AL	CAST AL	CAST AL
CONNECTION HEAD NEMA RATING REQ	4	4	4	YES
EXPLOSION PROOF HEAD	NO	NO	NO	NO
CONDUIT CONN. SIZE ON HEAD	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
THERMOWELL				
WELL MATERIAL	304SST	304SST	304SST	304SST
WELL CONSTRUCTION TYPE	TAPERED	TAPERED	TAPERED	TAPERED
PROCESS CONNECTION	3/4" SW	3/4" SW	3/4" SW	3/4" SW
BORE	0.260"	0.260"	0.260"	0.260"
"U" LENGTH SEE PAGE 4	2 1/2"	2 1/2"	2 1/2"	2 1/2"
"T" LENGHT SEE PAGE 4	1 3/4"	1 3/4"	1 3/4"	1 3/4"
"N" LENGHT SEE PAGE 4	2"	2"	2"	2"
MANUFACTURER				
ELEMENT MODEL #				

	BY	DATE	NOTES
ENGINEERING APPROVAL			* VENDOR TO ADVISE
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

TEMPERATURE ELEMENTS **V049-2-091, Rev 0**

TAG NAME	TE-603A	TE-653A	TE-703A	TE-803A
FLOW SHEET NO.	V049-0-006	V049-0-006	V049-0-006	V049-0-006
LINE NUMBER	688	689	730	830
SERVICE	NITROGEN	NITROGEN	NITROGEN	NITROGEN
FLUID	GAS	GAS	GAS	GAS
PRESSURE PSIG	25	25	25	25
TEMPERATURE DEGREES F	-5 to 375	-5 to 375	-5 to 375	-5 to 375
T / C OR 100 OHM PLATN. R.T.D. / TYPE	T/C T	T/C T	T/C T	T/C T
ALPHA COEFFICIENT IF R.T.D.	N/A	N/A	N/A	N/A
SINGLE OR DUAL ELEMENT	SINGLE	SINGLE	SINGLE	SINGLE
SPRING LOADED ELEMENT	YES	YES	YES	YES
ELEMENT LENGHT	*	*	*	*
SHEATH MATERIAL	304 SST	304 SST	304 SST	304 SST
SHEATH DIAMETER: NOMINAL	1/4"	1/4"	1/4"	1/4"
GROUNDED / UNGROUNDED / EXPOSED	GROUNDED	GROUNDED	GROUNDED	GROUNDED
CONNECTION HEAD				
CONNECTION HEAD MATERIAL	CAST AL	CAST AL	CAST AL	CAST AL
CONNECTION HEAD NEMA RATING REQ	4	4	4	YES
EXPLOSION PROOF HEAD	NO	NO	NO	NO
CONDUIT CONN. SIZE ON HEAD	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
THERMOWELL				
WELL MATERIAL	304SST	304SST	304SST	304SST
WELL CONSTRUCTION TYPE	TAPERED	TAPERED	TAPERED	TAPERED
PROCESS CONNECTION	3/4" SW	3/4" SW	3/4" SW	3/4" SW
BORE	0.260"	0.260"	0.260"	0.260"
"U" LENGTH SEE PAGE 4	2 1/2"	2 1/2"	2 1/2"	2 1/2"
"T" LENGHT SEE PAGE 4	1 3/4"	1 3/4"	1 3/4"	1 3/4"
"N" LENGHT SEE PAGE 4	2"	2"	2"	2"
MANUFACTURER				
ELEMENT MODEL #				

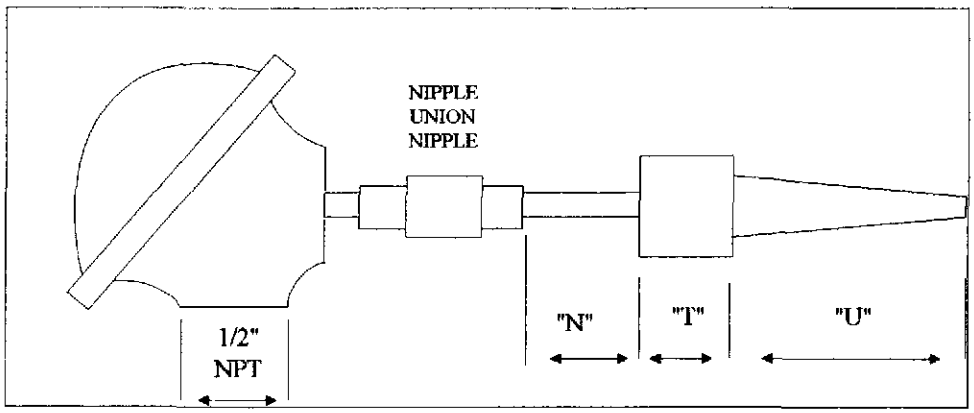
	BY	DATE	NOTES
ENGINEERING APPROVAL			* VENDOR TO ADVISE
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET
TEMPERATURE ELEMENTS

LIGO
V049-2-091, Rev 0



SPECIFICATION

FOR

VACUUM CONTROL SYSTEM

INTERLOCKS, PERMISSIVES

AND SOFTWARE ALARMS

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY _____

ELECTRICAL F. Bash

QUALITY ASSURANCE Alan Bradbrook /rea

TECHNICAL DIRECTOR D. A. McWilliam

PROJECT MANAGER _____

REV LTR	BY—DATE	APPD—DATE	DESCRIPTION OF ACTION
Ø	PPS 5/1/96	REB 5/6/96	Issued for Review DEO # 0155

PROCESS SYSTEMS INTERNATIONAL, INC				SPECIFICATION	
INITIAL APPROVALS	PREPARED BY PPS	DATE 5/1/96	APPROVED BY	DATE 5/6/96	Number A V049-2-092	Rev 0

TABLE OF CONTENTS

1 VACUUM CONTROL SYSTEM INTERLOCKS / PERMISSIVES / SOFTWARE ALARMS

1.0 INTERLOCK AND PERMISSIVE OVERVIEW

See Attachment-A for details on Interlocks and Permissives for the Washington Site.
See Attachment-B for details on Interlocks and Permissives for the Louisiana Site.

Attachments A and B contain a summary of all Vacuum Control System controlled device proposed interlocks and permissives.

1.1 SOFTWARE ALARM OVERVIEW

See Attachment C for a detailed Software Alarm Listing for the Washington Site.
See Attachment D for a detailed Software Alarm Listing for the Louisiana Site.

Attachments C and D contain a listing of Vacuum Control System proposed software generated alarms only.

All hardwired alarm inputs into the Vacuum Control System are listed in the LIGO instrument list V049-1-036.

1.2 EMERGENCY SHUTDOWN OVERVIEW

A control system emergency shutdown function (ESD) should be provided at each site to bring all controlled devices to a safe state in the case of an emergency.

ATTACHMENT-A

WASHINGTON SITE PERMISSIVES AND INTERLOCKS

Washington site

LEGEND

BSCx	Beam splitter chamber number x
WCPx	Cryopump number x
WGVx	Gate valve number x
LBMT	Left Beam Manifold Tube
LMSBT	Left Mid Station Beam Tube
LESBT	Left End Station Beam Tube
RBMBT	Right Beam Manifold Beam Tube
RMSBT	Right Mid Station Beam Tube
RESBT	Right End Station Beam Tube
PT-xA	Pirani vacuum gauge number x with location
PT-xB	Ion vacuum gauge number x with location
HS-x	Hand switch number
(xxx)	P&ID V049-0-xxx drawing

LOGIC, CONTROL, LEGEND

"WL1"	Do not open valve unless the difference in absolute vacuum gauge pressure is within one decade (factor of 10 of each other).
"WL2"	Do not close valve when LASER is activate.
"WL3"	Reset controller after clearing fault condition, then restart.
"WL4"	If XY-xxx is deenergized, then deactivate corresponding LIC-xxx.
"WL5"	If TE-xxx is above *TBD* °F, then deactivate corresponding JC-xxx.

WASHINGTON SITE

Beam tube valve—openning restrictions

Output—Effect / Input—Cause	WGV1 (013) HS--0119	WGV2 (013) HS-0129	WGV3 (014) HS-0139	WGV4 (014) HS-0149	WGV5 (012) HS-0129	WGV6 (012) HS-0169	WGV7 (015) HS-0179	WGV8 (015) HS-0189	WGV9 (011) HS-0209	WGV10 (011) HS-0219	WGV11 (011) HS-0229	WGV12 (011) HS-0239	WGV13 (016) HS-0309	WGV14 (016) HS-0319	WGV15 (016) HS-0329	WGV16 (016) HS-0339	WGV17 (010) HS-0409	WGV18 (010) HS-0419	WGV19 (017) HS-0509	WGV20 (017) HS-0519
PT-0120A&B, WBSC2 (002) PT-0180A&B, WBSC8 (002)	WL1																			
PT-0120A&B, WBSC2 (002) PT-0170A&B, WBSC7 (002)		WL1																		
PT-0140A&B, WBSC4 (002) PT-0180A&B, WBSC8 (002)			WL1																	
PT-0140A&B, WBSC4 (002) PT-0170A&B, WBSC7 (002)				WL1																
PT-0180A&B, WBSC8 (002) PT-0114A&B, WCP1 (012)					WL1															
PT-0114A&B, WCP1 (012) PT-0124A&B, LMBT (012)						WL1														
PT-0170A&B, WBSC7 (002) PT-0134A&B, WCP2 (015)							WL1													
PT-0134A&B, WCP2 (015) PT-0144A&B, RMBT (015)								WL1												

WASHINGTON SITE

Beam tube valve—openning restrictions

Output—Effect / Input—Cause	**WGV1 (013)** HS-0119	**WGV2 (013)** HS-0129	**WGV3 (014)** HS-0139	**WGV4 (014)** HS-0149	**WGV5 (012)** HS-0129	**WGV6 (012)** HS-0169	**WGV7 (015)** HS-0179	**WGV8 (015)** HS-0189	**WGV9 (011)** HS-0209	**WGV10 (011)** HS-0219	**WGV11 (011)** HS-0229	**WGV12 (011)** HS-0239	**WGV13 (016)** HS-0309	**WGV14 (016)** HS-0319	**WGV15 (016)** HS-0329	**WGV16 (016)** HS-0339	**WGV17 (010)** HS-0409	**WGV18 (010)** HS-0419	**WGV19 (017)** HS-0509	**WGV20 (017)** HS-0519
PT-0243A&B, LMSBT (011) PT-0244A&B, WCP3 (011)									WL1											
PT-0244A&B, WCP3 (011) PT-0210A&B, WBSC6 (002)										WL1										
PT-0210A&B, WBSC6 (012) PT-0245A&B, WCP4 (011)											WL1									
PT-0245A&B, WCP4 (011) PT-0246A&B, LMSBT (011)												WL1								
PT-0343A&B, RMSBT (016) PT-0344A&B, WCP5 (016)													WL1							
PT-0344A&B, WCP5 (016) PT-0310A&B, WBSC5 (002)														WL1						
PT-0310A&B, WBSC5 (002) PT-0345A&B, WCP6 (016)															WL1					
PT-0345A&B, WCP6 (016) PT-0346A&B, RMSBT (016)																WL1				

WASHINGTON SITE

Beam tube valve—openning restrictions

Output—Effect / Input—Cause	**WGV1 (013)** HS--0119	**WGV2 (013)** HS-0129	**WGV3 (014)** HS-0139	**WGV4 (014)** HS-0149	**WGV5 (012)** HS-0129	**WGV6 (012)** HS-0169	**WGV7 (015)** HS-0179	**WGV8 (015)** HS-0189	**WGV9 (011)** HS-0209	**WGV10 (011)** HS-0219	**WGV11 (011)** HS-0229	**WGV12 (011)** HS-0239	**WGV13 (016)** HS-0309	**WGV14 (016)** HS-0319	**WGV15 (016)** HS-0329	**WGV16 (016)** HS-0339	**WGV17 (010)** HS-0409	**WGV18 (010)** HS-0419	**WGV19 (017)** HS-0509	**WGV20 (017)** HS-0519
PT-0423A&B, WCP7(010) PT-0424A&B, LESBT (010)																	WL1			
PT-0424A&B, WCP7 (010) PT-0410A&B,WBS																		WL1		
PT-0523A&B, RESBT (017) PT-0524A&B, WCP8 (017)																			WL1	
PT-0524A&B, WCP8 (017) PT-0510A&B,WBS																				WL1

WASHINGTON SITE

Beam tube valve—closing restrictions

Output—Effect / Input—Cause	**WGV1 (013)** HS--0119	**WGV2 (013)** HS-0129	**WGV3 (014)** HS-0139	**WGV4 (014)** HS-0149	**WGV5 (012)** HS-0129	**WGV6 (012)** HS-0169	**WGV7 (015)** HS-0179	**WGV8 (015)** HS-0189	**WGV9 (011)** HS-0209	**WGV10 (011)** HS-0219	**WGV11 (011)** HS-0229	**WGV12 (011)** HS-0239	**WGV13 (016)** HS-0309	**WGV14 (016)** HS-0319	**WGV15 (016)** HS-0329	**WGV16 (016)** HS-0339	**WGV17 (010)** HS-0409	**WGV18 (010)** HS-0419	**WGV19 (017)** HS-0509	**WGV20 (017)** HS-0519
LASER active	WL2	WL2	WL2	WL2	WL2	WL2	WL2	WL2	WL2	WL2	WL2	WL2	WL2	WL2	WL2	WL2	WL2	WL2	WL2	WL2

WASHINGTON SITE

2500 L/S Ion pumps—fault & restart

Input/Cause \ Output/Effect	WIP1-1 (013) HS-0161A (START)	WIP1-2 (013) HS-0161C (START)	WIP2-1 (013) HS-0162A (START)	WIP2-2 (013) HS-0162C (START)	WIP3-1 (013) HS-0163A (START)	WIP3-2 (013) HS-0163C (START)	WIP4-1 (013) HS-0164A (START)	WIP4-2 (013) HS-0164C (START)	WIP5-1 (012) HS-0165A (START)	WIP5-2 (012) HS-0164C (START)	WIP6-1 (015) HS-0166A (START)	WIP6-2 (015) HS-0166C (START)	WIP7-1 (014) HS-0167A (START)	WIP7-2 (014) HS-0167C (START)	WIP8-1 (014) HS-0168A (START).	WIP8-2 (014) HS-0168C (START)
WIP1-1 (013), XA-161A WIP1-2 (013), XA-161B	WL3	WL3														
WIP2-1 (013), XA-162A WIP2-2 (013) XA-162B			WL3	WL3												
WIP3-1 (013) XA-163A WIP3-2 (013) XA-163B					WL3	WL3										
WIP4-1 (013) XA-164A WIP4-2 (013) XA-164B							WL3	WL3								
WIP5-1 (012) XA-165A WIP5-2 (012) XA-165B									WL3	WL3						
WIP6-1 (015) XA-166A WIP6-2 (015) XA-166B											WL3	WL3				
WIP7-1 (014) XA-167A WIP7-2 (014) XA-167B													WL3	WL3		
WIP8-1 (014) XA-168A WIP8-2 (014) XA-168B															WL3	WL3
WIP9-1 (011) XA-247A WIP9-2 (011) XA-247B																
WIP10-1 (016) XA-347A WIP10-2 (016) XA-347B																
WIP11-1 (0106) XA-422A WIP11-2 (010) XA-422B																
WIP12-1 (0107) XA-522A WIP12-2 (017) XA-522B																

WASHINGTON SITE

2500 L/S Ion pumps—fault & r

Input/Cause \ Output/Effect	WIP9-1 (011) HS-0247A (START)	WIP9-2 (011) HS-0247C (START)	WIP10-1 (016) HS-0347A (START)	WIP10-2 (016) HS-0347C (START)	WIP11-1 (010) HS-0422A (START)	WIP11-2 (010) HS-0422C (START)	WIP12-1 (017) HS-0522A (START)	WIP12-2 (017) HS-0522C (START)
WIP1-1 (013), XA-161A WIP1-2 (013), XA-161B								
WIP2-1 (013), XA-162A WIP2-2 (013) XA-162B								
WIP3-1 (013) XA-163A WIP3-2 (013) XA-163B								
WIP4-1 (013) XA-164A WIP4-2 (013) XA-164B								
WIP5-1 (012) XA-165A WIP5-2 (012) XA-165B								
WIP6-1 (015) XA-166A WIP6-2 (015) XA-166B								
WIP7-1 (014) XA-167A WIP7-2 (014) XA-167B								
WIP8-1 (014) XA-168A WIP8-2 (014) XA-168B								
WIP9-1 (011) XA-247A WIP9-2 (011) XA-247B	WL3	WL3						
WIP10-1 (016) XA-347A WIP10-2 (016) XA-347B			WL3	WL3				
WIP11-1 (0106) XA-422A WIP11-2 (010) XA-422B					WL3	WL3		
WIP12-1 (0107) XA-522A WIP12-2 (017) XA-522B							WL3	WL3

WASHINGTON SITE

Cryopump—liquid level control

Input/Cause \ Output/Effect	WCP1 (006), LIC-100	WCP2 (006), LIC-150	WCP3 (006), LIC-200	WCP4 (006), LIC-250	WCP5 (006), LIC-300	WCP6 (006), LIC-350	WCP7 (006), LIC-400	WCP8 (006), LIC-500
WCP1 (006) XY-100	WL4							
WCP2 (006) XY-150		WL4						
WCP3 (006) XY-200			WL4					
WCP4 (006) XY-250				WL4				
WCP5 (006) XY-300					WL4			
WCP6 (006) XY-350						WL4		
WCP7 (006) XY-400							WL4	
WCP8 (006) XY-500								WL4

WASHINGTON SITE

Cryopump regen electric heater—SCR controller

Input/Cause \ Output/Effect	WCP1 (006), JC-103	WCP2 (006), JC-153	WCP3 (006), JC-203	WCP4 (006), JC-253	WCP5 (006), JC-303	WCP6 (006), JC-353	WCP7 (006), JC-403	WCP8 (006), JC-503
WCP1 (006) TE-103B/C	WL5							
WCP2 (006) TE-153B/C		WL5						
WCP3 (006) TE-203B/C			WL5					
WCP4 (006) TE-253B/C				WL5				
WCP5 (006) TE-303B/C					WL5			
WCP6 (006) TE-353B/C						WL5		
WCP7 (006) TE-403B/C							WL5	
WCP8 (006) TE-503B/C								WL5

ATTACHMENT-B

LOUISIANA SITE PERMISSIVES AND INTERLOCKS

Louisiana site

LEGEND

BSCx	Beam splitter chamber number x
LCPx	Cryopump number x
LGVx	Gate valve number x
LMBT	Left Manifold Beam Tube
LMJBT	Left Mid Joint Beam Tube
LESBT	Left End Station Beam Tube
RMBT	Right Manifold Beam Tube
RMJBT	Right Mid Joint Beam Tube
RESBT	Right End Station Beam Tube
PT-xA	Pirani vacuum gauge number x with location
PT-xB	Ion vacuum gauge number x with location
HS-x	Hand switch number
(xxx)	P&ID V049-0-xxx drawing
NIC	Not In Contract

LOGIC, CONTROL, LEGEND

"LL1"	Do not open valve unless the difference in absolute vacuum gauge pressure is within one decade (factor of 10 of each other).
"LL2"	Do not close valve when LASER is activate.
"LL3"	Reset controller after clearing fault condition, then restart.
"LL4"	If XY-xxx is deenergized, then deactivate corresponding LIC-xxx.
"LL5"	If TE-xxx is above *TBD* °F, then deactivate corresponding JC-xxx.

LOUISIANA SITE

Beam tube valve—openning restrictions

Output / Input/Cause	LGV1 (023) HS-0619	LGV2 (023) HS-0629	LGV3 (022) HS-0659	LGV4 (022) HS-0669	LGV5 (024) HS-0679	LGV6 (024) HS-0689	LGV7 (021) HS-0750	LGV8 (021) HS-0850	LGV9 (020) HS-0709	LGV10 (020) HS-0719	LGV11 (025) HS-0809	LGV12 (025) HS-0819
PT-0620A&B, LBSC2 (002) PT-0680A&B, LMBT (022)	LL1											
PT-0620A&B, LBSC2 (002) PT-0670A&B, RMBT (024)		LL1										
PT-0680A&B, LMBT (022) PT-0614A&B, LCP1 (022)			LL1									
PT-0614A&B, LCP1 (022) PT-0624A&B, LMBT (022)				LL1								
PT-0670A&B, RMBT (002) PT-0634A&B, LCP2 (024)					LL1							
PT-0634A&B, LCP2 (024) PT-0644A&B, RMBT (024)						LL1						
NIC, PT-0751A&B NMJBT (021) PT-0752A&B LMJBT (021)							LL1					

LOUISIANA SITE

Beam tube valve—openning restrictions

Output / Input/Cause	LGV1 (023) HS-0619	LGV2 (023) HS-0629	LGV3 (022) HS-0659	LGV4 (022) HS-0669	LGV5 (024) HS-0679	LGV6 (024) HS-0689	LGV7 (021) HS-0750	LGV8 (021) HS-0850	LGV9 (020) HS-0709	LGV10 (020) HS-0719	LGV11 (025) HS-0809	LGV12 (025) HS-0819
NIC PT-0851A&B RMJBT (021) PT-0852A&B, RMJBT (021)								LL1				
PT-0723A&B, LESBT (020) PT-0724A&B, LCP3 (002)									LL1			
PT-0724A&B, LCP3 (020) PT-0710A&B, LBSC5 (002)										LL1		
PT-0823A&B, RESBT (025) PT-0824A&B, LCP4 (025)											LL1	
PT-0824A&B, LCP4 (025) PT-0810A&B, LBSC4 (002)												LL1

LOUISIANA SITE

Beam tube valve—closing restrictions

Output/Effect / Input/Cause	LGV1 (023) HS-0619	LGV2 (023) HS-0629	LGV3 (022) HS-0659	LGV4 (022) HS-0669	LGV5 (024) HS-0679	LGV6 (024) HS-0689	LGV7 (021) HS-0750	LGV8 (021) HS-0850	LGV9 (020) HS-0709	LGV10 (020) HS-0719	LGV11 (025) HS-0809	LGV12 (025) HS-0819
LASER active	LL2	LL2	LL2	LL2	LL2	LL2	LL2	LL2	LL2	LL2	LL2	LL2

LOUISIANA SITE

2500 L/S Ion pumps—fault & restart

Input/Cause \ Output/Effect	LIP1-1 (023) HS-0661A (START)	LIP1-2 (023) HS-0661C (START)	LIP2-1 (023) HS-0662A (START)	LIP2-2 (023) HS-0662C (START)	LIP3-1 (023) HS-0663A (START)	LIP3-2 (023) HS-0663C (START)	LIP4-1 (023) HS-0664A (START)	LIP4-2 (023) HS-0664C (START)	LIP5-1 (020) HS-0722A (START)	LIP5-2 (020) HS-0722C (START)	LIP6-1 (025) HS-0822A (START)	LIP6-2 (025) HS-0822C (START)
LIP1-1 (023) XA-661A	LL3											
LIP1-2 (023) XA-661B		LL3										
LIP2-1 (023) XA-662A			LL3									
LIP2-2 (023) XA-662B				LL3								
LIP3-1 (023) XA-663A					LL3							
LIP3-2 (023) XA-663B						LL3						
LIP4-1 (023) XA-664A							LL3					
LIP4-2 (023) XA-664B								LL3				
LIP5-1 (020) XA-722A									LL3			
LIP5-2 (020) XA-722B										LL3		
LIP6-1 (025) XA-822A											LL3	
LIP6-2 (025) XA-822B												LL3

LOUISIANA SITE

Cryopump—liquid level control

Input/Cause \ Output/Effect	LCP1 (006), LIC-600	LCP2 (006), LIC-650	LCP3 (006), LIC-700	LCP4 (006), LIC-800
LCP1 (006) XY-600	LL4			
LCP2 (006) XY-650		LL4		
LCP3 (006) XY-700			LL4	
LCP4 (006) XY-800				LL4

LOUISANA SITE

Cryopump regen electric heater—SCR controller

Input/Cause \ Output/Effect	LCP1 (006), JC-603	LCP2 (006), JC-653	LCP3 (006), JC-703	LCP4 (006), JC-803
LCP1 (006) TE-603B/C	LL5			
LCP2 (006) TE-653B/C		LL5		
LCP3 (006) TE-703B/C			LL5	
LCP4 (006) TE-803B/C				LL5

ATTACHMENT-C

WASHINGTON SITE SOFTWARE ALARM LISTING

WASHINGTON SITE SOFTWARE ALARM LISTING				RANGE SETTINGS			PROPOSED ALARMING		
V049-2-092 ATTACHMENT-C REV. 0				LOW RANGE	HIGH RANGE	UNITS	ALARM TRIP ELEMENT	TRIP SET POINT OR SWITCH TRIP ACTION	DELAY TIME SECONDS)
TAG #		PID #	SERVICE DESCRIPTION	OFF-IND.	ON-IND.				
			Cryopump WCP1						
LAH	100	006	Cryopump WCP1 High Level Alarm	0	100	%	LT-100	LT-100 >=98	
LAL	100	006	Cryopump WCP1 Low Level Alarm	0	100	%	LT-100	LT-100 =< 83	
PAH	101	006	Cryopump WCP1 High Pressure Alarm	0	25	PSIG	PT-101	PT-101 >= 10	
TAH	102	006	Cryopump WCP1 High Temp Alarm	-320	700	Deg F	TE-102	TE-102 >= 185	
TAH	103A	006	Cryopump WCP1 Heater High Temp Alarm	-320	700	Deg F	TE-103A	TE-103A >= 200	
TAH	103B	006	Cryopump WCP1 Heater High Temp Alarm	-320	700	Deg F	TE-103B/C	TE-103B >= TBD	
LAL	105	006	Dewer WCP1 Low Level Alarm	0	100	%	LT-105	LT-105 =< 10	
			Cryopump WCP2						
LAH	150	006	Cryopump WCP2 High Level Alarm	0	100	%	LT-150	LT-100 >=98	
LAL	150	006	Cryopump WCP2 Low Level Alarm	0	100	%	LT-150	LT-100 =< 83	
PAH	151	006	Cryopump WCP2 High Pressure Alarm	0	25	PSIG	PT-151	PT-101 >= 10	
TAH	152	006	Cryopump WCP2 High Temp Alarm	-320	700	Deg F	TE-152	TE-102 >= 185	
TAH	153A	006	Cryopump WCP2 Heater High Temp Alarm	-320	700	Deg F	TE-153A	TE-103A >= 200	
TAH	153B	006	Cryopump WCP2 Heater High Temp Alarm	-320	700	Deg F	TE-153B/C	TE-103B >= TBD	
LAL	155	006	Dewer WCP2 Low Level Alarm	0	100	%	LT-155	LT-105 =< 10	
			Cryopump WCP3						
LAH	200	006	Cryopump WCP3 High Level Alarm	0	100	%	LT-200	LT-100 >=98	
LAL	200	006	Cryopump WCP3 Low Level Alarm	0	100	%	LT-200	LT-100 =< 83	
PAH	201	006	Cryopump WCP3 High Pressure Alarm	0	25	PSIG	PT-201	PT-101 >= 10	
TAH	202	006	Cryopump WCP3 High Temp Alarm	-320	700	Deg F	TE-202	TE-102 >= 185	
TAH	203A	006	Cryopump WCP3 Heater High Temp Alarm	-320	700	Deg F	TE-203A	TE-103A >= 200	
TAH	203B	006	Cryopump WCP3 Heater High Temp Alarm	-320	700	Deg F	TE-203B/C	TE-103B >= TBD	
LAL	205	006	Dewer WCP3 Low Level Alarm	0	100	%	LT-205	LT-105 =< 10	
			Cryopump WCP4						
LAH	250	006	Cryopump WCP4 High Level Alarm	0	100	%	LT-250	LT-250 >=98	
LAL	250	006	Cryopump WCP4 Low Level Alarm	0	100	%	LT-250	LT-250 =< 83	
PAH	251	006	Cryopump WCP4 High Pressure Alarm	0	25	PSIG	PT-251	PT-251 >= 10	
TAH	252	006	Cryopump WCP4 High Temp Alarm	-320	700	Deg F	TE-252	TE-252 >= 185	
TAH	253A	006	Cryopump WCP4 Heater High Temp Alarm	-320	700	Deg F	TE-253A	TE-253A >= 200	
TAH	253B	006	Cryopump WCP4 Heater High Temp Alarm	-320	700	Deg F	TE-253B/C	TE-253B >= TBD	
LAL	255	006	Dewer WCP4 Low Level Alarm	0	100	%	LT-255	LT-255 =< 10	

WASHINGTON SITE SOFTWARE ALARM LISTING				RANGE SETTINGS			PROPOSED ALARMING		
V049-2-092 ATTACHMENT-C REV. 0				LOW RANGE	HIGH RANGE	UNITS	ALARM TRIP ELEMENT	TRIP SET POINT OR SWITCH TRIP ACTION	DELAY TIME SECONDS)
TAG #		PID #	SERVICE DESCRIPTION	OFF-IND.	ON-IND.				
			Cryopump WCP5						
LAH	300	006	Cryopump WCP5 High Level Alarm	0	100	%	LT-300	LT-300 >=98	
LAL	300	006	Cryopump WCP5 Low Level Alarm	0	100	%	LT-300	LT-300 =< 83	
PAH	301	006	Cryopump WCP5 High Pressure Alarm	0	25	PSIG	PT-301	PT-301 >= 10	
TAH	302	006	Cryopump WCP5 High Temp Alarm	-320	700	Deg F	TE-302	TE-302 >= 185	
TAH	303A	006	Cryopump WCP5 Heater High Temp Alarm	-320	700	Deg F	TE-303A	TE-303A >= 200	
TAH	303B	006	Cryopump WCP5 Heater High Temp Alarm	-320	700	Deg F	TE-303B/C	TE-303B >= TBD	
LAL	305	006	Dewer WCP5 Low Level Alarm	0	100	%	LT-305	LT-305 =< 10	
			Cryopump WCP6						
LAH	350	006	Cryopump WCP6 High Level Alarm	0	100	%	LT-350	LT-350 >=98	
LAL	350	006	Cryopump WCP6 Low Level Alarm	0	100	%	LT-350	LT-350 =< 83	
PAH	351	006	Cryopump WCP6 High Pressure Alarm	0	25	PSIG	PT-351	PT-351 >= 10	
TAH	352	006	Cryopump WCP6 High Temp Alarm	-320	700	Deg F	TE-352	TE-352 >= 185	
TAH	353A	006	Cryopump WCP6 Heater High Temp Alarm	-320	700	Deg F	TE-353A	TE-353A >= 200	
TAH	353B	006	Cryopump WCP6 Heater High Temp Alarm	-320	700	Deg F	TE-353B/C	TE-353B >= TBD	
LAL	355	006	Dewer WCP6 Low Level Alarm	0	100	%	LT-355	LT-355 =< 10	
			Cryopump WCP7						
LAH	400	006	Cryopump WCP7 High Level Alarm	0	100	%	LT-400	LT-400 >=98	
LAL	400	006	Cryopump WCP7 Low Level Alarm	0	100	%	LT-400	LT-400 =< 83	
PAH	401	006	Cryopump WCP7 High Pressure Alarm	0	25	PSIG	PT-401	PT-401 >= 10	
TAH	402	006	Cryopump WCP7 High Temp Alarm	-320	700	Deg F	TE-402	TE-402 >= 185	
TAH	403A	006	Cryopump WCP7 Heater High Temp Alarm	-320	700	Deg F	TE-403A	TE-403A >= 200	
TAH	403B	006	Cryopump WCP7 Heater High Temp Alarm	-320	700	Deg F	TE-403B/C	TE-403B >= TBD	
LAL	405	006	Dewer WCP7 Low Level Alarm	0	100	%	LT-405	LT-405 =< 10	
			Cryopump WCP8						
LAH	500	006	Cryopump WCP8 High Level Alarm	0	100	%	LT-500	LT-500 >=98	
LAL	500	006	Cryopump WCP8 Low Level Alarm	0	100	%	LT-500	LT-500 =< 83	
PAH	501	006	Cryopump WCP8 High Pressure Alarm	0	25	PSIG	PT-501	PT-501 >= 10	
TAH	502	006	Cryopump WCP8 High Temp Alarm	-320	700	Deg F	TE-502	TE-502 >= 185	
TAH	503A	006	Cryopump WCP8 Heater High Temp Alarm	-320	700	Deg F	TE-503A	TE-503A >= 200	
TAH	503B	006	Cryopump WCP8 Heater High Temp Alarm	-320	700	Deg F	TE-503B/C	TE-503B >= TBD	
LAL	505	006	Dewer WCP8 Low Level Alarm	0	100	%	LT-505	LT-505 =< 10	

ATTACHMENT-D

LOUISIANA SITE SOFTWARE ALARM LISTING

LOUISIANA SITE SOFTWARE ALARM LISTING				RANGE SETTINGS			PROPOSED ALARMING		
V049-2-092 ATTACHMENT-D REV. 0				LOW RANGE	HIGH RANGE	UNITS	ALARM TRIP ELEMENT	TRIP SET POINT OR SWITCH TRIP ACTION	DELAY TIME SECONDS)
TAG #		PID #	SERVICE DESCRIPTION	OFF-IND.	ON-IND.				
			Cryopump LCP1						
LAH	600	006	Cryopump LCP1 High Level Alarm	0	100	%	LT-600	LT-600 >=98	
LAL	600	006	Cryopump LCP1 Low Level Alarm	0	100	%	LT-600	LT-600 =< 83	
PAH	601	006	Cryopump LCP1 High Pressure Alarm	0	25	PSIG	PT-601	PT-601 >= 10	
TAH	602	006	Cryopump LCP1 High Temp Alarm	-320	700	Deg F	TE-602	TE-602 >= 185	
TAH	603A	006	Cryopump LCP1 Heater High Temp Alarm	-320	700	Deg F	TE-603A	TE-603A >= 200	
TAH	603B	006	Cryopump LCP1 Heater High Temp Alarm	-320	700	Deg F	TE-603B/C	TE-603B >= TBD	
LAL	605	006	Dewer LCP1 Low Level Alarm	0	100	%	LT-605	LT-605 =< 10	
			Cryopump LCP2						
LAH	650	006	Cryopump LCP2 High Level Alarm	0	100	%	LT-650	LT-650 >=98	
LAL	650	006	Cryopump LCP2 Low Level Alarm	0	100	%	LT-650	LT-650 =< 83	
PAH	651	006	Cryopump LCP2 High Pressure Alarm	0	25	PSIG	PT-651	PT-651 >= 10	
TAH	652	006	Cryopump LCP2 High Temp Alarm	-320	700	Deg F	TE-652	TE-652 >= 185	
TAH	653A	006	Cryopump LCP2 Heater High Temp Alarm	-320	700	Deg F	TE-653A	TE-653A >= 200	
TAH	653B	006	Cryopump LCP2 Heater High Temp Alarm	-320	700	Deg F	TE-653B/C	TE-653B >= TBD	
LAL	655	006	Dewer LCP2 Low Level Alarm	0	100	%	LT-655	LT-655 =< 10	
			Cryopump LCP3						
LAH	700	006	Cryopump LCP3 High Level Alarm	0	100	%	LT-700	LT-700 >=98	
LAL	700	006	Cryopump LCP3 Low Level Alarm	0	100	%	LT-700	LT-700 =< 83	
PAH	701	006	Cryopump LCP3 High Pressure Alarm	0	25	PSIG	PT-701	PT-701 >= 10	
TAH	702	006	Cryopump LCP3 High Temp Alarm	-320	700	Deg F	TE-702	TE-702 >= 185	
TAH	703A	006	Cryopump LCP3 Heater High Temp Alarm	-320	700	Deg F	TE-703A	TE-703A >= 200	
TAH	703B	006	Cryopump LCP3 Heater High Temp Alarm	-320	700	Deg F	TE-703B/C	TE-703B >= TBD	
LAL	705	006	Dewer LCP3 Low Level Alarm	0	100	%	LT-705	LT-705 =< 10	
			Cryopump LCP4						
LAH	800	006	Cryopump LCP4 High Level Alarm	0	100	%	LT-800	LT-800 >=98	
LAL	800	006	Cryopump LCP4 Low Level Alarm	0	100	%	LT-800	LT-800 =< 83	
PAH	801	006	Cryopump LCP4 High Pressure Alarm	0	25	PSIG	PT-801	PT-801 >= 10	
TAH	802	006	Cryopump LCP4 High Temp Alarm	-320	700	Deg F	TE-802	TE-802 >= 185	
TAH	803A	006	Cryopump LCP4 Heater High Temp Alarm	-320	700	Deg F	TE-803A	TE-803A >= 200	
TAH	803B	006	Cryopump LCP4 Heater High Temp Alarm	-320	700	Deg F	TE-803B/C	TE-803B >= TBD	
LAL	805	006	Dewer LCP4 Low Level Alarm	0	100	%	LT-805	LT-805 =< 10	

Title:

LIGO VACUUM EQUIPMENT; V59049

O RING SPECIFICATION

PROJECT ENGINEER S. Moten

TECHNICAL DIRECTOR [illegible]

QUALITY ASSURANCE [illegible]

PROJECT MANAGER [illegible]

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
Φ	Sm 12/27/95	Dm [illegible] 96	RELEASED PER DED 0035

PROCESS SYSTEMS INTERNATIONAL, INC.

SPECIFICATION

INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number	Rev
	Sm	12/27/95	REB	12/27/95	A V049-2-045	Φ

Title

O RING SPEC. V049-2-045

SM LIGOV7.WB1

SERVICE : ULTRA HIGH VACUUM SEALS

MATERIAL: MOLDED CORD STOCK; CERTIFIED DUPONT VITON E-60C

DUROMETER : 75

JOINTS : VULCANIZED SPLICE

CROSS-SECTION DIAMETER : 0.275 + - 0.006 INCHES

DEVELOPED LENGTH : SEE TABLE 1

SPECIAL REQUIREMENTS:

1.O RINGS SHALL BE SUPPLIED SUITABLE FOR ULTRA HIGH VACUUM SERVICE. ORINGS MUST BE SUPPLIED CONSISTENT WITH CLASS 100 CLEAN ROOM STANDARDS. HANDLING AND PACKAGING TO PREVENT CONTAMINATION FROM DIRT, HYDROCARBONS (OILS,GREASES,FINGERPRINTS ETC.),GRIT,CHIPS, MANUFACTURING RESIDUES,PARTICULATES (DUST,HAIR,LINT ETC.) IS REQUIRED.SUPPLIER MUST SUBMIT HANDLING AND PACKAGING PROCEDURES TO PSI, FOR APPROVAL, PRIOR TO MANUFACTURING O RINGS.

2. O RINGS SHALL BE INDIVIDUALLY PACKAGED IN SEALED PROTECTIVE POLYETHYLENE PLASTIC BAGS.BAGS SHALL BE PUNCTURE RESISTANT AND AIR TIGHT. BAGS SHALL BE MARKED WITH PART NO.,FLANGE SIZE,CORD LENGTH, AND LOT NO.

3. O RINGS WILL BE VACUUM BAKED BY PSI TO REMOVE (OFF-GAS) WATER, VOLATILE COMPOUNDS , AND GASSES, REMAINING IN THE BULK VITON. BAKING WILL BE DONE AT 150 C (300 F) , 1 E-4 TORR.

Number

Rev.

SPECIFICATION

Number	Rev.
A V049-2-045	Ø

Title

O RING SPEC. V049-2-045

SM LIGOV7.WB1

TABLE 1

PART NO.	FLANGE SIZE	CROSS SECT. INCHES	CORD LENGTH INCHES	REF. DWG.
V049M016	104	0.275 + - 0.006	337.5	V049-4-022
V049M017	104	0.275 + - 0.006	328.125	V049-4-022
V049M018	84	0.275 + - 0.006	274.375	V049-4-021
V049M019	84	0.275 + - 0.006	265.125	V049-4-021
V049M020	72	0.275 + - 0.006	237.125	V049-4-020
V049M021	72	0.275 + - 0.006	227.75	V049-4-020
V049M022	60	0.275 + - 0.006	200.625	V049-4-019
V049M023	60	0.275 + - 0.006	191.25	V049-4-019
V049M024	48	0.275 + - 0.006	162.5	V049-4-018
V049M025	48	0.275 + - 0.006	153.125	V049-4-018
V049M026	44	0.275 + - 0.006	150	V049-4-017
V049M027	44	0.275 + - 0.006	140.75	V049-4-017
V049M028	30	0.275 + - 0.006	106.5	V049-4-016
V049M029	30	0.275 + - 0.006	97.188	V049-4-016

Number

Rev.

SPECIFICATION

Number A V049-2-045 Rev. D

Title: **SPECIFICATION FOR STAINLESS STEEL VESSEL PLATE**

SPECIFICATION FOR

STAINLESS STEEL VESSEL PLATE

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: D. Curtis D. Curtis

STRUCTURAL ENGINEER: R D. Watts

QUALITY ASSURANCE: A L Budlong

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	REL. 4/26/96	D M W	RELEASED FOR FDR AND MAT'L. PURCHASE DEO 0142
0	D. M W		RELEASE PER DEO 0021 (MAT'L PROCUREMENT)

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number V049-2-041	Rev. 1
	R.E.C. 11/21/95	R C B 11/27/95		

SPECIFICATION TABLE OF CONTENTS

Number

Rev.

1.0 SCOPE

This specification covers the minimum technical requirements for the materials, fabrication, inspection, testing, preparation for shipping, shipment and delivery of the plate to be used for manufacturing ultra high vacuum boundary equipment.

All attachments are incorporated herein by reference and made a part of this specification.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE AND DELIVERY

Plate shall be delivered in lots as follows:

PSI Part No.	Lot No.	Plate Size	Qty	Destination	Date
V049M149 1	1.	1/4 x 84 x 254	2	PSI, Westborough	1 July 1996
V049M150 1	1.	1/4 x 63 x 254	2	PSI, Westborough	1 July 1996
V049M151 1	1.	1/4 x 80 x 144	2	PSI, Westborough	1 July 1996
V049M152 1	1.	1/4 x 49 x 254	2	PSI, Westborough	1 July 1996
V049M153 1	1.	1/4 x 62 x 192	2	PSI, Westborough	1 July 1996
V049M154 1	1.	1/4 x 120 x 229	13	PSI, Westborough	1 July 1996
V049M155 1	1.	1/4 x 72 x 229	1	PSI, Westborough	1 July 1996
V049M156 1	1.	1/4 x 99 x 120	6	PSI, Westborough	1 July 1996
V049M157 1	1.	1/4 x 90 x 98	4	PSI, Westborough	1 July 1996
V049M158 1	1.	1/4 x 66 x 142	2	PSI, Westborough	1 July 1996
V049M159 1	1.	1/4 x 96 x 142	1	PSI, Westborough	1 July 1996
V049P7815 14	1.	1/2 x 76 x 270	7	PSI, Westborough	1 July 1996
V049P7817 14	1.	1/2 x 62 x 195	6	PSI, Westborough	1 July 1996
V049M163 1	1.	1/4 x 72 x 154	4	PSI, Westborough	1 July 1996
V049M164 1	1.	1/4 x 96 x 229	1	PSI, Westborough	1 July 1996
V049M166 1	1.	1/4 x 88 x 154	2	PSI, Westborough	1 July 1996
V049P7801 14	1.	1/2 x 91 1/2 x 333	5	PSI, Westborough	1 July 1996
V049P7802 14	1.	1/4 x 60 x 332	5	PSI, Westborough	1 July 1996
V049P7803 14	1.	1/2 x 72 x 195	5	PSI, Westborough	1 July 1996

Number

Rev.

SPECIFICATION FOR STAINLESS STEEL VESSEL PLATE

PSI Part No.	Lot No.	Plate Size	Qty	Destination	Date
V049M170 1	2.	1/4 x 40 x 144	2	PSI, Westborough	1 November 1996
V049M171 1	2.	1/4 x 84 x 229	2	PSI, Westborough	1 November 1996
V049M154 1	2.	1/4 x 120 x 229	2	PSI, Westborough	1 November 1996
V049M156 1	2.	1/4 x 99 x 120	6	PSI, Westborough	1 November 1996
V049M174 1	2.	1/4 x 54 x 192	2	PSI, Westborough	1 November 1996
V049M175 1	2.	1/4 x 70 x 229	8	PSI, Westborough	1 November 1996
V049M158 1	2.	1/4 x 66 x 142	2	PSI, Westborough	1 November 1996
V049M177 1	2.	3/8 x 96 x 192	2	PSI, Westborough	1 November 1996
V049M178 1	2.	1/4 x 88 x 142	2	PSI, Westborough	1 November 1996
V049M159 1	2.	1/4 x 96 x 142	2	PSI, Westborough	1 November 1996
V049M166 1	2.	1/4 x 88 x 154	4	PSI, Westborough	1 November 1996
V049P7815 14	2.	1/2 x 76 x 270	6	PSI, Westborough	1 November 1996
V049P7817 14	2.	1/2 x 62 x 195	6	PSI, Westborough	1 November 1996
V049P7801 14	2.	1/2 x 91 1/2 x 333	5	PSI, Westborough	1 November 1996
V049P7802 14	2.	1/4 x 60 x 332	5	PSI, Westborough	1 November 1996
V049P7803 14	2.	1/2 x 72 x 195	5	PSI, Westborough	1 November 1996
V049M152 1	2.	1/4 x 49 x 254	3	PSI, Westborough	1 November 1996

PSI Part No.	Lot No.	Plate Size	Qty.	Destination	Date
V049M174 1	3.	1/4 x 54 x 192	1	PSI, Westborough	1 February 1997
V049M175 1	3.	1/4 x 70 x 229	4	PSI, Westborough	1 February 1997
V049M149 1	3.	1/4 x 84 x 254	2	PSI, Westborough	1 February 1997
V049M150 1	3.	1/4 x 63 x 254	2	PSI, Westborough	1 February 1997
V049M152 1	3.	1/4 x 49 x 254	4	PSI, Westborough	1 February 1997
V049M170 1	3.	1/4 x 40 x 144	6	PSI, Westborough	1 February 1997
V049M157 1	3.	1/4 x 90 x 98	2	PSI, Westborough	1 February 1997
V049M156 1	3.	1/4 x 99 x 120	6	PSI, Westborough	1 February 1997
V049M154 1	3.	1/4 x 120 x 229	16	PSI, Westborough	1 February 1997
V049M159 1	3.	1/4 x 96 x 142	2	PSI, Westborough	1 February 1997
V049M198 1	3.	1/4 x 55 x 154	2	PSI, Westborough	1 February 1997
V049M164 1	3.	1/4 x 96 x 229	1	PSI, Westborough	1 February 1997
V049M153 1	3.	1/4 x 62 x 192	2	PSI, Westborough	1 February 1997
V049M177 1	3.	3/8 x 96 x 192	1	PSI, Westborough	1 February 1997
V049M158 1	3.	1/4 x 66 x 142	2	PSI, Westborough	1 February 1997
V049M155 1	3.	1/4 x 72 x 229	1	PSI, Westborough	1 February 1997
V049P7801 14	3.	1/2 x 91 1/2 x 333	5	PSI, Westborough	1 February 1997
V049P7802 14	3.	1/4 x 60 x 332	5	PSI, Westborough	1 February 1997
V049P7803 14	3.	1/2 x 72 x 195	5	PSI, Westborough	1 February 1997
V049P7817 14	3.	1/2 x 62 x 195	7	PSI, Westborough	1 February 1997
V049P7815 14	3.	1/2 x 76 x 270	7	PSI, Westborough	1 February 1997

3.0 MATERIAL REQUIREMENTS

3.1 This material shall conform to the requirements of ASME Specification SA-240 Type 304/304L with the additional supplementary requirements described in this specification. The material is to be dual certified to meet the material grade of 304 and 304L.

3.2 Applicable Codes

3.2.1 ASME Boiler & Pressure Vessel Code, Section II, "Materials", the 1992 Edition with the 1994 Addenda.

3.2.2 ASTM A-480, "Standard Specification for General Requirements for Flat-Roll Stainless and Heat-Resisting Steel Plate, Sheet, and Strip".

3.2.3 ASTM A-700, "Standard Packages for Packaging, marking, and Loading Methods for Steel Products for Domestic Shipment".

3.3 Any apparent conflicts between the requirements given herein and the applicable ASME Specification shall be brought to the attention of PSI for clarification.

4.0 MANUFACTURE

4.1 Thickness Tolerance

The material shall be furnished in the thickness(es) specified in the purchase order. The thickness tolerance shall meet ASTM A-480 requirements.

4.2 Width and Length Tolerance

The plate material shall be cut to the minimim size specified in the purchase order. The width and length plus tolerance of the finished material shall not exceed the tolerances specified in ASME SA-480 specification, the minus tolerance is 0.0 in..

4.3 Surface Finish

Hot rolled, Annealed, and Pickled (HRAP) mill finish is acceptable.

4.4 Chemistry and Mechanical Properties

The material shall meet the chemistry requirements as specified in SA 240 Type 304L, and the mechanical requirement of SA240 Type 304 material specification.

4.4.1 The material shall be dual certified as type 304/304L.

4.5 After final cleaning and pickling, no grinding with abrasive wheels, cloth or stones is permitted. No iron, carbon steel or other contaminants (such as grease, cloride compounds, oil hydrocarbons) to come in contact with the plate.

4.6 Cleanliness

This material is intended for use in a high vacuum application. Potential hydrocarbon contamination shall be eliminated. Also, the material shall be wrapped and covered at all times the material is not being processed to minimize possible exposure to contaminants. The plate shall be cleaned prior to shipment.

5.0 MATERIAL TESTING

5.1 A 2" wide coupon, the width of one plate is to be supplied for each heat number supplied. The coupon must be pickled the same as the plate.

6.0 INSPECTION/WITNESS

6.1 The purchaser shall have the right to witness all manufacturing processes.

7.0 REJECTIONS AND REPAIR OF DEFECTS

7.1 No weld splices or repair welding is permitted to the material.

8.0 IDENTIFICATION

8.1 Identification of the material shall be maintained through all manufacturing processes.

8.2 If material identity is lost, the plate shall be requalified by making all tests that were required for the material or as indicated in this specification.

8.3 Marking the finished materials with marking fluids, die stamps, and/or electro-etching is not permitted. A vibratory tool with a minimum tip radius of .005" is acceptable for marking one side only of the finished plate. All other marking methods must be approved by the purchaser prior to use. All plates shall be marked 6" in from both edges in one corner. When stacked for shipment, all markings shall be in the same corner for easy identification upon receipt at PSI. The minimum marking is to be the heat/lot number.

9.0 DOCUMENTATION

9.1 The Certified Material Test Report (CMTR) shall be provided to the purchaser a minimum of 48 hours prior to shipment of the material.

9.2 A record of the material thickness for each group of materials is required. Thickness shall be measured and recorded at both edges and the center of the plates.

10.0 PACKAGING, STORING AND SHIPPING

10.1 The material shall be packaged for shipment as described in ASTM A700-94, Section 11.3.3 and Figure 56 (wrapped package on skids) with the additional supplementary requirements as described herein.

10.2 The plate material shall be wrapped in waterproof polyethylene and covered with a tarp immediately after all steel processing operations have been completed to minimize contamination. The material shall remain packaged and covered until it is necessary to remove the covering and packaging material for further processing.

10.2 The material shall be shipped as specified in the purchase order.

11.0 NON-ESCORT PRIVILEGES AND INSPECTION RIGHT

Non-escort privileges for Buyer, Owner, Government and Owner representatives to all areas of the facilities where the work is being performed shall be arranged. This will include access to all areas where material is being processed and stored.

ATTACHMENT "A"
LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR: V59049	JOB NO.: V59049
EQUIPMENT: Vacuum Vessel Plate	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-041

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE			X	2	X		
VENDOR Q.A. PLAN			X	2	X		
CLEANING PROCEDURE			X	2	X		
PREP FOR SHIPMENT PROCEDURE			X	2	X		
WELDING PROCEDURES							
ASSEMBLY DRAWINGS							
DESIGN REVIEW							
CERTIFIED MATERIAL TEST REPORTS			X	2	X		
IN-PROCESS INSPECTIONS		X		2	X		
OPERATION & MAINTENANCE MANUALS							
SHOP TEST PLAN							
SHOP TEST (WITH REPORT)							
SHOP DIMENSIONAL INSPECTION		X		2	X		

Title: SPECIFICATION FOR STAINLESS STEEL FLANGE FORGINGS

SPECIFICATION FOR

STAINLESS STEEL FLANGE FORGINGS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: D. Curtis D. Curtis

STRUCTURAL ENGINEER: R.D. Gatto

QUALITY ASSURANCE: A R Bradbrook

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Rick Bayley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
3	REC 9/11/96	MES 9/11/96	REVISED TOLERANCES IN SECTION 4.0. ADDED SCHEDULE SECTION 2.0 DEO# 0117
2	D.M.W 3-15-96	REC for RB	REV SECT 3.5 (MAX SULFUR CONTEN) PER DEO # 0094
1	REC 12/22/95	D McW	REVISED SECT. 3,4, 3.5, 8.1, 9.1 DEO# 0037
0	D McW		ISSUED PER DEO 0021 (MAT'L PROCUREMENT)

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE REC 11/21/95	APPROVED DATE REC 11/27/95	Number A V049-2-040	Rev. 3

SPECIFICATION TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum technical requirements for the materials, fabrication, inspection, testing, preparation for shipping, shipment and delivery of the flange forgings to be used for manufacturing ultra high vacuum boundary equipment.

All attachments are incorporated herein by reference and made a part of this specification.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE OF DELIVERIES

2.1 Flange rings shall be delivered in lots with sizes and quantities as specified in the purchase order.

3.0 MATERIAL REQUIREMENTS

3.1 This material shall conform to the requirements of ASME Specification SA-182 Grade F Type 304L as given in the ASME Code 1992 Edition through 1994 Addenda with the additional supplementary requirements described in this specification.

3.2 Applicable Codes

3.2.1 ASME Boiler & Pressure Vessel Code, Section II, "Materials", 1992 Edition through 1994 Addenda.

3.2.2 ASTM A-700, "Standard Packages for Packaging, marking, and Loading Methods for Steel Products for Domestic Shipment".

3.3 Any apparent conflicts between the requirements given herein and the applicable ASME Specification shall be brought to the attention of PSI for clarification.

4.0 MANUFACTURE

4.1 Thickness Tolerance, + .06 - 0

The forgings shall be rough machined to the thickness(es) specified in the purchase order.

4.2 ID/OD Tolerance, ID -.06+0, OD + .06-0

The forgings shall be furnished in the diameters as specified in the purchase order.

4.2.1 The ID/OD are to be concentric within ± 1/32".

4.3 Flatness Tolerance

The machined forgings shall be flat to ±1/32" across the diameter.

4.4 Surface Finish

The surface finish of the forgings shall be 250/500 RMS on four sides.

4.5 Chemistry and Mechanical Properties

The material shall meet the chemistry and mechanical requirements as specified in SA 182 Grade F, 304L material specification. The final content of sulfur is to be limited to 0.006%.

4.6 No grinding with abrasive wheels, cloths or stones is permitted. No iron carbon steel or other contaminants (such as grease, oil or hydrocarbons) to come in contact with the forging after the cleaning process. Machining fluids shall be water soluble and free of oil and sulfur.

4.7 Cleanliness

The forgings are intended for use in a high vacuum application. Potential hydrocarbon contamination shall be eliminated. Also, the material shall be wrapped and covered at all times the material is not being processed to minimize possible exposure to contaminants. The forgings shall be steam cleaned prior to shipment.

5.0 MATERIAL TESTING

5.1 2" x 2" material coupons for each heat of material, must be supplied to PSI for approval prior to release for shipment. The coupons are to be cut from the same heat number, lot and thickness of material to be supplied.

6.0 INSPECTION/WITNESS

6.1 The purchaser shall have the right to witness all manufacturing processes.

6.2 The purchaser shall be informed 5 working days before the forging material is formed.

7.0 REJECTIONS AND REPAIR OF DEFECTS

7.1 No weld splices or repair welding is permitted to the material and forgings.

8.0 IDENTIFICATION

8.1 Identification of the material shall be maintained through all manufacturing processes.

8.2 If material identity is lost, the forging shall be requalified by making all tests that were required for the material or as indicated in this specification.

8.3 Marking the finished materials with marking fluids, die stamps, and/or electro-etching is not permitted. A vibratory tool with a minimum tip radius of .005" is acceptable for marking the outside only of the finished materials. All other marking methods must be approved by the purchaser prior to use.

9.0 DOCUMENTATION

9.1 The Certified Material Test Report (CMTR) shall be provided to the purchaser with the shipment of the material, and available for review during inspection visits prior to shipment.

9.2 A record of the material thickness for each flange forging is required.

10.0 PACKAGING, STORING AND SHIPPING

10.1 The material shall be cleaned and protected from contamination prior to shipment. The material shall be shipped covered in a closed trailer or tightly wrapped with a waterproof covering if shipped on an open bed.

11.0 NON-ESCORT PRIVILEGES AND INSPECTION RIGHT

Non-escort privileges for Buyer, Owner, Government and Owner representatives to all areas of the facilities where the work is being performed shall be arranged. This will include access to fabrication, assembly, cleaning and test areas for the purpose of monitoring activities.

ATTACHMENT "A"
LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR: V59049	JOB NO.: V59049
EQUIPMENT:Flange Forgings	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO: V049-2-040

TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:	Inspector: Date:
MILESTONE SCHEDULE			X	2	X		
VENDOR Q.A. PLAN			X	2	X		
CLEANING PROCEDURE			X	2	X		
PREP FOR SHIPMENT PROCEDURE			X	2	X		
WELDING PROCEDURES							
ASSEMBLY DRAWINGS							
DESIGN REVIEW							
CERTIFIED MATERIAL TEST REPORTS			X	2	X		
IN-PROCESS INSPECTIONS		X		2	X		
OPERATION & MAINTENANCE MANUALS							
SHOP TEST PLAN							
SHOP TEST (WITH REPORT)							
SHOP DIMENSIONAL INSPECTION		X		2	X		

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Title: SPECIFICATION FOR STAINLESS STEEL VESSEL HEADS

SPECIFICATION FOR

STAINLESS STEEL VESSEL HEADS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: D. Curtis D. Curtis

STRUCTURAL ENGINEER: R. D. Watts

QUALITY ASSURANCE: Alan L Bradbrook

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
2	REL, 4/8/96	D.M.W	ADDED DELIVERY SCHEDULE DEO# 0115
1	REL, 12/28/95	D.M.W	REVISED SECT. 3.7 & 8.1 DEO # 0037.
0	D.M.W		ISSUE PER DEO 0021 (MAT'L. PROCUREMENT)

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number A V049-2-039	Rev. 2
	REL 11/21/95	REB 11/27/95		

SPECIFICATION TABLE OF CONTENTS

1.0 SCOPE

This specification covers the minimum technical requirements for the materials, fabrication, inspection, testing, preparation for shipping, shipment and delivery of the heads to be used for manufacturing ultra-high vacuum boundary equipment.

All attachments are incorporated herein by reference and made a part of this specification.

Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

2.0 SCHEDULE

2.1 Head delivery shall be as follows:

ITEM NO.	PART NO.	I.D.	QTY.	DELIVERY SITE	DATE
1	V049M001-1	104.5	6	PSI, Westborough	15 July 1996
2	V049M001-1	104.5	6	PSI, Westborough	1 Nov. 1996
3	V049M001-1	104.5	3	PSI, Westborough	1 Feb. 1997
4	V049M010-1	104.5	6	PSI, Westborough	15 July 1996
5	V049M010-1	104.5	6	PSI, Westborough	1 Nov. 1996
6	V049M010-1	104.5	3	PSI, Westborough	1 Feb. 1997
7	V049M132-1	84.25	12	PSI, Westborough	15 July 1996
8	V049M132-1	84.25	12	PSI, Westborough	1 Nov. 1996
9	V049M132-1	84.25	12	PSI, Westborough	1 Feb. 1997
10.	V049M002-1	60.5	10	PSI, Westborough	15 July 1996
11	V049M002-1	60.5	10	PSI, Westborough	1 Nov. 1996
12	V049M002-1	60.5	6	PSI, Westborough	1 Feb. 1997
13	V049M138-1	80.0	6	PSI, Westborough	15 July 1996
14	V049M138-1	80.0	6	PSI, Westborough	1 Nov. 1996
15	V049M138-1	80.0	6	PSI, Westborough	1 Feb. 1997
16	V049M138-1	80.0	6	PSI, Westborough	15 Apr. 1997

3.0 MATERIAL REQUIREMENTS

3.1 This material shall conform to the requirements of ASME Specification SA-240 Type 304L with the additional supplementary requirements described in this specification. The material used shall be hot rolled, annealed and pickled. If the material is supplied dual certified to grade 304/304L, this will be acceptable to PSI.

3.2 Applicable Codes

3.2.1 ASME Boiler & Pressure Vessel Code, Section II, "Materials", the 1992 Edition through the 1994 Addenda.

3.2.2 ASTM A-480, "Standard Specification for General Requirements for Flat-Roll Stainless and Heat-Resisting Steel Plate, Sheet, and Strip".

3.2.3 ASTM A-700, "Standard Packages for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment".

3.3 Any apparent conflicts between the requirements given herein and the applicable ASME Specification shall be brought to the attention of PSI for clarification.

4.0 MANUFACTURE

4.1 Thickness Tolerance

The heads shall be furnished in the minimum thickness(es) specified in the purchase order.

4.2 Circumference Tolerance ± 1/8"

4.3 Out-of-Round Tolerance ± 1/4" for 105 in. I.D. Heads, ± 1/8" for 30.5 in. I.D. to 84.5 in. heads.

4.4 Heads to be square trimmed by manufacturer to a flatness tolerance of ± 1/8".

4.5 Heads to be manufactured without center holes. Welding not permitted.

4.6 Surface Finish.

Cold rolled and pickled surface finish is acceptable.

4.7 No grinding with abrasive wheels, cloth or stones is permitted after final cleaning. No iron, carbon steel or other contaminants (such as grease, oil, hydrocarbons) to come in contact with the heads after the pickle process. Machining fluids shall be water soluble and free of oil and sulfur.

4.8 Cleanliness

The heads are intended for use in a high vacuum application. Potential hydrocarbon contamination shall be eliminated. Also, the material shall be wrapped and covered at all times the material is not being processed to minimize possible exposure to contaminants. Heads to be covered with polyethylene sheet for shipment.

5.0 MATERIAL TESTING

5.1 2" x 2" material coupons must be supplied to PSI for approval prior to release for shipment. The coupons are to be cut from the same heat number, lot and thickness of material to be supplied.

6.0 INSPECTION/WITNESS

6.1 The purchaser shall have the right to witness all manufacturing processes.

6.2 The purchaser shall be informed 5 working days before the head material is formed.

7.0 REJECTIONS AND REPAIR OF DEFECTS

7.1 No weld splices or repair welding is permitted to the material or formed heads.

8.0 IDENTIFICATION

8.1 Identification of the material shall be maintained through all manufacturing processes.

8.2 If material identity of the heads is lost, they shall be requalified by making all tests that were required for the material or as indicated in this specification.

8.3 Marking the finished heads with marking fluids, die stamps, and/or electro-etching is not permitted. A vibratory tool with a minimum tip radius of .005" is acceptable for marking the outside only of the finished materials. All other marking methods must be approved by the purchaser prior to use. All heads shall be marked in the straight flange area 2" up from the edge.

9.0 DOCUMENTATION

9.1 The Certified Material Test Report (CMTR) shall be provided to the purchaser with the shipment of the material and available for review during inspection visits prior to shipment.

9.2 A record of the material thickness for each head is required. Thickness shall be measured and recorded at both the knuckle and the center of the head.

10.0 PACKAGING, STORING AND SHIPPING

10.1 The material shall be packaged for shipment as described in ASTM A700-94, Sections 12.4.9 and 12.4.10 with the additional supplementary requirements as described herein.

10.2 The head material shall be wrapped in waterproof polyethylene and covered with a tarp immediately after all steel processing operations have been completed to minimize contamination. The material shall remain packaged and covered until it is necessary to remove the covering and packaging material for further processing.

10.3 The heads shall be shipped as specified in the purchase order.

11.0 NON-ESCORT PRIVILEGES AND INSPECTION RIGHT

Non-escort privileges for Buyer, Owner, Government and Owner representatives to all areas of the facilities where the work is being performed shall be arranged. This will include access to fabrication, assembly, cleaning and test areas for the purpose of monitoring activities.