VOLUME II ATTACHMENTS

ATTACHMENT 5

LIGO-E960965-01-V

4. **SHOCK, VIBRATION, AND ACOUSTICS ANALYSIS**

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

6. **SPECIFICATIONS**

TITLE	DOCUMENT NO.	REVISION
I. Equipment Specifications		
(Deleted)		
Main Roughing Pump Carts	V049-2-001	3
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
6", 10" and 14" Gate Valves	V049-2-006	2
Vacuum Gauges	V049-2-007	1
Bakeout Blanket System	V049-2-009	4
Clean Air Supplies	V049-2-011	1
LN_2 Dewars	V049-2-013	2
Vacuum Jacketed Piping	V049-2-016	1
Bellows Expansion Joints	V049-2-017	5
Ambient Air Vaporizers	V049-2-055	1
80K Pump Regeneration Heater	V049-2-056	1
Small Vacuum Valves	V049-2-059	1
Clean Qtr Turn Valves	V049-2-060	1
Cryogenic Control Valves	V049-2-062	2
Bakeout Cart	V049-2-068	5
80K Pump, Burst Disc	V049-2-138	1

TITLE	DOCUMENT NO.	REVISION
II. Equipment Specifications		
80K Pump, Manual Regen Valve	V049-2-140	1
80K Pump, Vent Heater	V049-2-141	0
Clean Room Fan/Filter Modules	V049-2-142	2
HAM Cleanroom Panels	V049-2-144	0
BSC Cleanroom Panels	V049-2-145	0
Portable Gowning Room	V049-2-157	0
80K Pump, Vent Line Check Valve	V049-2-162	1
80K Pump, Reservoir Relief Valve	V049-2-164	0
80K Pump, Manual Bypass Valve	V049-2-165	0
LN_2 Thermal Relief Valve	V049-2-166	0
LN_2 Manual Cooldown Valve	V049-2-167	0
80K Pump, LN_2 Supply Line Filter	V049-2-176	0
80K Pump, Derime Valves	V049-2-177	0
III. Instrument & Control Specifications		
Deleted		
Instrument List	V049-1-036	2
Personal Computers	V049-2-049	0
Bakeout System Thermocouple Measurement System	V049-2-050	2
T/C Measurement PLC Interface	V049-2-051	1
Bakeout System PC-PlC Interface	V049-2-057	0
Bakeout System PC Interface Software	V049-2-058	0
Flow Meter	V049-2-079	1
Differential Pressure Transmitters	V049-2-088	0
Level Transmitters	V049-2-089	3
Pressure Transmitters	V049-2-090	4
Temperature Elements	V049-2-091	0
Interlocks, Permissives and Software Alarms	V049-2-092	0
IV. Material Specifications		
Piping Design and Material	V049-2-037	3
Stainless Steel Vessel Heads	V049-2-039	4
Stainless Steel Flange Forgings	V049-2-040	6
Stainless Steel Vessel Plate	V049-2-041	3
O-Rings	V049-2-045	5
Rings Cut From Plate	V049-2-134	1

MEASUREMENT AND ANALYSIS OF LIGO VACUUM SYSTEM SHOCK VIBRATION, AND ACOUSTIC NOISE

(Rev. 1)

Prepared by:

Kyle Martini, Klaus Kleinschmidt, Joel Garrelick, Carina Ting

May 6, 1996

Report U-2379-2041

Prepared for:

Process Systems International, Inc.

20 Walkup Drive

Westborough, MA 01581-5003

Cambridge Acoustical Associates, Inc.

200 Boston Avenue, Suite 2500

Medford, MA 02155-4243

TABLE OF CONTENTS

		Page
I.	INTRODUCTION AND SUMMARY	1
II.	LIGO SPECIFICATIONS	2
	A. VIBRATION	2
	B. NOISE	3
	C. SHOCK	3
III.	APPROACH TO SPECIFICATION COMPLIANCE	3
	A. OVERALL PLAN	3
	B. SOURCES OF EQUIPMENT VIBRATION, NOISE, AND SHOCK	4
	C. VERIFICATION TESTING	5
	D. VIBRATION MITIGATION	8
	E. NOISE MITIGATION	11
	F. SHOCK MITIGATION	12
IV.	SOURCE MEASUREMENTS	13
V.	TRANSMISSION ANALYSIS	13
	A. VIBRATION	13
	B. NOISE	21
VI.	LIGO COMMISSION TESTING	24
	REFERENCES	26
FIGURES		27-39

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:

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

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

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

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. $Y_j \quad (Z_j)^{-1} \quad [(1 \; i)\omega(\rho h/k_f)/2]^{-1}$ 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 $\gamma \; [1 \; \Omega^{-2}]^{1/4}$ 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} $(4/\sqrt{3}(\rho ch^2)_i$ is the drive point impedance of the manifold plating assumed to be of infinite extent [12] and Z_{pltg}/Z_{slab} $(\rho ch^2)_i/(\rho ch^2)_{slab}$«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.

REFERENCES

1 Vacuum Equipment Specification, LIGO Facility, LIGO-E94-0002-01-V, Rev. 1, 28 March 1995, p.11.

2 C.M. Harris, Handbook of Acoustical Measurements and Noise Control, (3rd Ed., McGraw-Hill Book Co., NY, 1991)pp. 43.4-43.5.

3 J.S. Bendat and A.G. Piersol, Engineering Applications of Correlation and Spectral Analysis, (John Wiley & Sons, NY, 1980) pp. 264-270.

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

5 C.M. Harris and C.E. Crede (Ed), Shock and Vibration Handbook, Vol. 1, (McGraw-Hill Book Co., NY, 1961)pp. 10.24-10.25.

6 The NASTRAN" Theoretical Manual, NASA SP-221(04), National Aeronautics and Space Administration, Washington, DC (1977).

7 LIGO Technical Foundation Analyses Executive Summary and Discussions, The Ralph M. Parsons Company Contract Number: PP150969, December 4, 1995.

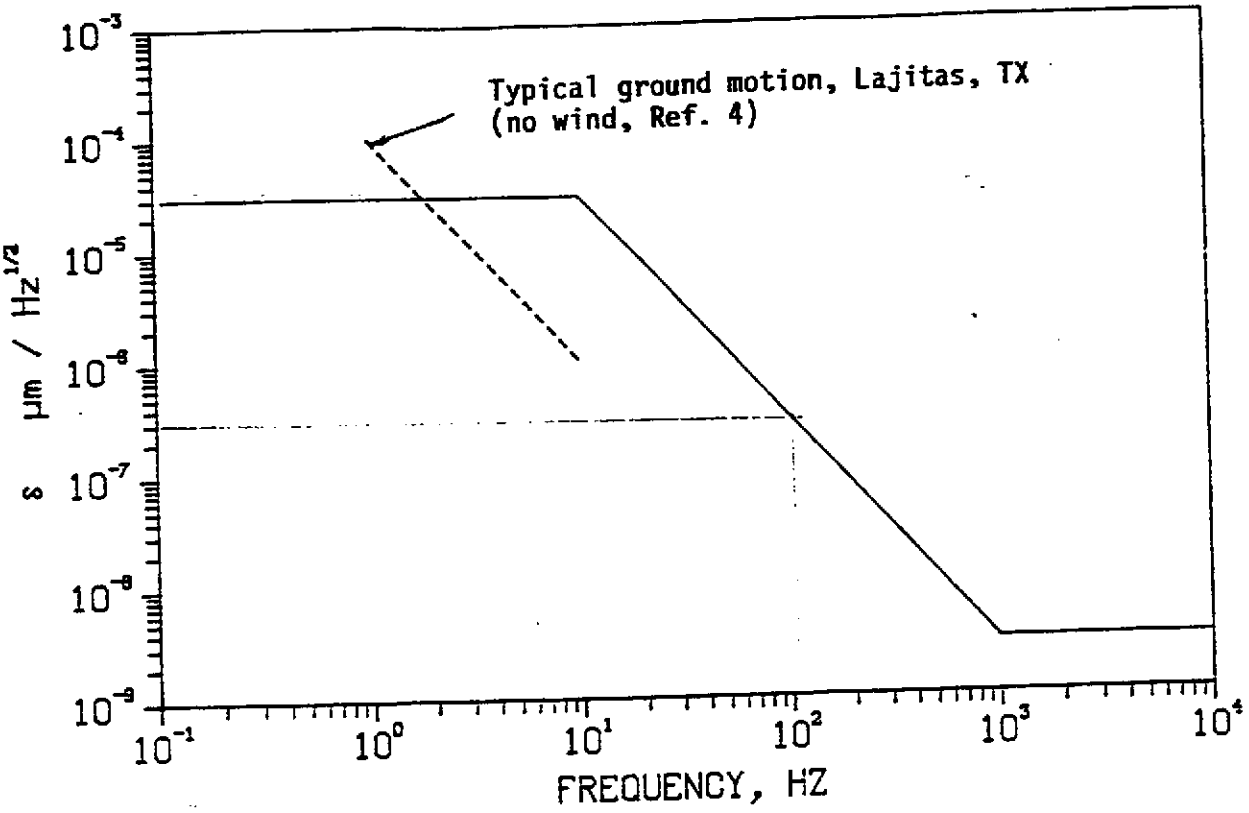
8. Richard H. Lyon, Statistical Energy Analysis of Dynamical Systems, The MIT Press, Cambridge, MA, 1975.

9. S. H. Crandall and R. Lotz, On the Coupling Loss Factor in Statistical Energy Analysis, J. Acoust. Soc. Am., 49, 352-356 (1971). Also, J. Garrelick, Dynamic Response of Coupled Systems: A Comparison Between Statistical Energy and Deterministic Systems, CAA Technical Report U-392-213 prepared for The Office of Naval Research under Contract N-00014-69-C-0056 , Structural Mechanics Program, September 1972.

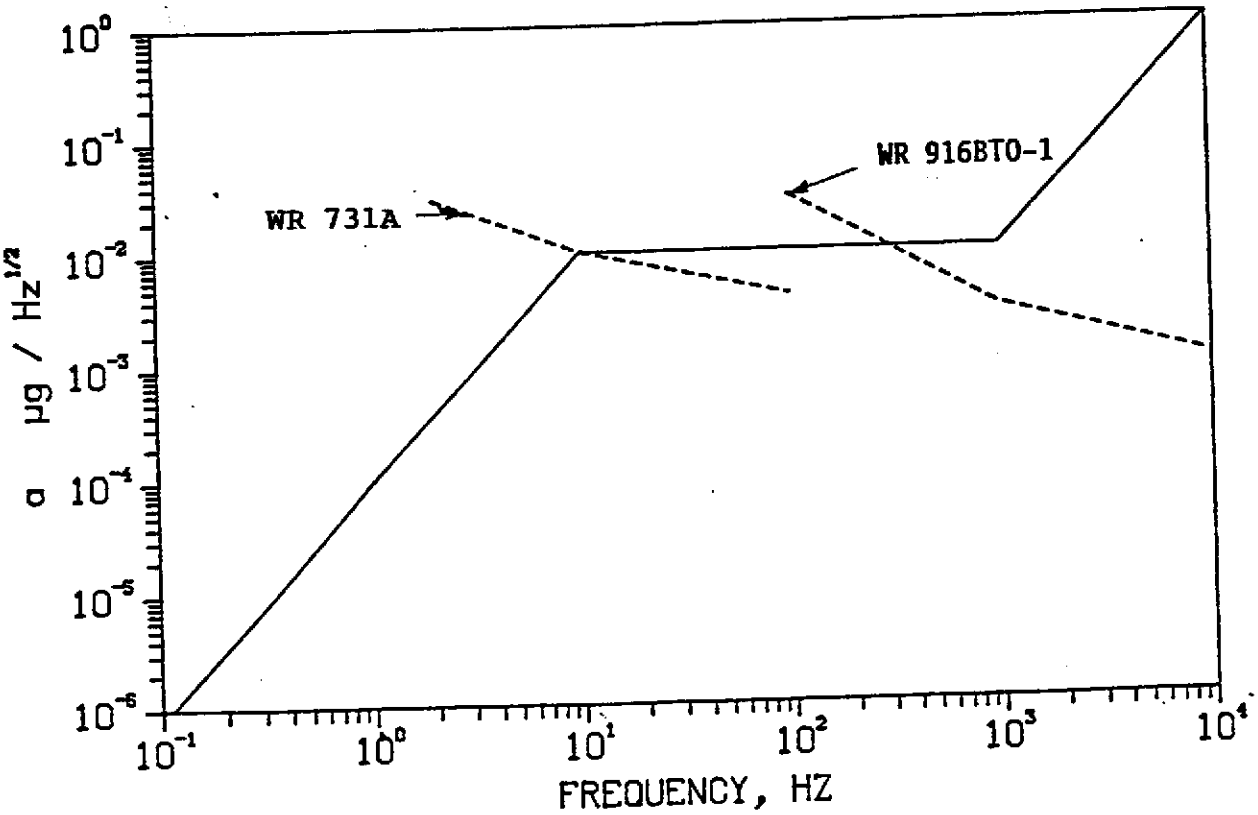
10. L. Cremer, M. Heckl and E.E. Ungar, Structure-borne Sound, Springer-Verlag, Berlin, 1973, Ch V.

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

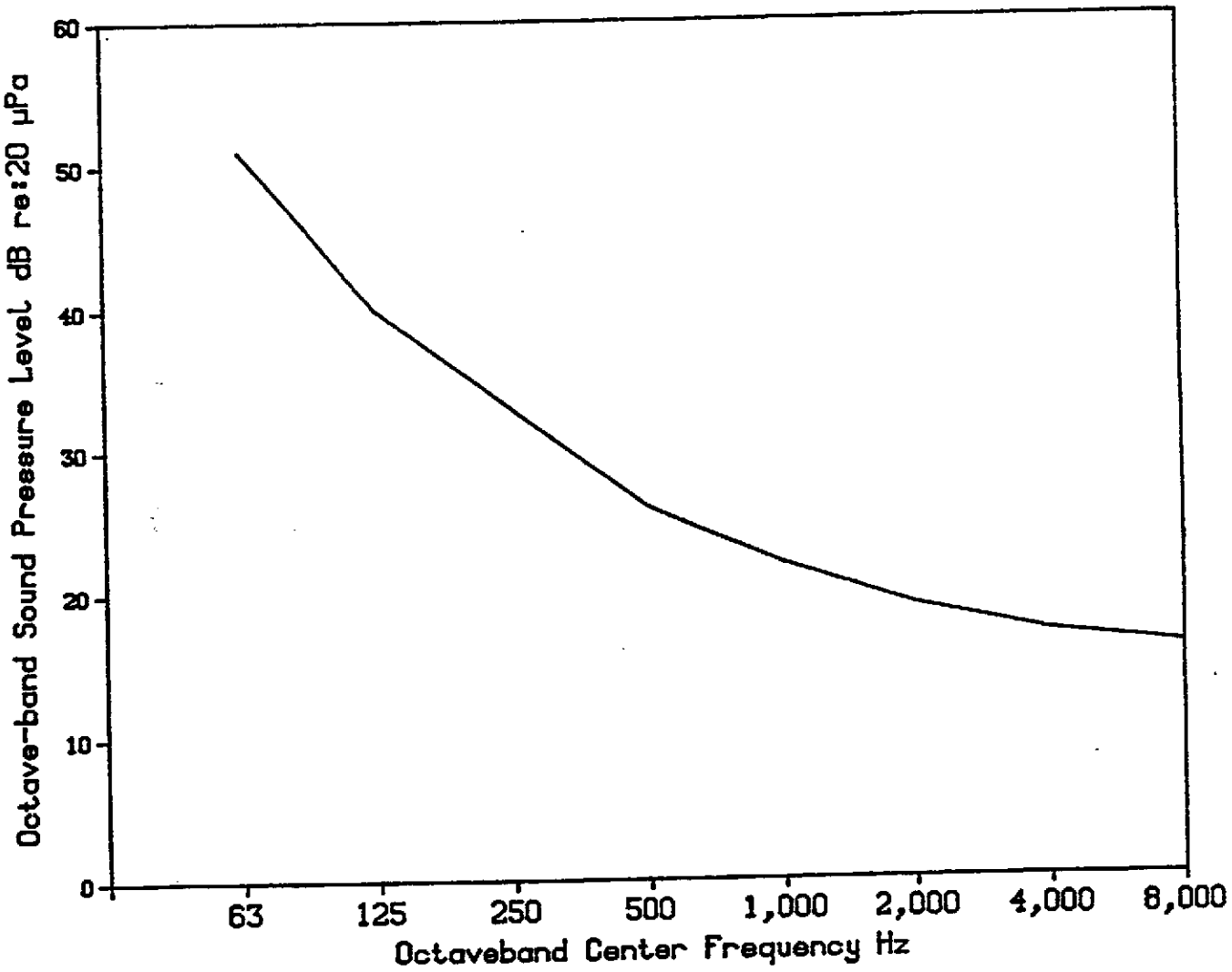


Fig. 2 Noise criterion-20 (NC-20) octave band sound pressure levels.

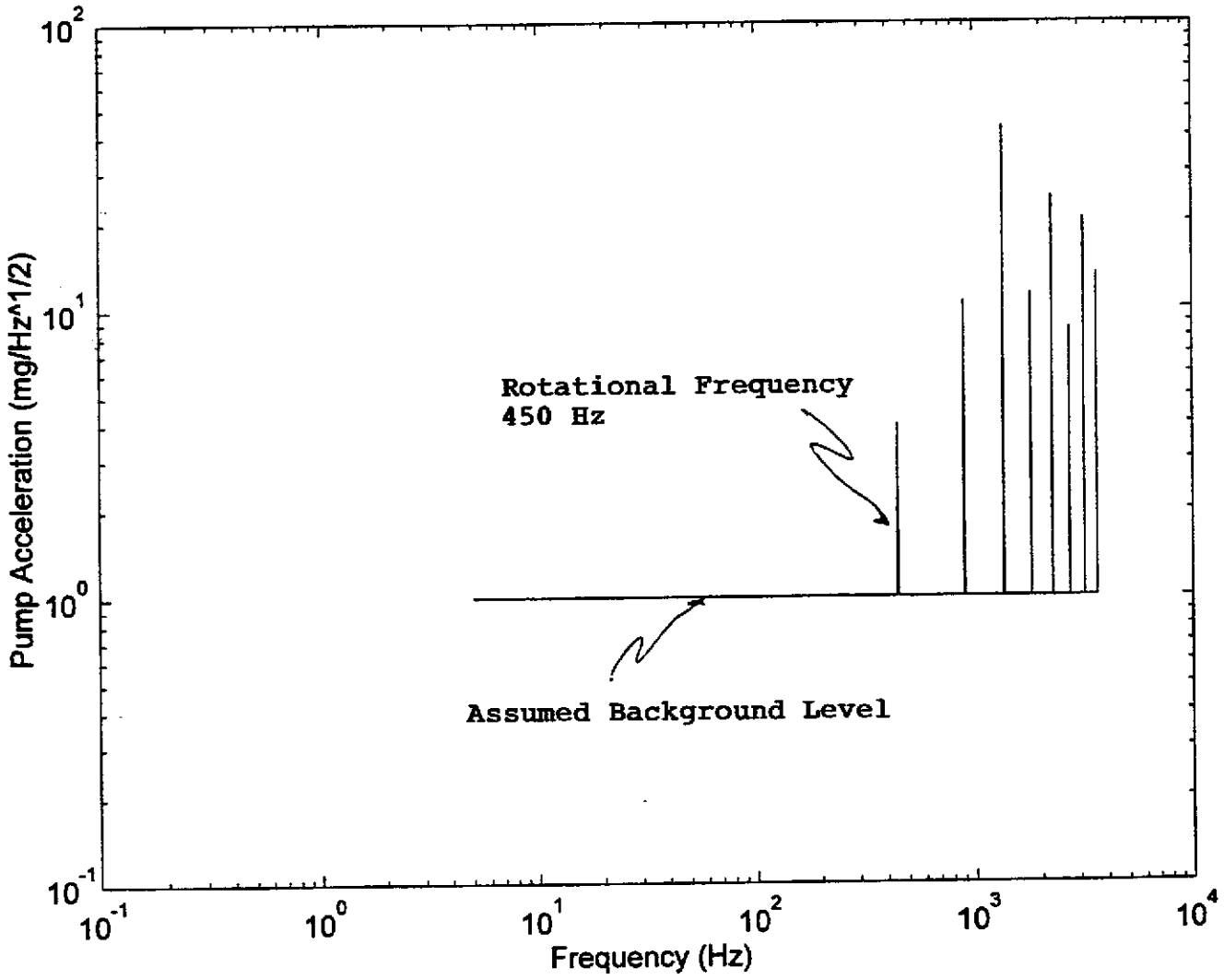


Fig. 3 Estimated source level of turbomolecular pump.

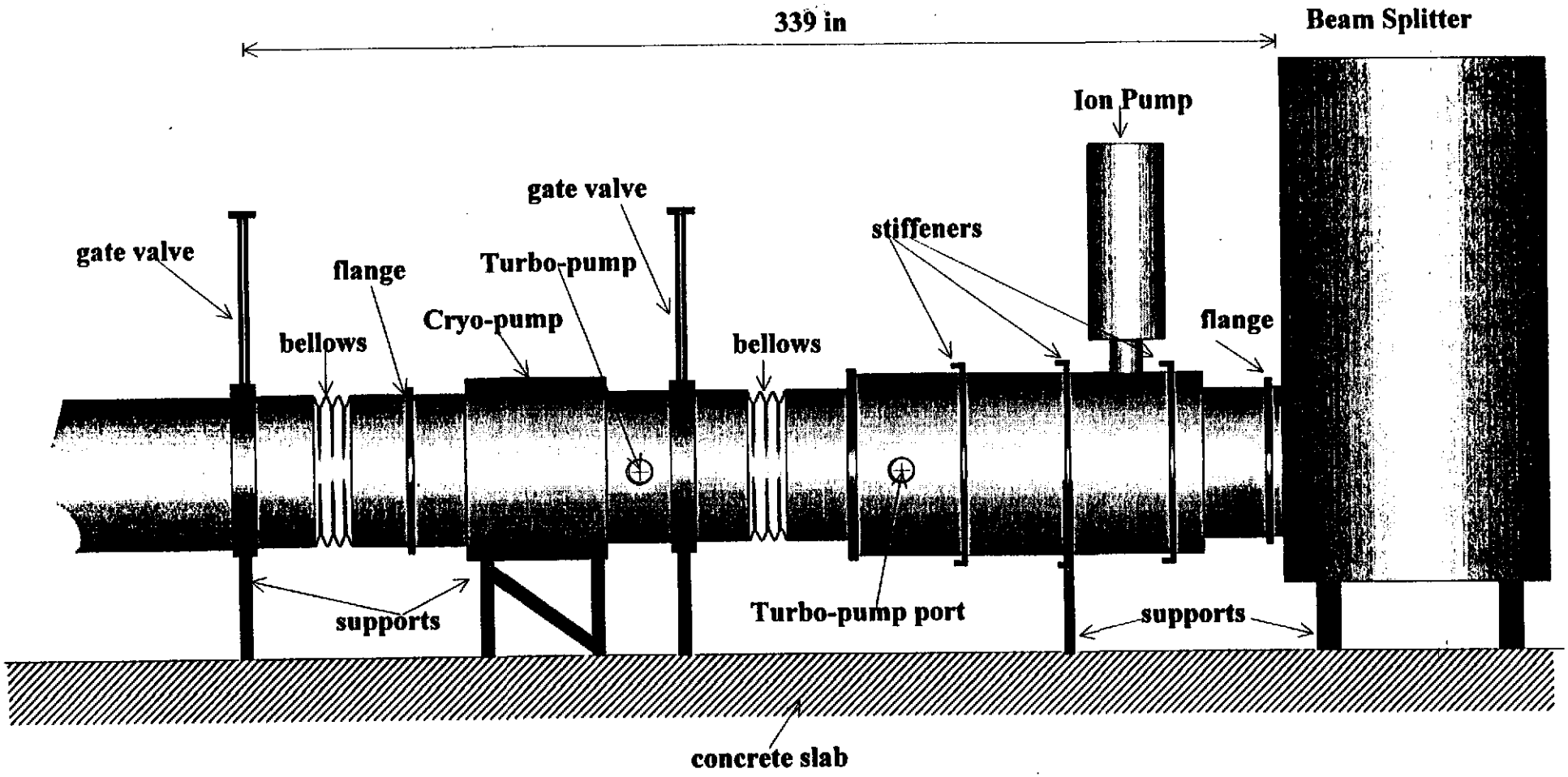


Fig. 4 Sketch of end station vacuum equipment.

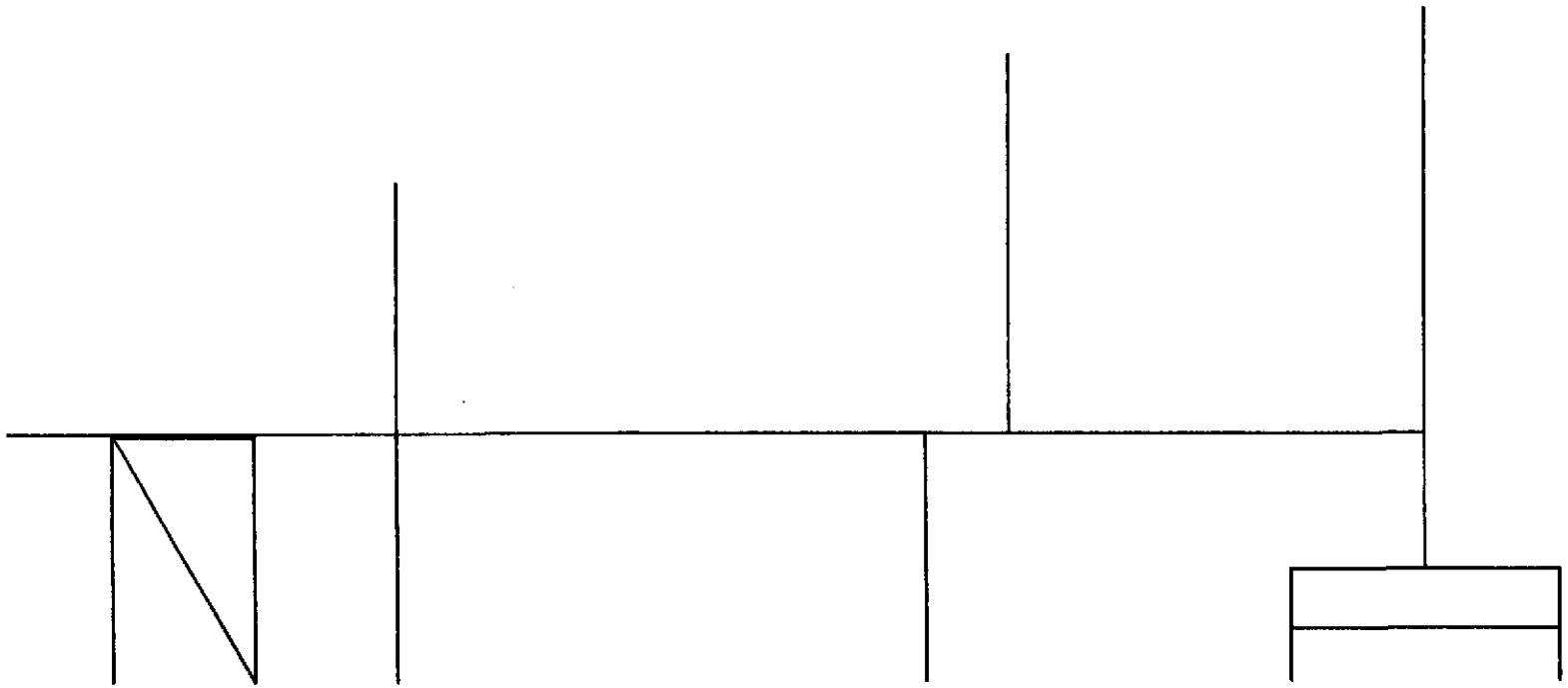


Fig. 5 Nastran plot of low frequency beam model.

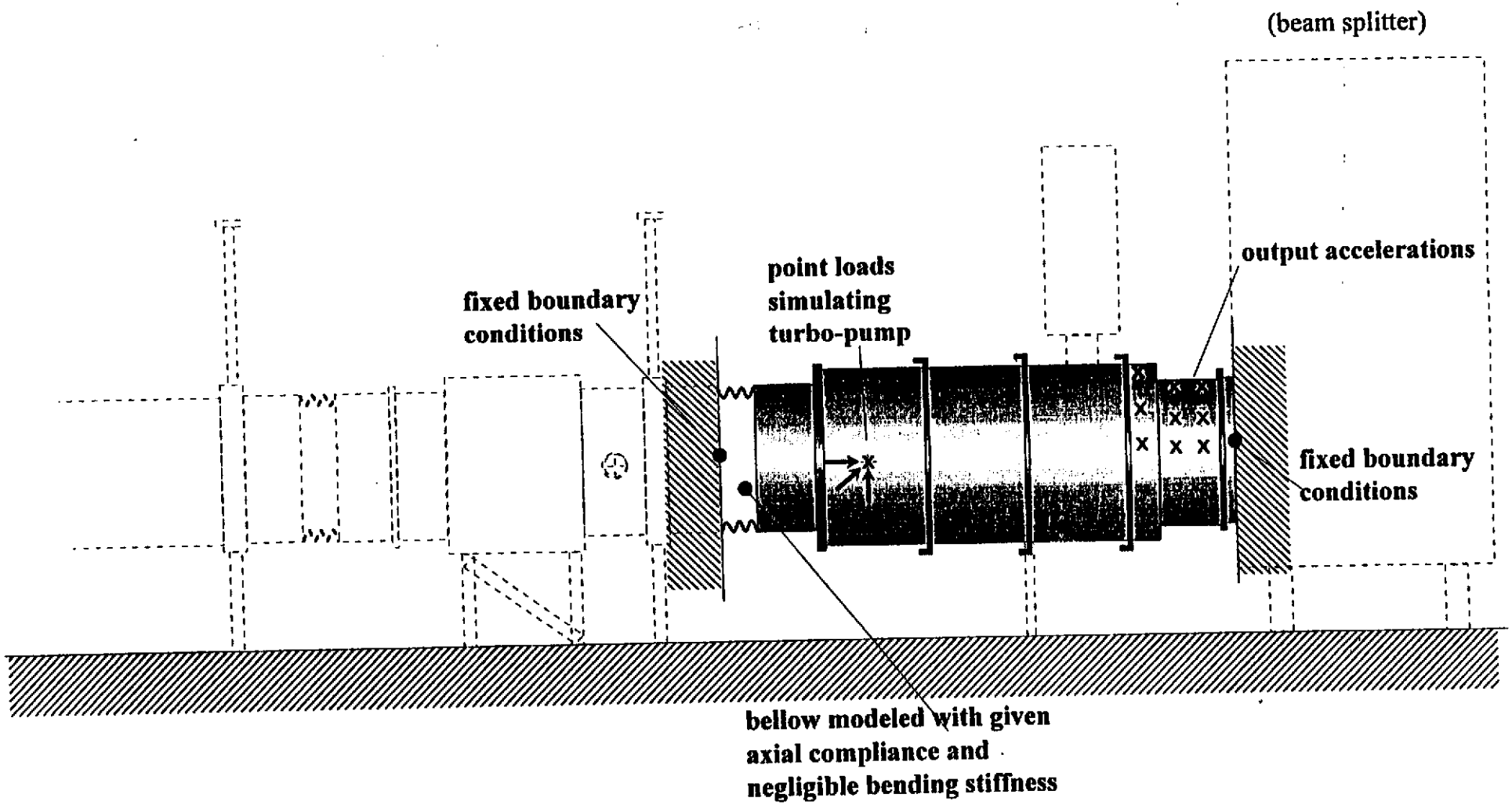


Fig. 6 Portion of end station included in midfrequency model.

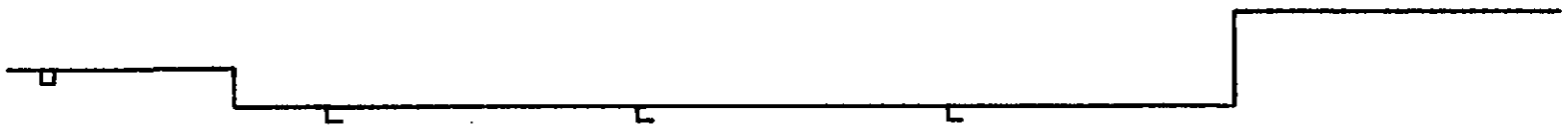


Fig. 7 Nastran plot of midfrquency axisymmetric model.

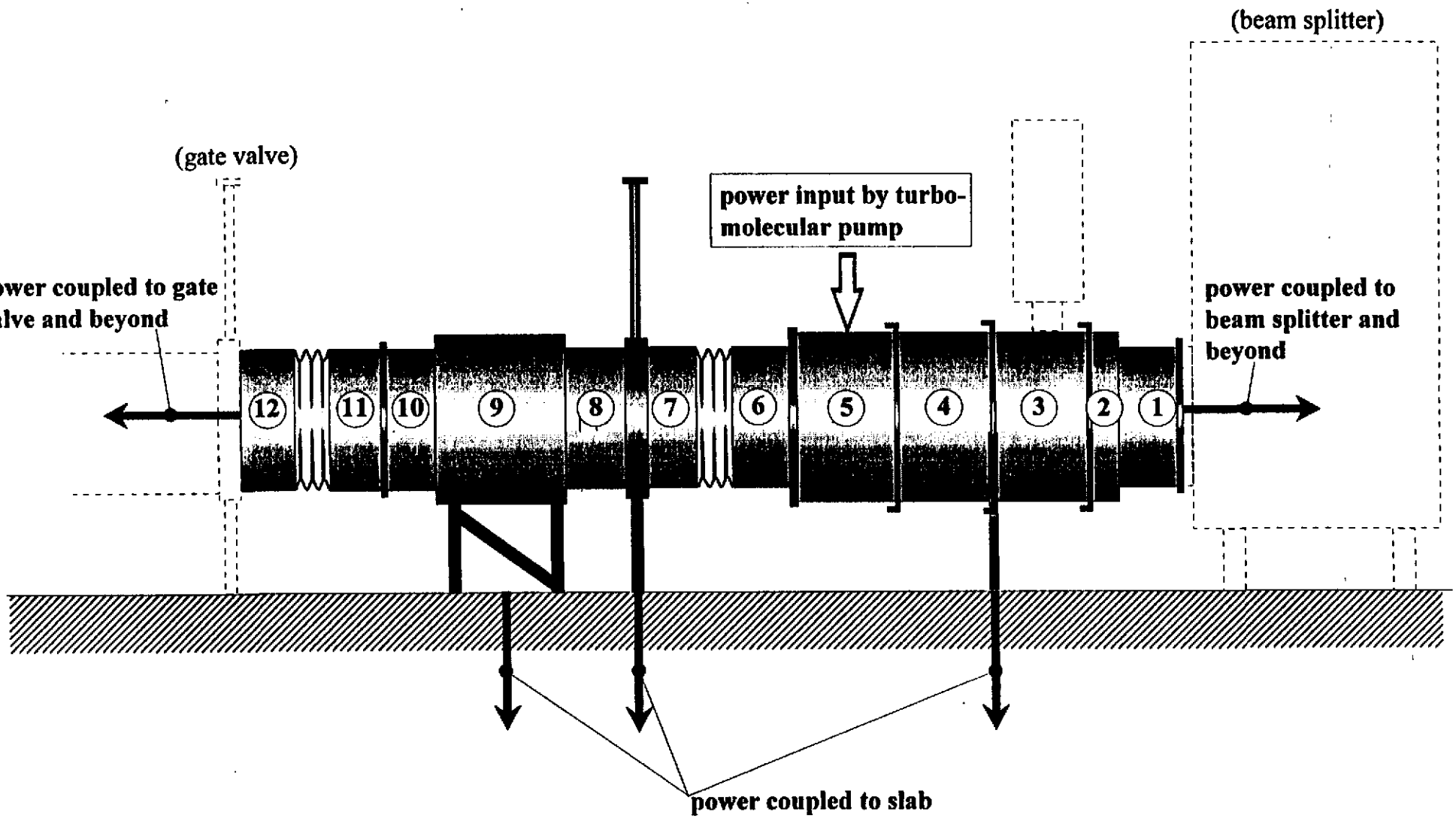
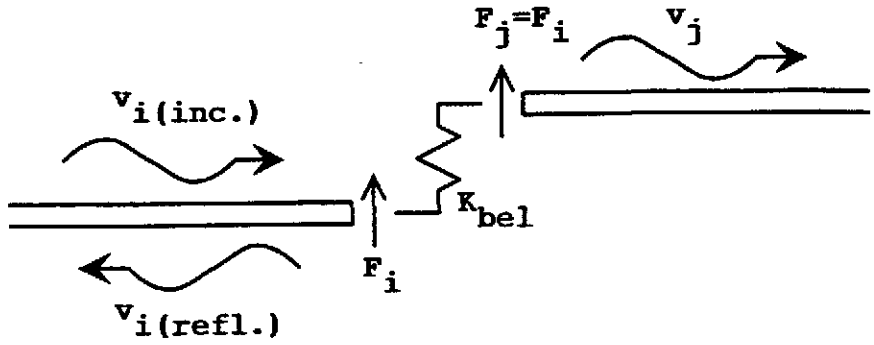
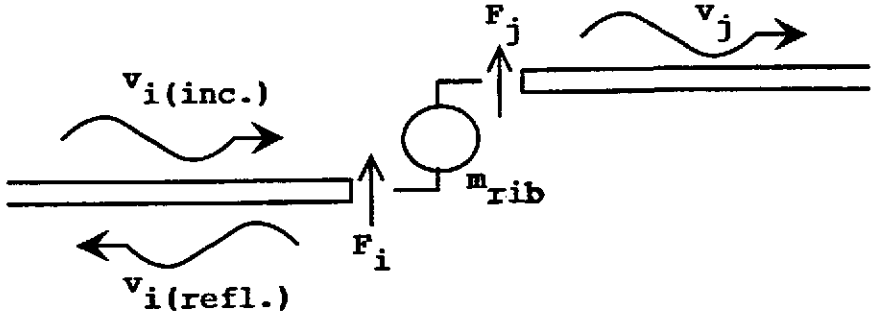


Fig. 8 SEA subsystem representation of end section structure.

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

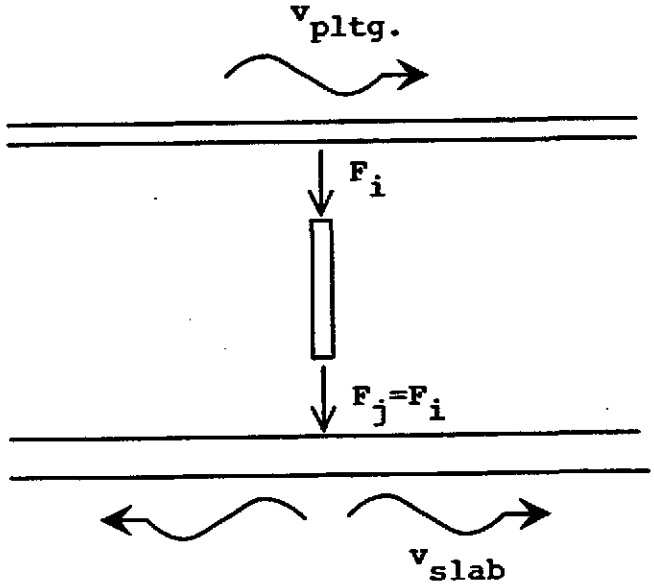


Fig. 9 Models for computing subsystem coupling loss factors.

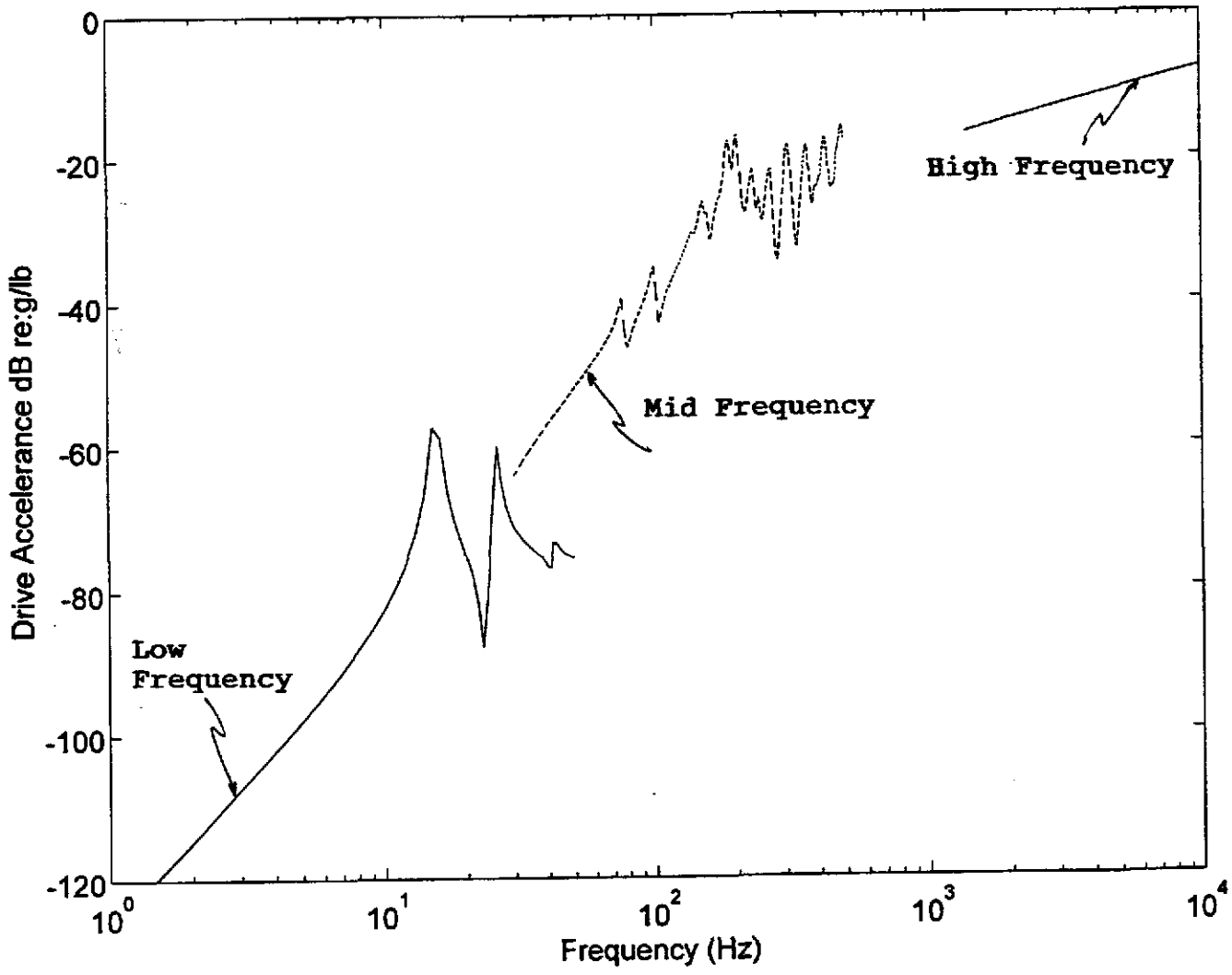


Fig. 10 Drive point accelerance at turbomolecular pump (radial direction

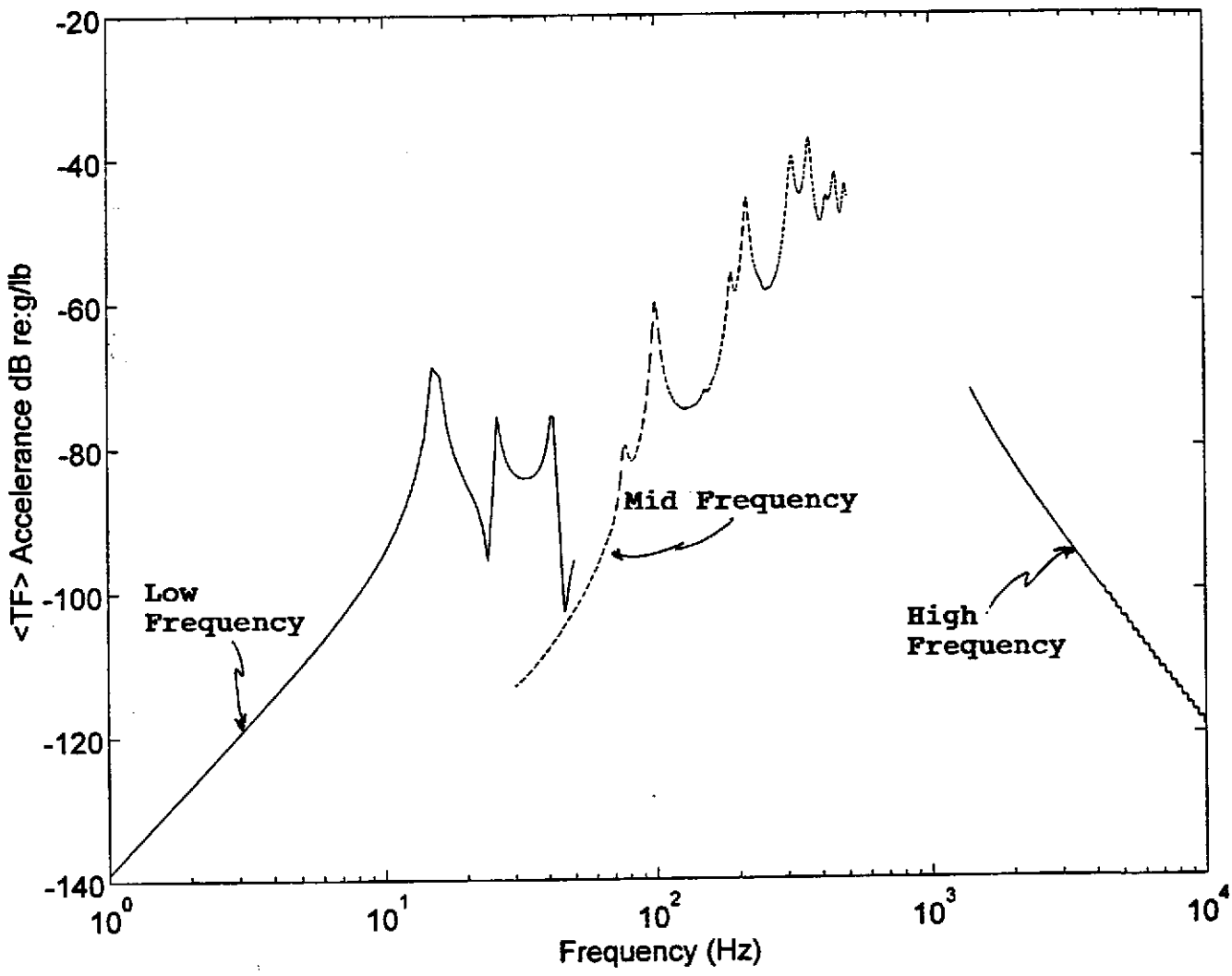


Fig. 11 Transfer accelerance from turbo pump to beam splitter.

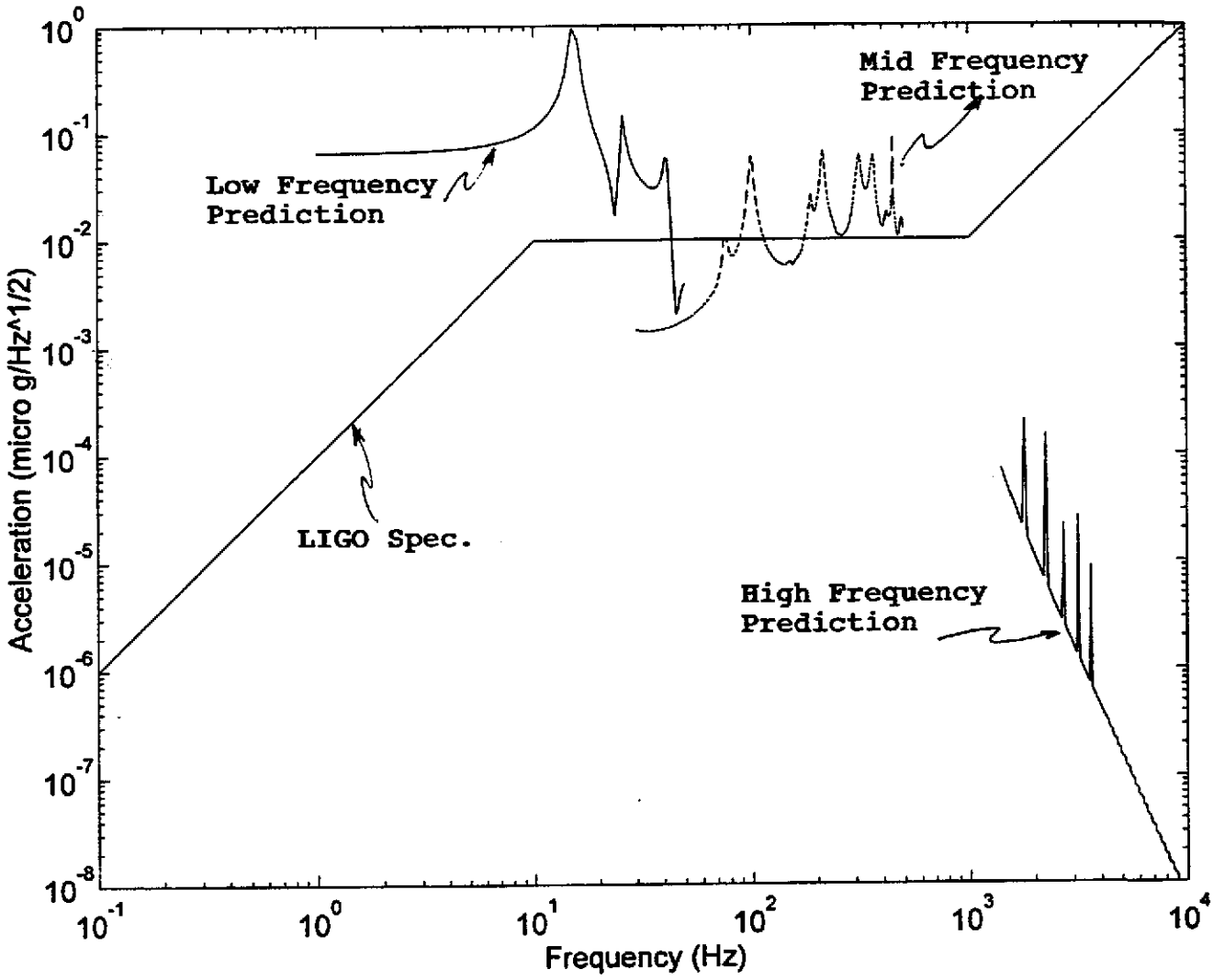


Fig. 12 Predicted acceleration levels at beam splitter compared to LIGO spec.

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: Alan L Bullock

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Richard Bagley

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

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED D. McW	DATE 5-1-96	APPROVED RBB 5/1/96 DATE	Number A V049-1-095 Rev. 0

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: SM 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: AM 5/1/96
Approved by: D a. m i w Allen

Date: 5/1/96

File: LIGODR1.WB1

Quantity:

Item	Spec Ref	Description of Design Requirement	Action, Conclusion, or Assignment	Action By	Date Required	Status
			---	---	---	---
	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. A. 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. Bach		
System or Component:	Main Ion Pumps		**Aproved by:** D. W. McWilliams		

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			
9						
10						
11						
12						
13						
14						
15						
16						

96:009.FB

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. Barh	
System or Component:	Annulus Ion Pumps		**Aproved by:**	Daniel Sigg	

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			
8						
9						
10						
11						
12						
13						
14						
15						
16						

Project Design Requirements/Goals

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

Project : Ligo Vacuum Equipment
Project No: V59049
Specification No: LIGO-E940002-V
Rev: 3
Date: November 21, 1995
System or Component **80K Pump**

Approved By: D A m Williams File: 80Kpmp .wb1

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. Stein
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: T. Thomas Ray Stein
Approved By: D. A. McWilliams

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. McWilliams	

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			
9						
10						
11						
12						
13						
14						
15						
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. MacWilliams	

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: Thomas M. Stark
Approved By: D. A. M. Williams

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. 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/5.5	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 Bradford

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 1-2-96	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	TMS 9-26-95		REVISED FOR UPDATED PRELIMINARY DESIGN

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

TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Testing

7.0 Inspection

8.0 Warranty

Attachment A	Quality Assurance Requirements Summary
Attachment B	V049-2-033 Rev 1 General Equipment Requirements
~~Attachment C~~	~~V049-4-010 Rev. P3~~ ~~Pumpcart Arrangements~~

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:	SPECNO.: 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: Allan H Baldwin

TECHNICAL DIRECTOR: D. C. McWilliams

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
4	Sm 3/20/96	J. McW	REVISED PER DEO 0100
3	Sm 12/26/95	D. McW 1-2-96	REVISED FOR PURCHASE DEO0034
2	Sm 11/9/95		REVISED PER CLIENT COMMENTS DEO0015
1	Sm 11/2/95		REVISED ATTACHMENT C P&ID V049-0-041 TO P2
0	Sm 10/16/95	D. McW 10-20-95	REVISED & ISSUED FOR QUOTATION & APPROVAL DEO 0014
P1	TMS 9-26-95		REVISED FOR UPDATED PRELIMINARY DESIGN

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

TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Testing

7.0 Inspection

8.0 Warranty

Attachment A	Quality Assurance Requirement Summary
Attachment B	V049-2-033 Rev. 1 General Equipment Requirements
~~Attachment C~~	~~V049-4-011 Rev. P3~~ ~~Pump Cart Arrangement~~

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:	SPECNO.: 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 [illegible]

TECHNICAL DIRECTOR: D.C. McWilliams

PROJECT MANAGER: Richard Bayley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
3	DM 3/20/96	D.McW 3-20-96	REVISED FOR PURCHASE DEO 0100
2	DM 12/26/95		REVISED FOR PURCHASE DEO 0034
1	DM 11/9/95		REVISED PER CUSTOMER COMMENTS DEO 0015
0	DM 10/16/95		REVISED & ISSUED FOR QUOTATION & APPROVAL / DEO 0007
P1	TMS 9-26-95		REVISED FOR UPDATED PRELIMINARY DESIGN

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED: DMoore	DATE: 6/14/95	APPROVED: REB	DATE: 9/26/95	Number V049-2-003 A	Rev. 3

SPECIFICATION TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Testing

7.0 Inspection

8.0 Warranty

Attachment A Quality Assurance Requirements Summary

Attachment B V049-2-033 Rev. 1
General Equipment Requirements

~~Attachment C V049-0-042 Rev. P1
Piping and Instrumentation Diagram~~

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 Bridbrook

TECHNICAL DIRECTOR: D. C. McWilliams

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
2	3-13-96	RES	RELEASED FOR PURCHASE PER DEO # 0092
1	2-14-96	REB	RELEASED FOR PURCHASE PER DEO 0063
0	SJC 11-16-95		RELEASED FOR APPROVAL OF QUOTATION PER DEO 0018
P1	10-19-95	REB	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

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Testing

7.0 Inspection

8.0 Warranty

Attachment A LIGO QA Requirements Summary

Attachment B General Equipment Requirements

PSI Specification V049-2-033, Rev. 2

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

Number

Rev.

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.

SPECIFICATION

Number A V049-2-004 Rev. 2

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 1×10^{-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 1×10^{-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

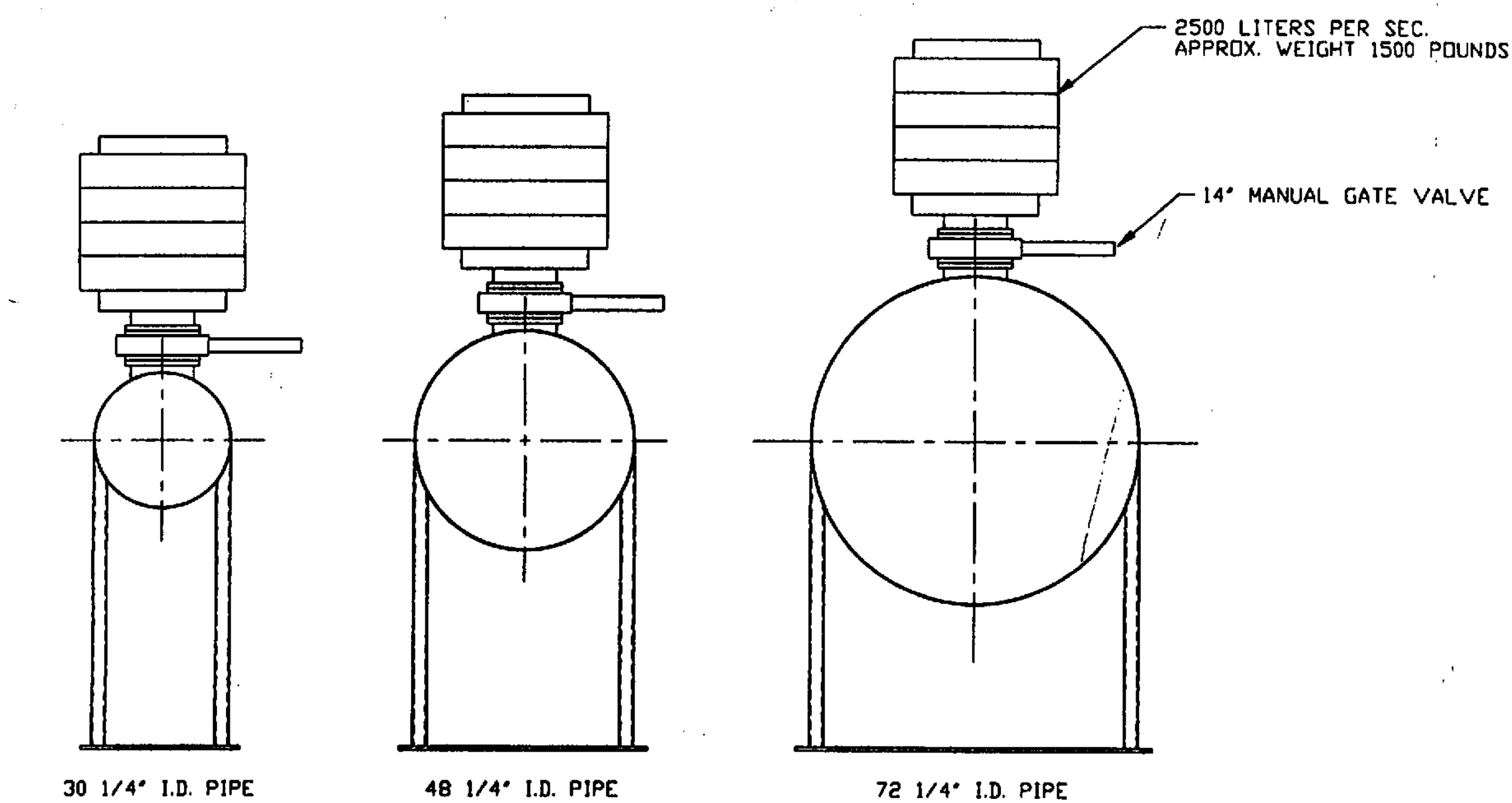
Refer to RFQ for warranty requirements.

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							



PROPRIETARY AND CONFIDENTIAL

THIS DOCUMENT CONTAINS PROPRIETARY INFORMATION BELONGING TO PROCESS SYSTEMS INTERNATIONAL, INC. OR ITS AFFILIATED COMPANIES AND SHALL BE USED ONLY FOR THE PURPOSE FOR WHICH IT WAS SUPPLIED. IT SHALL NOT BE COPIED, REPRODUCED OR OTHERWISE USED, NOR SHALL SUCH INFORMATION BE FURNISHED IN WHOLE OR IN PART TO OTHERS EXCEPT IN ACCORDANCE WITH THE TERMS OF ANY AGREEMENT UNDER WHICH IT WAS SUPPLIED OR WITH THE PRIOR WRITTEN CONSENT OF PROCESS SYSTEMS INTERNATIONAL, INC. AND SHALL BE RETURNED UPON REQUEST

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONAL ±
ANGULAR/MACH [illegible]
TWO PLACE DECIMAL ± [illegible]
THREE PLACE DECIMAL ± [illegible]
FINISHES SURFACE [illegible]
BREAK CORNERS [illegible]
REMOVE ALL BURRS

DO NOT SCALE THIS DWG.

USED ON

NEXT ASS'Y

REV	DESCRIPTION						CHKD	DRWN	DATE	DCO#

ISSUE DESCRIPTION

PROCESS SYSTEMS INTERNATIONAL, INC.
[illegible] MASSACHUSETTS [illegible] USA

ION PUMP SUPPORTS
LIGO VACUUM EQUIPMENT

CAD FILE	SIZE	DWG NO	REV.
IONPUMP	B		0

SCALE N.T.S. SHEET 1 OF 1

Sept 27, 1995 - 1407-41

SPECIFICATION TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Testing

7.0 Inspection

8.0 Warranty

Attachment A LIGO QA Requirements Summary

Attachment B Mating Flange Details
PSI Drawings V049-4-017 & -018, Rev. P1

Attachment C General Equipment Requirements
PSI Specification V049-2-033, Rev. 2

Attachment D Deleted

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.

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 R Bradbury

TECHNICAL DIRECTOR: D. Q. McWilliams

PROJECT MANAGER: Rachel Bayley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
2	Sm 10/21/96	DMcW 10-22-96	REVISED PER DEO 0316
1	TMS 2-22-96	DMcW	REVISED FOR PURCHASE PER DEO 0070
0	TMS 11-2-95	DMcW 11-3-95	REVISED AND RELEASED FOR QUOTATION AND APPROVAL / DEO 0011

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

SPECIFICATION TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Testing

7.0 Inspection

8.0 Warranty

Attachment A	LIGO QA Requirements Summary
Attachment B	General Equipment Requirements PSI Specification V049-2-033, Rev. 2
Attachment C	Deleted

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 per the purchase order.

	Quantity
Valve Usage:	1
Washington Site:	
6"	4
10"	16
14"	12
Louisiana Site:	
6"	3
10"	9
14"	6
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, 12" 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 1×10^{-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.

Valves shall have a visible position indicator showing the location of the valve gate relative to the fully open and fully closed positions.

Valves shall be marked with "open" and "close" handwheel rotation arrows.

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.

Number

Rev.

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.

4.16 Valves shall be supplied with suitable lifting lugs or eyes for handling during installation or maintenance operations.

4.17. Valves shall be supplied with removable studs made of a non-galling material such as silicon bronze or silver plated stainless steel. Studs shall have U.S. standard threads and be of an appropriate length for mating flange installation.

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 M. Stan

QUALITY ASSURANCE: Allan R. Bradbrook

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Bilal Bayly

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	FAB 7-31-96	D. McW ASB	RELEASED FOR PURCHASE PER DEO # 0234
0	SJC 1-31-96	D. McW	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 T. Stan 6-14-95	APPROVED DATE REB 9/26/95	Number V049-2-007 A	Rev. 1

TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Testing

7.0 Inspection

8.0 Warranty

Attachment A — LIGO QA Requirements Summary

Attachment B — General Equipment Requirements
PSI Specification V049-2-033, Rev. 2

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:

Destination	Quantity	Mfg. Release Date	Delivery Date	Description
Washington Site:	24	4/28/97	9/1/97	Vacuum gauge pair, mounted on 2 3/4" CF Flange, 2 3/4" tee mounting (include gasket, bolts and any needed accessories).
	1	4/28/97	9/1/97	Spare Vacuum Gauge Pair
Louisiana Site:	13	10/26/97	3/1/98	Vacuum gauge pair, mounted on 2 3/4" CF Flange, 2 3/4" tee mounting (include gasket, bolts and any needed accessories).
	1	10/26/97	3/1/98	Spare Vacuum Gauge Pair
Total Required	39			

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 1×10^{-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 1×10^{-3} torr to 1×10^{-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	275^0 C
Cold Cathode Gauges	275^0 C

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		

Title: SPECIFICATION FOR BAKEOUT SYSTEM

SPECIFICATION FOR

BAKEOUT BLANKET SYSTEM

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: F. Bash

QUALITY ASSURANCE: R. Bullock

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Rachel Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
4	FMB 10/2/96	RES 10/9/96	RELEASE FOR PURCHASE (PER DEO # 0258)
3	DP 6/28/96	D. M. W	RELEASE FOR RFQ (PER DEO # 0193)
2	FMB 5-2-96	D. M. W 5-2-96	RELEASE FOR FDR (PER DEO # 0164)
1	4-5-96	45-96	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 F. Bash DATE 1-15-96	APPROVED D. M. W DATE 1-15-96	Number V049-2-009	Rev. 4

SPECIFICATION TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Testing

7.0 Inspection

8.0 Warranty

Attachment A	LIGO Quality Assurance Req'ts Summary
Attachment B (General Equipment Requirements)	V049-2-033, Rev. 2
Attachment C	Isolatable Bakeout Section - Drawings
Attachment D	Equipment Drawings
Attachment E	V049-2-019, Sheets 1 & 2, Rev. 1 (Heater Bakeout System - Power and TC Cable Connectors)

1.0 SCOPE

1.1 General Information

1.1.1 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.

1.1.2 All attachments are part of this specification.

1.1.3 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.

1.1.4 AutoCAD R12 electronic files of V049-4-series of drawings will be available to Vendor for blanket design. Fabrication drawings for all of the LIGO Vacuum Equipment components requiring bakeout will be sent to Vendor as they become available.

1.1.5 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.

1.2 Heating Blankets

1.2.1 Furnish a system of reusable heating blankets that consists of enough blankets to bakeout the largest isolatable section of vacuum equipment (An isolatable section is a section of vacuum equipment that is closed off by one or more 44" or 48" gate valve, e.g. Vertex section corner station). Only one isolatable section will be baked out at the same time as indicated on each drawing of Attachment C.

These blankets should be also designed to be reusable on any of the remaining isolatable sections as equipment configuration permits. Equipment configuration shape may necessitate additional blankets if some blankets from the largest isolatable section cannot be reused on the other isolatable sections.

1.2.3 Portion of supports (legs) near equipment attachment require heating blankets.

Support Leg Blankets: Blankets for support legs need only be heated from the outside surface, that is there is no need to have a heating surface on the inside of the square tube. For supports which have a complex shape, such as the saddle legs on the HAM chamber, a boxed blanket configuration is adequate, that is the blanket need not follow the shape of the support.

1.2.4 Tubing that connects to the vacuum equipment requires heating blanket coverage up to and including the isolation valve.

Back to air line including the angle valve
10" pumpout port including 10 inch gate valve
6" pumpout port including 6 inch gate valve
14" port including 14" gate valve and ion pump

Annulus tubing: the annulus tubing require only insulation from the connection at the large flange for over a length of approximately 12 inches.

The largest isolatable section will (have) require blankets for:
4 main ion pumps _ 4 gate valves - 14 inch
One 6" Port + 6" gate valve
One 10" Port + 10" gate valve
One Back to air connection + isolation valve

The other isolatable sections will have less than 4 main ion pumps, one 6" port, one 10" port and one back to air connect.

1.2.5 At annulus piping, brackets, and thermocouple access patches, furnish insulation similar in construction to heating blankets, but non-heating.

1.3 Heating Blanket Controls

The Buyer will furnish equipment to control a separate 277V circuit to each blanket and to monitor the blanket's temperature.

2.0 SCHEDULE

2.1 Furnish bakeout blanket sets as listed on Attachment D and deliver to PSI (Westborough, MA).

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 AND BAKEOUT REQUIREMENTS

3.1 General Blanket Requirements

The bakeout (heating) 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°C ± 20°C @ a rate of 1.8°C/hr. For design purposes, the blankets shall be capable of heating the vessels and components to 200°C in 48 hours except to 250°C at gauge pairs. 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 +/-20°C for all vessel or component surfaces.

The Buyer will furnish the programmable blanket controls, power distribution with overload protection, and interconnecting cables.

3.2 Gauge Pair Blanket

Each gauge pair heating jacket shall be an independent controlled heating zone and shall be capable of heating the gauge pair to 250°C in 48 hours. Gauge pairs consists of a Convectron and cold cathode gauge mounted on a 1.5" TEE with 2-3/4" Conflat flange fittings. Two thermocouples shall be furnished to monitor temperature on each gauge surface. The approximate dimensions of a gauge pair assembly are 12" x 6" x 12".

3.3 Equipment Support Legs

To maintain temperature at the vessel wall, where the supports attach the to vessel, heater blankets are required at the support legs. These heater blankets shall partially or fully cover the legs depending on length and power density of the heating blanket. The vendor shall furnish adequate power density and blanket coverage of the support legs. Tradeoff can be made between power density and coverage requirements. The support legs are made of carbon steel.

The following are estimated power densities and coverage requirements. Less blanket coverage at the support leg may be furnished if a higher power density is used to maintain the required bakeout temperature of the vacuum equipment. Further dimensional details are given in the Attachment D drawings.

Component	Estimated Minimum Power Density	Blanket Coverage	Support Leg Dimensions
BSC Support Legs	600 W/m^2	Fully	8"X8" X 0.63" Tube x 48" Tall
HAM Saddles	3500 W/m^2	Fully	66" x 0.5" x 14" Tall At Valley x 28" Tall At Edges
Mode Cleaner Tube Support Legs	600 W/m^2	Partially (48")	2" x 3" x 0.13" Tube x 70" Tall
72" Dia Beam Manifold Support Legs	600 W/m^2	Partially (48")	4"x 2" x 0.31" Tube x 75" Tall
48"/44" Gate Valve Support Legs	600 W/m^2	Partially (48")	I Beam 4" x 4" x 0.25" x 36" Tall
Cryopump Support Legs	600 W/m^2	Partially (48")	4" x 4" x 0.5" Tube x 70" Tall
48" Dia Spool Support Legs	600 W/m^2	Partially (48")	4" x 4" x 0.5" Tube x 70" Tall

3.4 Vacuum Equipment Adjacent to The Isolatable Bakeout Section

When one isolatable section is being baked, the spool piece on the other side of 48" gate valve needs to be heated to maintain the bakeout temperature of the gate valve . The required power density for a blanket length of 0.3m is 1700 W/m^2. For spool pieces adjacent to gate valves that are longer than 0.3m, at least 0.3m minimum length of the spool shall have blanket coverage at a power density of 1700 W/m,^{2} or a tradeoff can be made for a longer blanket section at a lower power density but in any case sufficient to keep the gate at 150°C.

Spool Piece	Power Density W/M^2	Minimum Length With Higher Power Density Heater
WA-15A	1700	0.3 m (Entire spool)
WA-15B	1700	0.3 m (Entire spool)
B-6 or B-7	1700	0.3 m
B-4B or B-4A	1700	0.3 m
WA-3A	1700	0.3 m
WA-3B	1700	0.3 m

4.0 GENERAL EQUIPMENT REQUIREMENTS

4.1 Disregard parts of Attachment "B" (Specification # V049-2-033) not applicable to this work.

5.0 DESIGN REQUIREMENTS

5.1 Mechanical Requirements

5.1.1 Bakeout blanket sets shall be based on Attachment D equipment drawings. Blankets shall be of durable construction, designed to be installed, removed and reinstalled on the vessels without degradation.

5.1.2 Blankets shall be constructed to be non-shedding and suitable for installation, removal and storage in a Fed. Std. 209 Class 50,000 cleanroom.

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

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

5.1.5 The size of each blanket shall be suitable for installing without the use of special equipment.

5.1.6 Each blanket shall be capable of being secured properly on the equipment in any position (horizontal, vertical) without sliding off its desired location and without gaps between blanket and surface being heated. The blankets shall accommodate equipment expansion caused by bakeout heating.

5.1.7 Provide blankets with flaps made of fiberglass fabric and Velcro, lacing ties or lacing hooks to interconnect blankets without gaps.

5.1.8 Provide blankets with strap loops and nylon straps to ensure that the individual heating blankets are held tight against the body being heated.

5.1.9 Non-heated patches are acceptable for thermocouple access opening and for annulus piping, brackets, lifting lugs and other appendages where thermal insulation is needed.

5.1.10 Each blanket shall be properly tagged with a permanent label identifying the blanket and noting its wattage and measured ohmic resistance. Locate labeling on the blanket outer cover near the power cable. Blanket identification shall match the bakeout blanket layout configuration as shown on Vendor's drawings. Tag numbering method shall be coordinated with PSI.

5.1.11 Each blanket shall have an approximate 3" x 5" removable patch to allow the installation of the thermocouples onto the metal surface. This patch shall be in the middle of the blanket.

5.1.12 Outer and inner blanket cover material shall be submitted to the customer for acceptance prior to fabrication. Outer jacket shall be the low emissivity type.

5.2 Electrical Requirements

5.2.1 Instrumentation Requirements

5.2.1.1 Each blanket shall have two thermocouples. Attach thermocouples to opposite sides of 3" x 5" blanket opening. Provide a type "J", #20 AWG stranded, shielded, 300 volts, 260°C Teflon insulated thermocouple cables with non-rusting braided jacket. Make one end of each cable 24" long and terminate with male connector as indicated on Attachment E drawing. Tag cables near connector with blanket number. Make other end of each cable 12" long with junction in ring type terminal and isolate cable shield from ring terminal as indicated on Attachment E drawing. As an option, quote ungrounded (electrically insulated from shield) thermocouple junction.

5.2.2 Controls Requirements

5.2.2.1 Controls for local operation will be furnished by the Buyer.

5.2.3 Power Requirements

5.2.3.1 The system shall be powered from 480Y/277V, grounded power system.

5.2.3.2 Each blanket shall be rated for a 277V source and shall have a 2-foot long (minimum) power cable terminated as indicated on Attachment E drawing. Locate emerging cable through eyelet at least 12" from 3" x 5" blanket opening and anchor cable to blanket cover. Power wiring shall be stranded copper, 600V, 260°C minimum. Power requirements shall not exceed 8 amps per blanket. Tag cable bear connector with blanket number.

5.2.3.3 The maximum power allotments at each isolatable section are as follows:

ISOLATABLE SECTIONS see Attachment C drawings	**MAX**
Vertex section (sheet 1)	180 kW
Left beam tube manifold section (sheet 2)	140kW
Right beam tube manifold section (sheet 3)	140kW
Diagonal section (sheet 4)	180 kW
Right mid station (sheet 5)	105kW
Left mid station (sheet 6)	105kW
Right end station (sheet 7)	70kW
Left end station (sheet 8)	70kW

6.0 REQUIRED DOCUMENTATION

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

- Catalog data sheets or other published materials showing appearance, electrical ratings, and performance characteristics of blanket components.
- 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.

7.0 SHOP TESTING

The Vendor shall submit standard testing procedures for acceptance. The Vendor shall test blankets and repair defective components. Submit test reports. The Buyer reserves the right to witness shop testing.

8.0 INSPECTION

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

9.0 WARRANTY

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

SPECIFICATION FOR

GENERAL EQUIPMENT REQUIREMENTS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Thomas R. Stein

QUALITY ASSURANCE: Alan L. Bradbrook ALB

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Richard Bagley

JAN 03 1996

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
2	dm 12/26/95		REVISED ATTACH. A PARA C.5.1 DEO 0034
1	TMS 11-9-95	D. McW 11-9-95	REVISED PER CUSTOMER COMMENTS / DEO 0019
0	TMS 10-14-95	D. McW 10-28-95	REVISED AND ISSUED FOR QUOTATION AND APPROVAL / DEO 0004

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number V049-2-033 / Rev. A / 2
	TMS	10-26-95	RCB	10/27/95	

SPECIFICATION TABLE OF CONTENTS

1.0 Definitions
2.0 Deleted
3.0 General Requirements
4.0 Codes and Standards
5.0 Design Requirements
6.0 Materials
7.0 Utilities
8.0 Welding
9.0 Required Documentation
10.0 Nameplates
11.0 Cleaning and Painting
12.0 Quality Assurance Requirements
13.0 Preparation for Shipment
14.0 Startup Assistance
15.0 Deleted

Attachment A Other Electrical Requirements

Number

Rev.

1.0 DEFINITIONS

1.1 The "Vendor" is defined as the successful bidder accepting responsibility for meeting all requirements of this specification.

1.2 The "Owner" is defined as the California Institute of Technology (Caltech) in partnership with the Massachusetts Institute of Technology (MIT), under a grant from the National Science Foundation.

1.3 The "Buyer" is defined as Process Systems International, Inc. (PSI).

1.4 The "sites" are located on the Hanford reservation near Richland, Washington and in Livingston, Louisiana.

2.0 DELETED

3.0 GENERAL REQUIREMENTS

3.1 The Vendor shall be responsible for coordination of all subsuppliers and for overall warranty and guarantees of all equipment, including their compatibility. The Vendor shall comply with all applicable referenced specifications and standards and invoke them on each subsupplier purchase order.

3.2 Equipment will be installed at Hanford (near Richland), Washington and in Livingston, Louisiana. Unless otherwise indicated, equipment shall be capable of continuous service in an indoor location with a controlled temperature of 23 ± 1.5 C and a relative humidity controlled at 40 ± 5%. The equipment will, however, be exposed to diurnal and seasonal ranges during shipment, construction and power loss. It shall, therefore, not be damaged by exposure to temperature in the range of -20 to +40 C, or a humidity of 100%.

3.3 The Buyer shall be notified at least 10 working days prior to the start of major fabrication, assembly or testing.

3.4 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.

4.0 CODES AND STANDARDS

4.1 Priority of Codes and Standards

1. Codes
2. Standards
3. Data Sheets
4. This Specification

4.2 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.

4.3 Applicable Codes and Standards:

American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code
Pressure Vessels: Section VIII, Division 1
Welding and Brazing Qualifications: Section IX

American National Standards Institute (ANSI)
ANSI A58.1: ASCE Minimum Design loads for Buildings and Other Structures

International Standards Organization
ISO Standard 2861: Flange Standards

Expansion Joint Manufacturers' Association (EJMA)
EJMA Standards

Government Standards
Building and safety codes: local, state and federal, including OSHA
Federal Standard 209 for Cleanrooms

5.0 DESIGN REQUIREMENTS

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 design, materials and workmanship as required elsewhere in the Contract.

5.1 Mechanical Requirements

5.1.1 Equipment feet or mounting plates shall have machined surfaces. Shim stock used shall be stainless steel.

5.1.2 Each vacuum element greater than 12" in diameter shall be designed, fabricated and tested in accordance with the latest edition of the ASME B&PV Code, Section VIII, Division 1, and subsequent addenda (except as noted under section 8.0, Welding), even though vacuum chambers lie outside of the scope of that document..

5.1.3 Bolt holes in flanges shall straddle natural centerlines.

5.1.4 Reasonable measures shall be taken to minimize noise. The goal is for acoustic noise to not exceed NC-15 when measured at any point within 1' of the equipment.

5.1.5 Reasonable measures shall be taken to minimize vibration. The goal is for the vibration of any item of equipment not to induce motion of the walls of any vacuum chamber or of the facility floor within 1 meter of any chamber which exceeds the following spectral density limits:

Frequency Band, Hz	Vibration Limit, m/√Hz
0.1 - 10	3×10^{-11}
10 - 1000	$3 \times 10^{-9} \times (1/f)^2$
1000 - 10000	3×10^{-15}

The above limits apply when all simultaneously operating equipment is running, and in the absence of vibration from other sources. Limited narrow band exceptions may be permitted, subject to Buyer's acceptance. Compliance with this requirement may be demonstrated by any combination of measurements and analysis, subject to Buyer's acceptance.

5.1.6 ANSI Standard A58.1 shall be applied to determine the probability of earthquakes and seismic coefficients at the two sites.

5.1.7 No equipment shall emit or harbor particulates at a level inconsistent with maintenance of a clean environment conforming to Federal Standard 209 Class 50,000.

5.1.8 The equipment shall be designed for a minimum serviceable life of 20 years.

5.1.9 Exposure of the equipment to ambient conditions during construction, power failure or control failure shall not result in damage.

5.1.10 Separable parts shall be fully interchangeable between assemblies.

5.1.11 Adequate clearance shall be provided for assembly of mating flanges and for handles. External access shall be provided to all vacuum seams for leak checking.

5.1.12 Elements heavier than 50 pounds shall have lifting lugs installed.

5.1.13 Vendor shall specify all bolt torque requirements in the equipment operating and maintenance manual.

5.2 Electrical Requirements

5.2.1 General Electrical Requirements

5.2.1.1 Electrical equipment and wiring shall conform to the National Electric Code.

5.2.1.2 All electrical equipment shall meet commercial standards for EMI (see Attachment A).

5.2.1.3 Electrical equipment shall meet the acoustic noise and vibration requriements of Sections 5.1.4 and 5.1.5, above.

5.2.1.4 See Attachment A for other electrical requirements.

5.2.2 Instrumentation Requirements

5.2.2.1 Instrumentation shall be of industrial quality and shall be subject to the acceptance of the Buyer.

5.2.2.2 Vibration monitoring is not a requirement of this specification.

5.2.2.3 Unless otherwise indicated, analog instrument signals shall be 4-20 ma or 0-10 VDC.

5.2.3 Controls Requirements

Control signals shall be 24 VDC.

5.2.4 Power Requirements

5.2.4.1 Motors shall comply with the Vendor's standard specifications, unless otherwise required by this specification. The minimum service factor of motors shall be 1.15. Motors shall be sized so that they can start and accelerate their loads to design speed at 90% voltage, and shall be energy efficient, if required by local or state codes.

5.2.4.2 Motors less than 3/4 HP shall be 120 VAC, 1 phase, 60 Hz. Those 3/4 HP to 200 HP shall be 460 VAC, 3 phase, 60 Hz.

6.0 MATERIALS

6.1 Materials used for pressure or vacuum retaining parts, nuts, bolts and studs shall be new. Where practicable, materials shall be of US origin; where not, materials from Canada, the European Community or Japan may be used. The Vendor's quotation shall identify the country of origin and how he intends to establish material traceability and conformance of composition and properties to applicable codes.

6.2 Copies of mill test reports of chamber and flange materials shall be furnished. Other nozzles, small parts, small flange nozzles, and bolting materials shall be furnished with a Certificate of Compliance.

6.3 Fabricated components exposed to vacuum shall be made from type 304L or 316L stainless steel using low carbon weld filler wire, where required. Standard catalog items of 304 or 316 stainless steel are acceptable if not available in 304L or 316L. Copper, aluminum and prebaked Viton (Dupont Type E-60C, manufactured by Parker or Buyer-accepted equal) must be used for seals. Vacuum feedthroughs must utilize UHV compatible glass or ceramic. All other materials are subject to Buyer's acceptance.

6.4 Vacuum surfaces shall not be allowed to come into contact with carbon steel or oil, including during forming, handling or manufacture. Machining fluids shall be water soluble and free of oil and sulfur.

6.5 When manufacturing materials are marked for material identification or traceability, marking shall be done on the outside, and not on surfaces that will be exposed to vacuum.

7.0 UTILITIES

The following utilities are available. The vendor shall state in his proposal the usage of each utility.

7.1 Electric Power

120 VAC, 1 phase, 60 Hz
480 VAC, 3 phase, 60 Hz or 208/120 VAC, 3 phase, 60 Hz

7.2 Instrument Air: 80 psig, -60 C Dew Point

7.3 Deleted.

8.0 WELDING

8.1 Welding exposed to vacuum shall be done by the gas tungsten arc inert gas (GTAW) process, with a 100% Argon shield and purged back gas.

8.2 Welding techniques shall deviate from the ASME Code in accordance with the best ultra high vacuum practice to eliminate any "virtual leaks" in the welds. Wherever practicable, welds shall be internal and continuous. External welds for structural purposes shall be intermittent to eliminate trapped volumes.

8.3 Defective welds shall be repaired by removal to sound metal and rewelding.

8.4 Vacuum weld procedures shall include steps to avoid contamination of the heat affected zone with air, hydrogen, hydrocarbons or water. This requires that inert purge gas, such as argon, be used to flood the vacuum side of heated portions. All vacuum surfaces and weld wire shall be cleaned prior to welding

8.5 The finished product shall be free of weld spatter, cutoff spatter, free iron, weld oxidation and defects. There shall be no grinding or abrasion of completed welds or internal vacuum surfaces. Completed welds shall only be cleaned with SS wire brushes that have not previously come in contact with carbon steel.

8.6 All welding procedures, procedure qualifications and welders employed on this job shall be qualified in accordance with ASME Section IX, latest edition.

9.0 REQUIRED DOCUMENTATION

9.1 Drawings

9.1.1 Assembly drawings shall be submitted for the Buyer's review prior to fabrication. They shall include all pertinent design data and calculations, including design pressures and temperatures.

9.1.2 Drawing acceptance must be obtained from the Buyer prior to the start of fabrication. Drawing acceptance does not constitute acceptance of any errors or of any deviation from these specifications or any instructions relating to the work. The Vendor shall call attention to any such deviations by separate written notice. Unless specific written acceptance is obtained from the Buyer, deviations are not acceptable.

9.1.3 If changes are made to any drawing subsequent to acceptance, drawings shall be resubmitted with all changes clearly identified. "As-Built" drawings shall be submitted.

9.1.4 Drawings in AutoCad, Release 12.0 are preferred. All documents stored electronically (procedures and CAD drawings) shall be backed up daily and the back-up tape shall be stored in a fire-proof safe.

9.2 Mechanical Data

9.2.1 Dimensioned outline drawings (indicating weights and center of gravity). These shall be submitted with the Vendor's proposal.

9.2.2 Connection sizes and ratings, design and test pressures and temperatures.

9.2.3 Cross-section drawings of all seals identifying all seal parts and materials.

9.2.4 Allowable nozzle loads, if applicable.

9.2.5 All procedures to be utilized shall be submitted for acceptance prior to use. This includes welding, QA, cleaning, testing, welding, Heat Treating, leak testing, etc.

9.3 Electrical Data

9.3.1 Electrical schematics and wiring diagrams

9.3.2 Control logic documentation

9.3.3 Instrument data sheets

9.3.4 Motor data sheets

9.4 Acoustic Noise and Vibration (See Sections 5.1.4 and 5.1.5)

9.4.1 A plan describing how the Vendor will address the design issues associated with acoustic noise and vibration is to be submitted.

9.4.2 An analysis of the equipment's design dynamic characteristics (mass, center of gravity, isolator stiffness, transmissibility). The analysis shall support the Vendor's claim of meeting or not meeting the specification requirements. In the case that the requirements are not met, the Vendor shall show that all reasonable engineering attempts have been made to meet them, and the design will be subject to the Buyer's written acceptance prior to the start of manufacturing.

9.5 Test and QA Data

The following shall be submitted where applicable:

9.5.1 Manufacturer's Code Data Report

9.5.2 Nameplate facsimile

9.5.3 Hydrotest results (Deleted)

9.5.4 Performance and leak test procedures and results

9.5.5 Mill test reports and certificates of conformance per Section 6.2

9.6 Other Documentation

9.6.1 Schedule, including design, material procurement and fabrication activities

9.6.2 Priced spare parts list with recommended spares

9.6.3 Installation, Operation and Maintenance Manual, including drawings

9.6.4 A status report with updated schedule shall be submitted monthly

10.0 NAMEPLATES

10.1 Each separable part (except fasteners, seals and interchangeable, standard blank flanges) shall be permanently marked with a unique identification number in a location readily viewable.

10.2 Each item shall have a stainless steel nameplate (permanently attached if practical). Nameplates shall include the Vendor's standard data. Where provided, each motor shall also have a nameplate.

11.0 CLEANING AND PAINTING

11.1 Equipment internals shall be cleaned and free of all foreign materials.

11.2 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.

11.3 Surfaces exposed to vacuum shall be cleaned in accordance with procedures accepted by the Buyer prior to fabrication and installation. Surface recontamination during subsequent processes shall be prevented. Cleaning procedures for ultra high vacuum service shall be required.

11.4 Items shall be wrapped or sealed after cleaning to maintain cleanliness through handling, transportation and storage. Care shall be taken to minimize exposure to corrosive environments, such as those containing chloride compounds.

12.0 QUALITY ASSURANCE REQUIREMENTS

The responsibility for inspection and testing rests with the Vendor. However, the Buyer reserves the right to review equipment at any time during the fabrication to assure that the work performed is in accordance with this contract. The Vendor shall give the Buyer 10 working days notice prior to the start of major fabrication, assembly or testing so that his representative may witness these tests.

The vendor shall have implemented inspection system in effect at all times during this contract. The inspection system shall comply with the following:

Design Control And Change Control
Provide a system to control the issuance of documents and drawings including changes to the locations where the work is being performed. The system shall address both electronic files and hard copies.

Material Control
Provides system that controls materials from receipt through the finished product. This system shall assure that only accepted items are used and installed. Physical identification shall be used to the maximum extent possible.

Quality Planning (Traveler)
A system of shop travelers shall be established for all work in process. The traveler shall contain Hold/Witness points of the Vendor, the Buyer and the Owner. All planning documents shall be submitted to the buyer for acceptance prior to fabrication.

Receiving Inspection
Measures shall be established to inspect incoming materials to the applicable procurement documents. Status of materials shall be visible, by tagging or marking.

In-Process And Final Inspection
A system of inspection and test status shall be maintained using tags, markings, shop travelers, stamps or inspection records.

Control Of Special Process' And Testing
A system shall be established to assure that welding, heat treatment, cleaning and NDE are accomplished under controlled conditions, in accordance with written procedures, using qualified personnel, to the applicable codes and standards.

Calibration Of Measuring And Test Equipment
A system shall be established and documented to assure that tools, gages, instruments and other inspection, measuring, and testing equipment are of the proper range, type and accuracy. The above shall be controlled, calibrated, and certified against nationally known standards (NIST).

Control Of Non-Conformances
A system shall be established and documented to control items or services which do not conform to requirements. The system shall include appropriate procedures for identification, documentation, segregation, disposition and notification.

Documentation And Records
Sufficient records shall be prepared as work is performed to furnish documentary evidence of the quality of items and activities affecting quality.

13.0 PREPARATION FOR SHIPMENT

13.1 Items shall be completely drained and dried.

13.2 Bolted connections shall be made up before shipment.

13.3 Aluminum plate shipping covers shall be attached with bolts to flanged connections, and with suitable attachments to other connections.

13.4 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.

13.5 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.

13.6 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.

13.7 Surfaces that will see vacuum shall be further protected by, after final cleaning, sealing openings with oil-free heavy duty aluminum foil, attaching the nozzle cover and applying shrink wrapped plastic.

14.0 STARTUP ASSISTANCE

The services of a qualified startup assistant shall be provided on request of the Buyer or the Owner to provide operator training and startup assistance at the sites.

15.0 DELETED

Title

ATTACHMENT A

OTHER ELECTRICAL REQUIREMENTS

1.0 Definitions

2.0 Exceptions

3.0 Codes and Standards

4.0 Labeled and Listed Equipment

5.0 General Assembly Requirements

6.0 Wiring

7.0 Field Connection Boxes

8.0 Testing

9.0 Deleted

10.0 Motor Data Sheets

JAN 08 1996

Number

Rev.

SPECIFICATION

Number		Rev.
A	V049-2-033 Attach. A	2

1.0 DEFINITIONS

Indicated	Shown or noted.
Labeled	Approved by nationally recognized testing company.
Permitted	As by code, Contract Documents, or Buyer.
Provide	Furnish and assemble.
Buyer	Process Systems International (PSI)
Required	As by Contract Documents and/or applicable codes and standards.
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.

2.0 EXCEPTIONS

If the Vendor cannot meet requirements established under this specification and its attachments, provide a list of deviations with your proposal. In the absence of a list of deviations, it shall be deemed that the Vendor's product is fully in compliance with this specification.

3.0 CODES AND STANDARDS

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

4.0 LABELED AND LISTED EQUIPMENT

Provide UL label (or that of other nationally recognized testing company) or listed components where such standards exist.

5.0 GENERAL ASSEMBLY REQUIREMENTS

5.1 Arrange and assemble components in accordance with their manufacturers' specifications.

5.2 Label components with the equipment designation as indicated using adhesive backed labels with 1/8" high lettering.

5.3 Label terminal strips as indicated using printed manufacturer's labels.

5.4 Where air-actuated valves require pilot solenoids, mount the solenoid valves on the air operated valves.

6.0 WIRING

Install wiring in raceways, wireways, or neatly tirewrapped wire bundles. Provide product data for all cables.

6.1 Power Wire

6.1.1 Provide #12 AWG or larger single, stranded copper conductors with Type THHN-THWN or MTW insulation rated 90 C, 600 volts.

6.1.2 Use black colored insulation, except green for equipment grounding conductors.

6.2 Control Wire (Discrete Signals)

6.2.1 120 VAC: Provide #14 AWG, stranded copper, multiconductor cable with Type THHN-THWN or MTW insulation rated 90 C, 600 volts.

6.2.2 24 VDC: provide #16 AWG stranded copper, twisted pairs, single or multipair cables rated 90 C and 300 volts.

6.2.3 Color code conductors as follows:

120 VAC—Line	Red
120 VAC—Neutral	White
24 VDC	Blue
External Source	Yellow
Ground	Green

6.2.4 Identify each single conductor at each end with wire number or designation. Use printed, sleeve type wire marker.

6.3 Instrument Wire (Analog Signals)

6.3.1 4-20 mA: Provide #16 AWG or larger, stranded copper, individually shielded twisted pairs, single or multipair cables rated 90 C, 300 volts unless otherwise indicated. Where practicable, install cables spaced at least 12 inches away from power and control wiring.

6.3.2 Provide shielded twisted pair cables with one black and one white conductor.

6.4 Thermocouple Wire

6.4.1 Provide #16 AWG solid thermocouple extension cable shielded, rated 105 C, 300 volts of type required.

6.4.2 Provide thermocouple extension wire in accordance ISA color coding standards.

6.5 Wire and Cable Installations

6.5.1 Identify each cable end with cable number or designation. Use printed sleeve wire marker.

6.5.2 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. Do not 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.

6.6 Wiring Terminations and Connectors

6.6.1 Control Wiring

6.6.1.1 To terminate #10 AWG and smaller conductors to buses, enclosures, and similar applications, provide compression (crimp) terminals.

6.6.1.2 To terminate #8 AWG and larger conductors, provide either compression (crimp) connectors using matching installing tool or mechanical screw type connectors.

6.6.1.3 Where more than one conductor requires termination, provide screw or pressure type insulated terminal blocks.

6.6.2 Instrument Wire

6.6.2.1 Use insulating sleeve to secure shielding at instrument end of cable. Clip shields to avoid protruding from insulating sleeve.

6.6.2.2 Coil, insulate, and label ends of spare conductors.

6.6.2.3 Remove insulation from ends of conductors using mechanical or electric heat type stripper.

6.7 Equipment Grounding

6.7.1 Bond motors, heaters, and other electrical equipment to skid base. Weld to diagonal corners of skid base a 4 by 6 by 1/2 inch steel plate with two 3/8"-16 tapped holes spaced two inches apart, or if steel base is at least 1/2 inch thick, tap holes directly into steel base.

6.7.2 Do not ground instrument shielding. Use insulating tape or heat shrink to secure shielding at instrument end of cable. Connect shielding at other end of cable to junction box terminal. (Shielding connects to a single ground reference point at Owner's controller or I/O rack.)

6.7.3 Completely remove paint, dirt, and corrosion down to bare metal where connectors, lugs, and other metal components are attached to mounting panels and enclosures to assure grounding continuity.

6.7.4 Where a grounding stud or existing panel mounting bolt is used, the Vendor may provide the grounding conductor with a ring-tongue terminal and a "star" type washer installed between the panel and terminal. Use hexagon nut to secure tightly.

7.0 FIELD CONNECTION BOXES

7.1 To facilitate field wiring, provide separate power, control, and instrument NEMA 4 or 12 type enclosures, unless otherwise required, with terminals and a minimum of 20 percent spare terminals.

7.2 Arrange surrounding work and location of boxes to permit box accessibility and to permit (bottom, sides, top, and rear) entrance of field conduits.

7.3 In power box, segregate voltage systems using barriers or separate boxes. Use box to terminate motors, heaters, and other branch circuits with #8 AWG and small wiring. PSI will field wire larger circuits directly to equipment junction boxes.

7.4 In instrument box, segregate temperature element wiring using barriers or separate boxes.

8.0 TESTING

It is the Vendor's responsibility to conduct the following tests without damage to equipment.

8.1 Wire Testing

8.1.1 Check point-to-point continuity of each conductor to ensure that wiring is intact and terminated at the proper place at both ends.

8.1.2 Verify wire connections are made in accordance with terminal wiring diagrams and schedules.

8.1.3 Deleted

8.1.4 All defective wiring shall be replaced and the unit retested.

8.2 Motors

8.2.1 Before connecting motor, measure motor winding resistance in accordance with manufacturer's recommendations.

8.3 Test each three-phase motor for proper rotary direction.

8.4 Submit a signed test report for each electrical test conductor.

9.0 Deleted

10.0 MOTOR DATA SHEETS

The attached motor data sheets shall be completed by the Vendor and submitted to the Buyer with the Vendor's proposal.

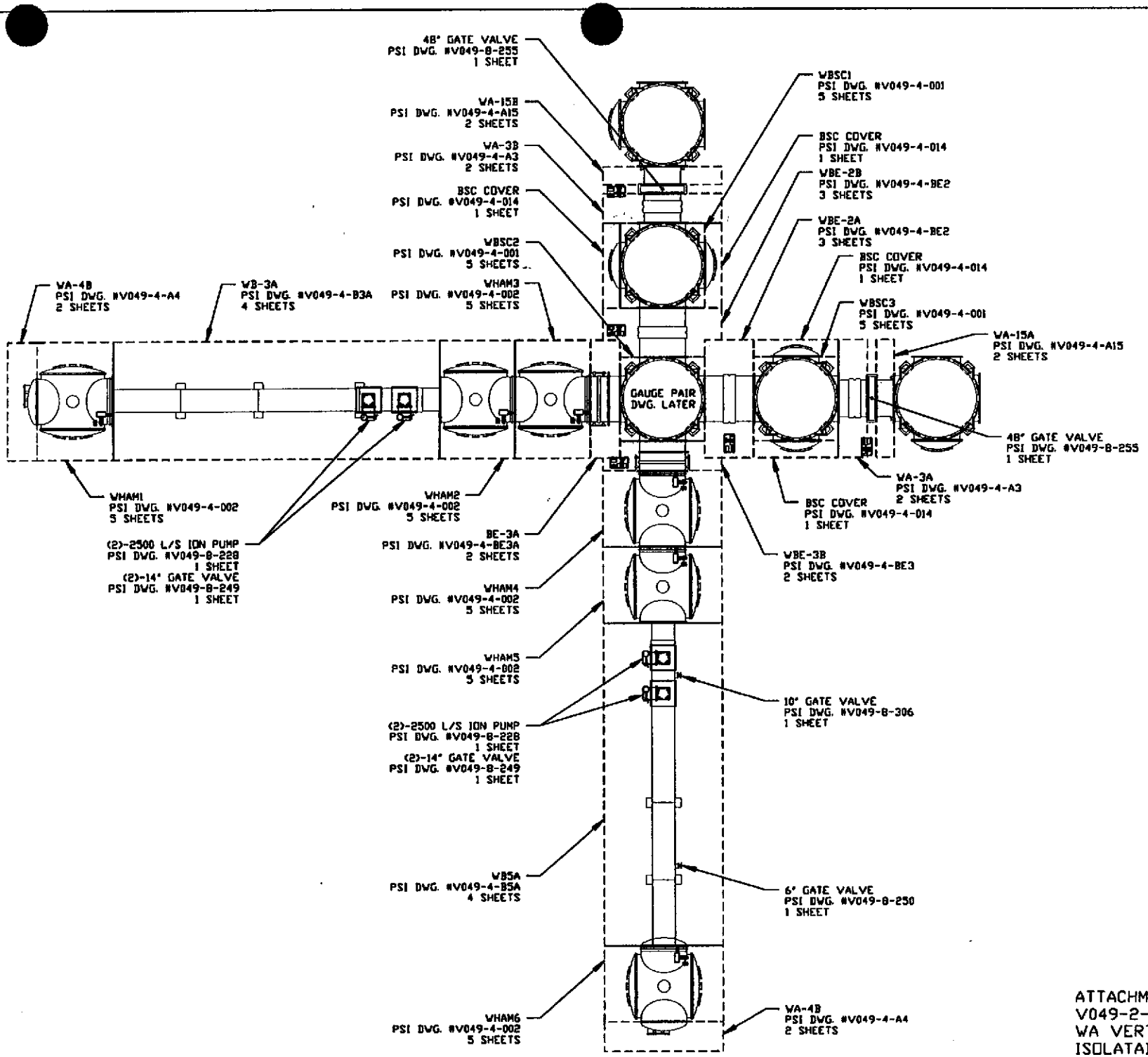
MOTOR DATA SHEET - DESIGN PARAMETERS

ITEM	DESIGN PARAMETERS	MOTOR DATA	MOTOR DATA	MOTOR DATA	MOTOR DATA
1	Motor Identification (tag)				
2a	Volts				
2b	Phases				
2c	Hertz				
3	Synchronous RPMs				
4	Efficiency (premium/energy/norm)				
5	Service Factor				
6	Load Brake Horse Power				
7	Starting Torque				
8	Type Load (fan/pump/comp)				
9	Drive (belt/direct couple)				
10	Rotation (CW/CCW)				
11	Enclosure				
12	Mounting (horz/vert)				
12a	NEMA Type Flange				
12b	Vertical Trust (up/down)				
13	Indoor/Outdoor Use				
14	Space Heater, 120V (no/watts)				
15	Winding Temp Sensor (yes/no)				
16	Bearing Temp Sensor (yes/no)				

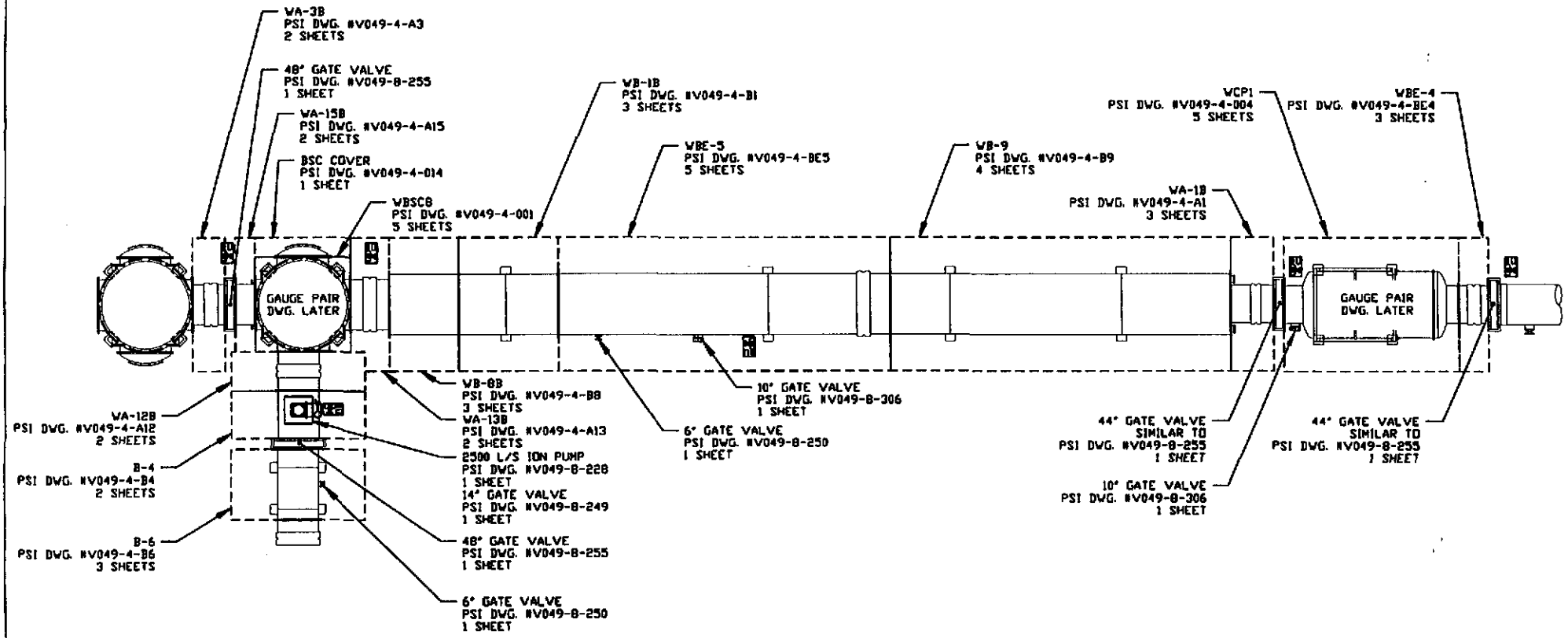
MOTOR DATA SHEET - MANUFACTURER'S NAMEPLATE

ITEM	MANUFACTURER'S NAMEPLATE	MOTOR DATA	MOTOR DATA	MOTOR DATA	MOTOR DATA
1	Motor Identification (tag)				
2a	Mfr:				
2b	Type				
2c	Frame Size				
3	Horsepower Output				
4	Time Rating (NEMA MG1-10.35)				
5	Max Ambient Temperature				
6	Insulation System				
7	RPM @ Rated Load				
8	Frequency				
90	Phases				
10	Rated Load Amps				
11	Voltage				
12	Locked Rotor Amps or NEMA Code Ltr				
13	NEMA Design Letter				
14	Efficiency				
15	Service Factor				
16	Thermal Protectors				

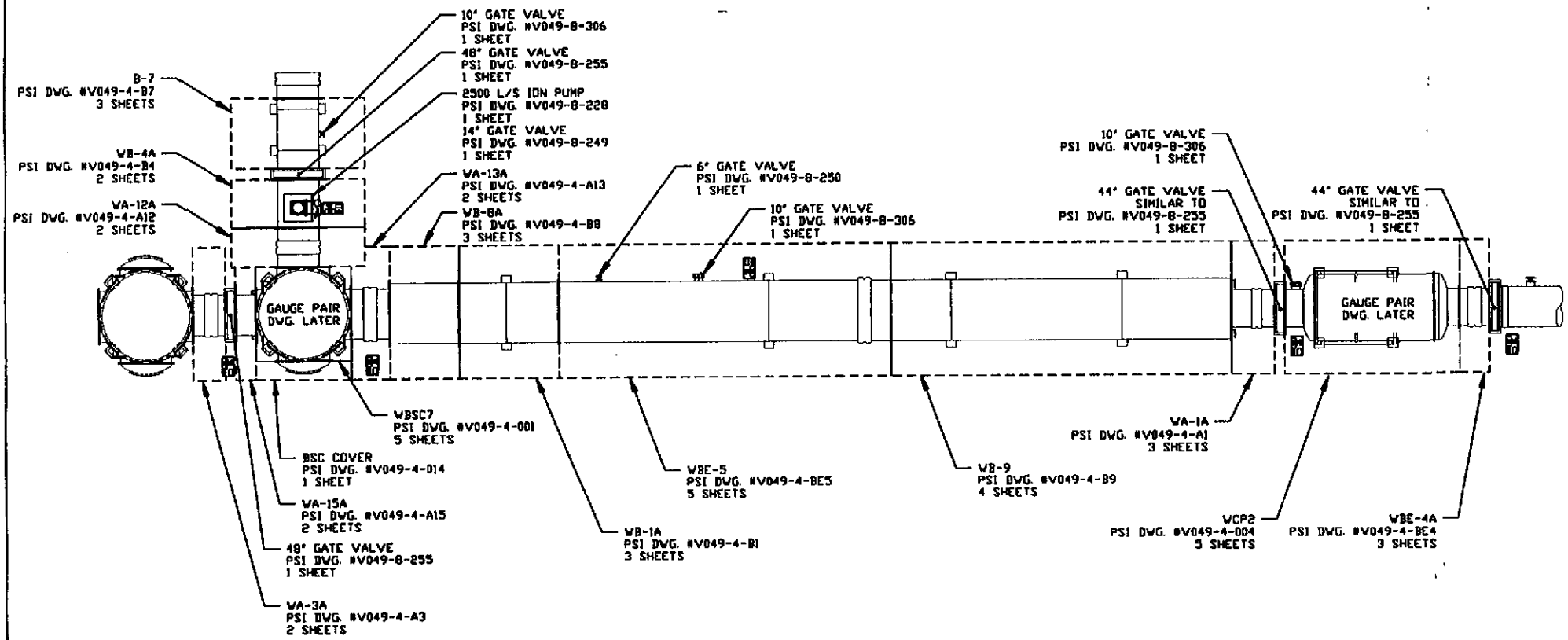
ITEM	MANUFACTURER'S DATA	MOTOR DATA	MOTOR DATA	MOTOR DATA	MOTOR DATA
1	Motor Identification (tag)				
2	Bearing Type				
3	Bearing Lub				
4	Efficiency @ Full Load				
5	Efficiency @ 3/4 Load				
6	Efficiency @ 1/2 Load				
7	Power Factor @ Full Load				
8	Power Factor @ 3/4 Load				
9	Power Factor @ 1/2 Load				
10	Space Heater Voltage				
11	Space Heater Watts				



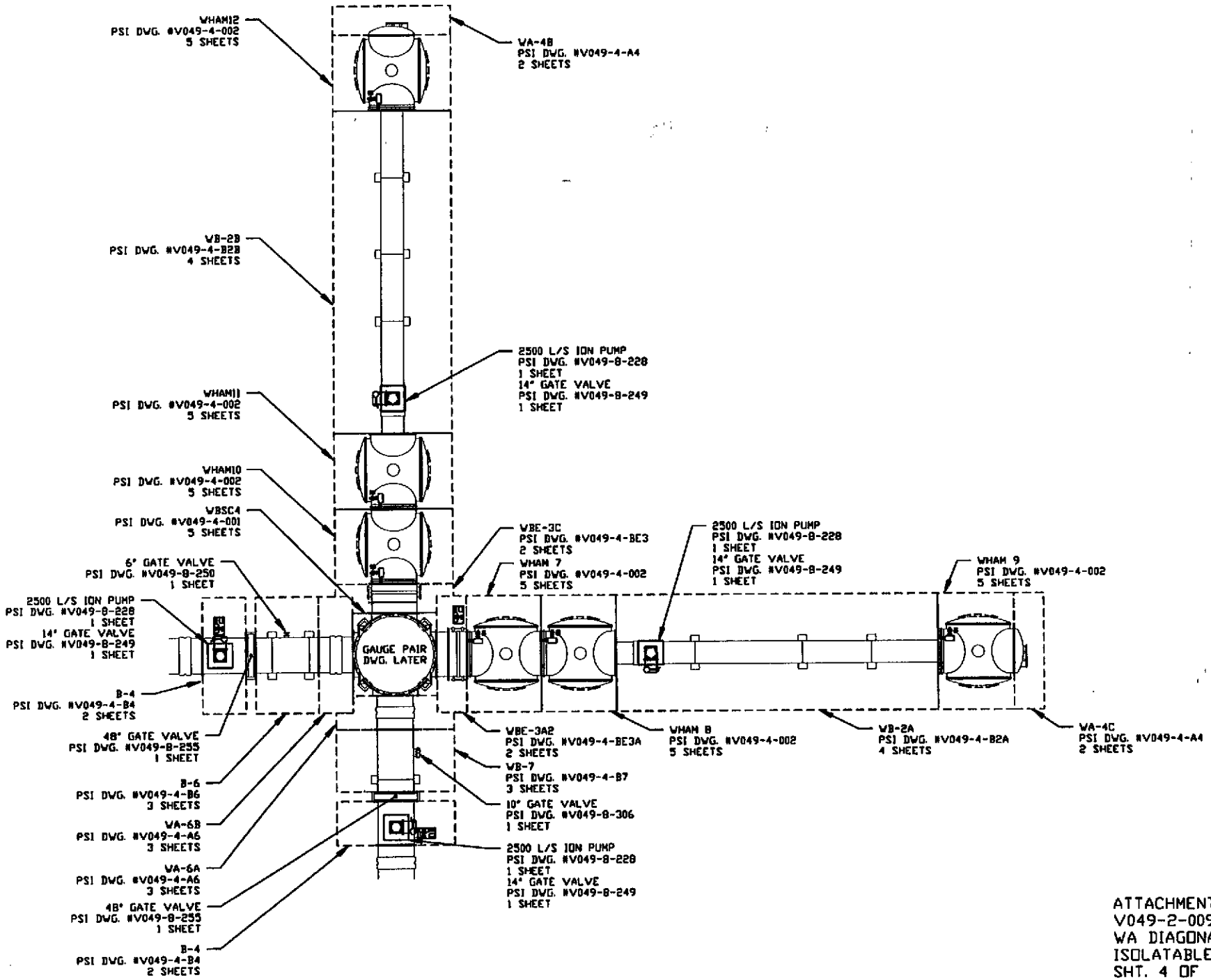
ATTACHMENT C
V049-2-009 REV. 4
WA VERTEX SECTION
ISOLATABLE SECTION
SHT. 1 OF 8



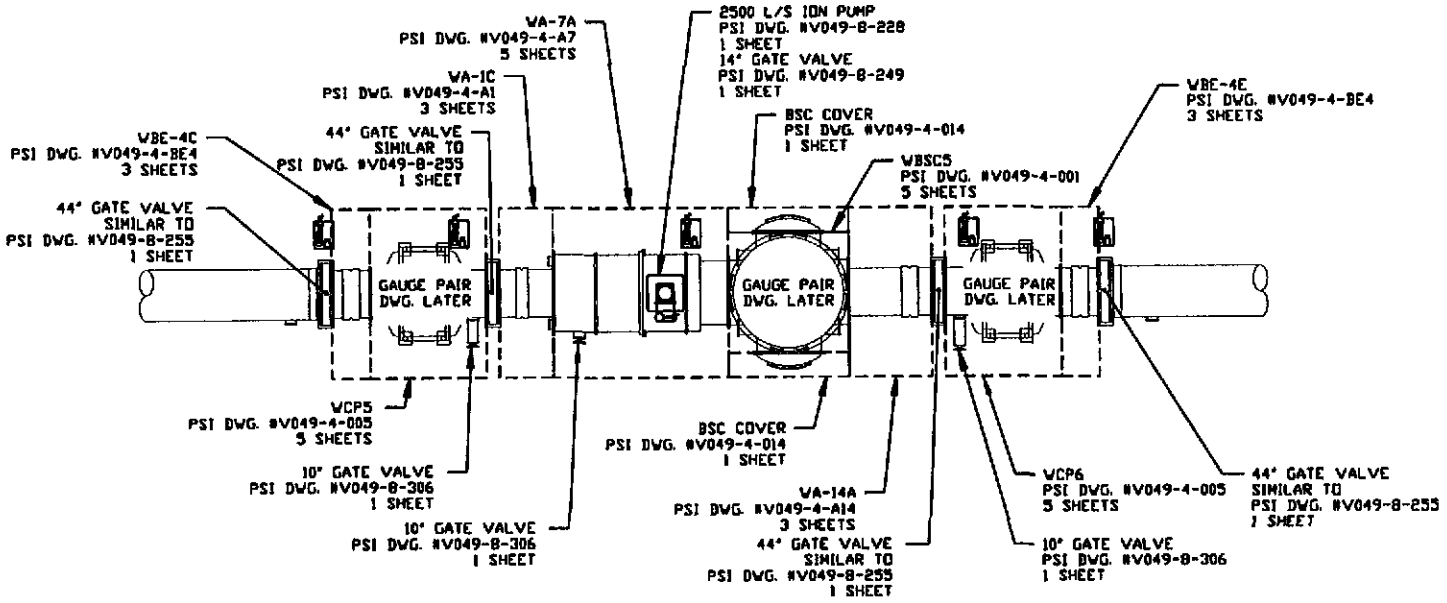
ATTACHMENT C
V049-2-009 REV. 4
WA LEFT BEAM MANIFOLD
ISOLATABLE SECTION
SHT. 2 OF 8



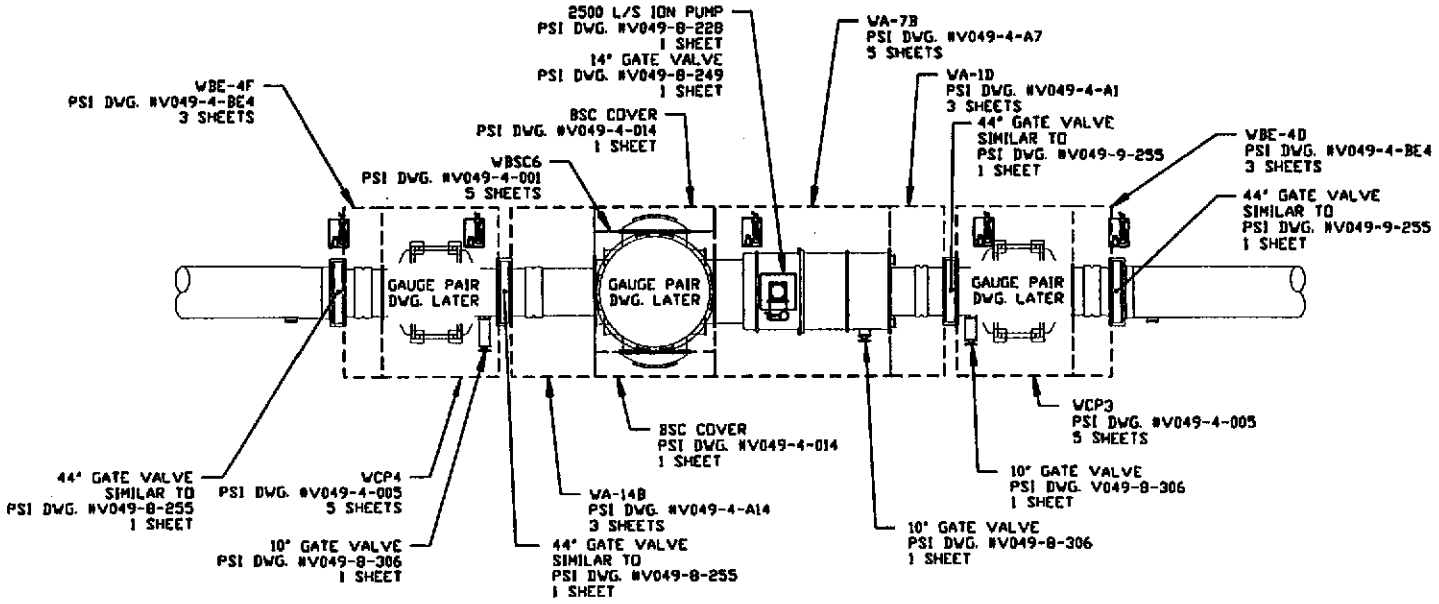
ATTACHMENT C
V049-2-009 REV. 4
WA RIGHT BEAM MANIFOLD
ISOLATABLE SECTION
SHT. 3 OF 8



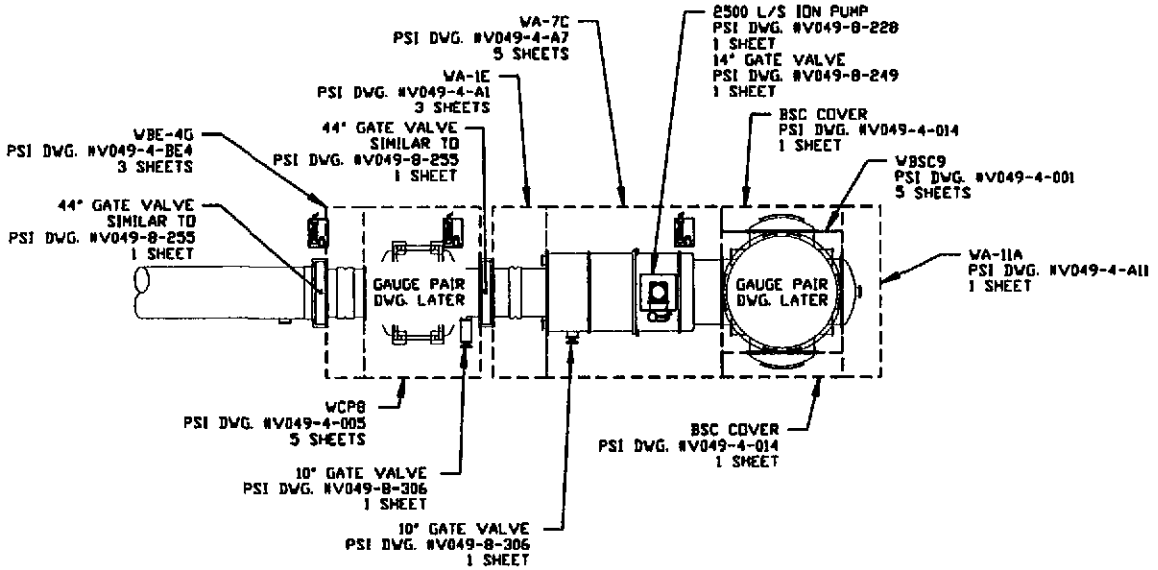
ATTACHMENT C
V049-2-009 REV. 4
WA DIAGONAL SECTION
ISOLATABLE SECTION
SHT. 4 OF 8



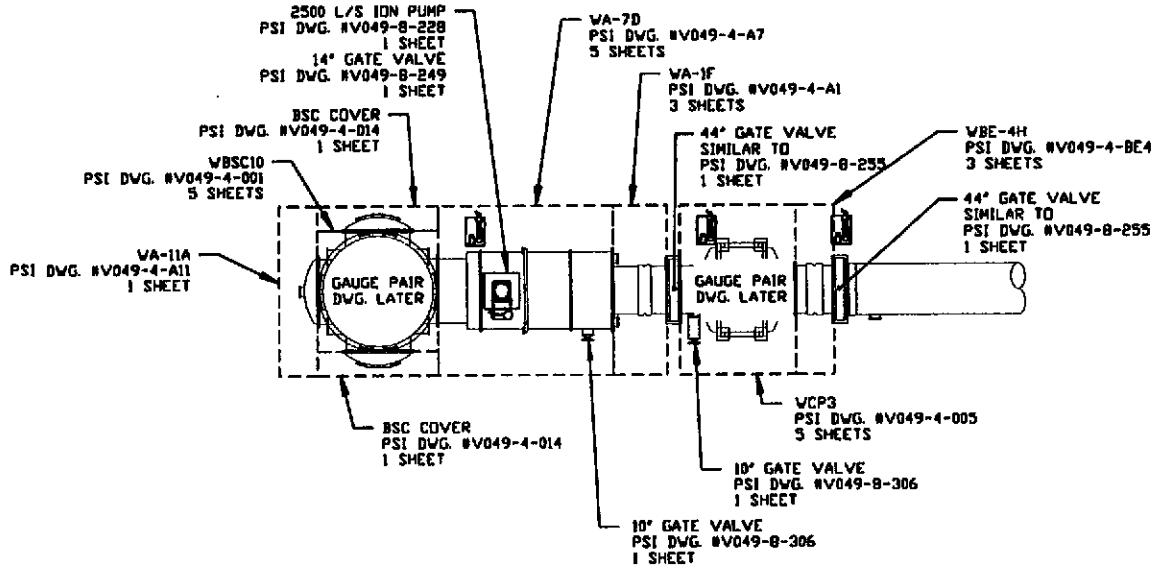
ATTACHMENT C
V049-2-009 REV. 4
WA RIGHT MID STATION
ISOLATABLE SECTION
SHT. 5 OF 8



ATTACHMENT C
V049-2-009 *REV. 4*
WA LEFT MID STATION
ISOLATABLE SECTION
SHT. 6 OF 8



ATTACHMENT C
V049-2-009 *REV. 4*
WA RIGHT END STATION
ISOLATABLE SECTION
SHT. 7 OF 8



ATTACHMENT C
V049-2-009 *REV. 4*
WA LEFT END STATION
ISOLATABLE SECTION
SHT. 8 OF 8

V049-2-009	REV. 4	10/04/96

ATTACHMENT D
TO SPECIFICATION V049-2-009, REV.4
LIGO BAKEOUT BLANKETS
FOR VACUUM EQUIPMENT

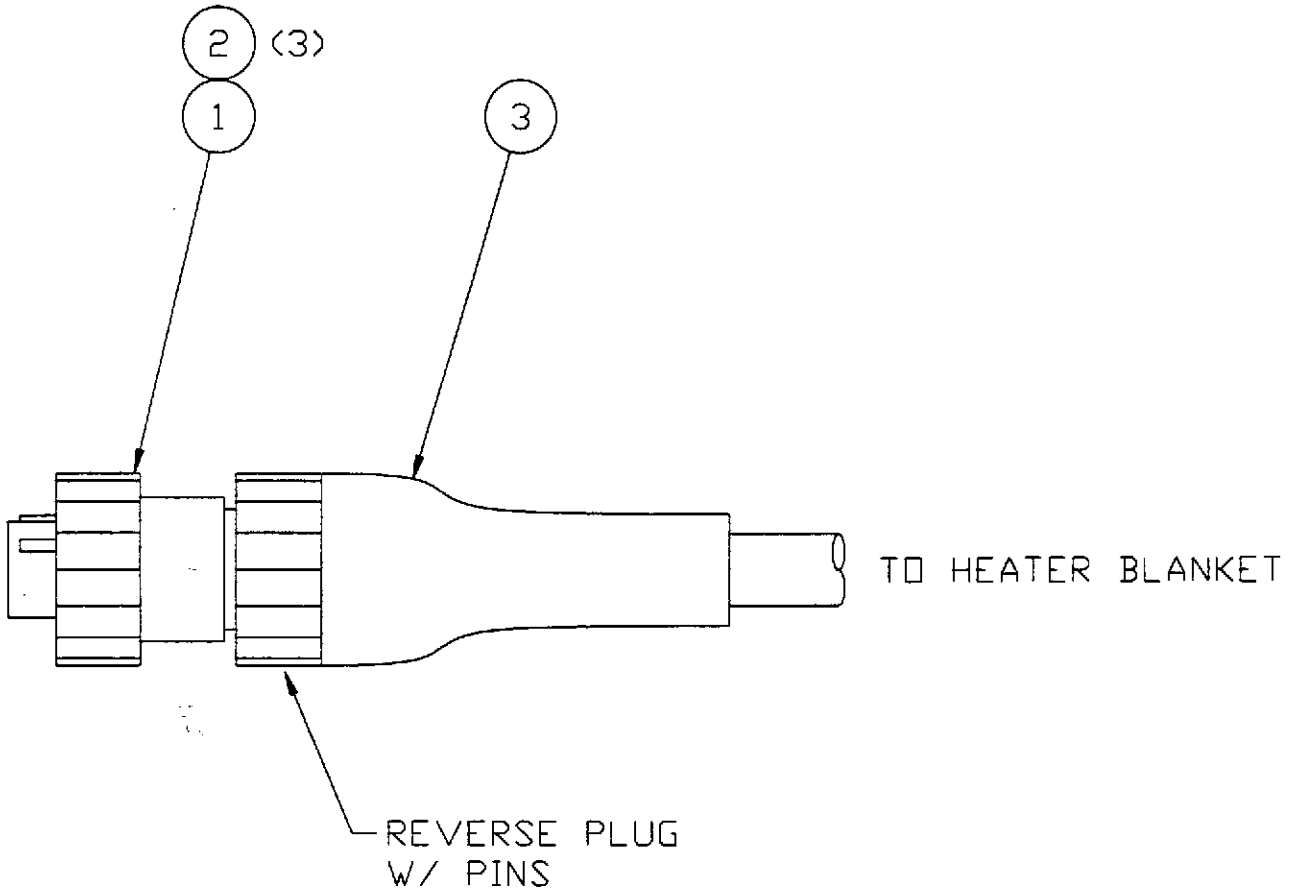
DRAWING NUMBER	REV	DESCRIPTION	QTY	ASSEMBLY DWGS REQ'D BY DATE	BLANKETS REQ'D BY DATE
V049-0-001	0	P & ID VAC EQUIP LEGEND	-	-	-
V049-4-101 (1 SHEETS)	0	BEAM SPLITTER CHAMBER (BSC) SEE ANNULUS PIPING, V049-4-025 SEE BELLOWS TIE ROD, V049-4-040 SEE RGA/AUX. TURBO CONN., V049-4-045 SEE 75 L/S ION PUMP, V049-4-077 SEE COVERS, V049-4-014 & V049-4-A11	1 2	11/29/96	01/17/97 09/05/97
V049-4-002 (1 SHEETS)	0	HORIZ. ACCESS MODULE (HAM) SEE TYPE A4 COVER, V049-4-A4 SEE BELLOWS, V049-2-53 SEE ANNULUS PIPING, V049-4-054	1 5	11/01/96	12/13/96 09/05/97
V049-4-004 (5 SHEETS)	0	80K CRYOPUMP LONG GENERAL ARRG. SEE CLEAN AIR PIPE AND VALVE V049-5-014, SECTIONS L & M	1	11/15/96	01/03/97
V049-4-005 (5 SHEETS)	0	80K CRYOPUMP SHORT GENERAL ARRG SEE CLEAN AIR PIPE AND VALVE, V049-5-019, SECTION D V049-5-023, SECTION D	1	11/15/96	01/03/97
V049-4-014 (1 SHEET)	0	COVER TYPE I BEAM SPLITTER CHAMBER	4	11/15/96	01/03/97
V049-4-025 (1 SHEET)	1	BSC ANNULUS PIPING ARRANGEMENT	1 2	11/29/96	01/17/97 09/05/97
V049-4-040 (1 SHEET)	3	HAM BELLOWS TIE ROD ASSEMBLY SEE V049-4-001	-		
V049-4-045 (1 SHEET)	0	RGA/AUX TURBO CONN ASSEMBLY	-		
V049-4-053 (1 SHEET)	0	60.5 ID METAL BELLOWS HORIZONTAL C SEE V049-4-002	-		
V049-4-054 (1 SHEET)	0	HAM ANNULUS PIPING	2 4	11/01/96	12/13/96 09/05/97
V049-4-077 (1 SHEET)	1	75 L/S ION PUMP - BSC SEE V049-4-001	-		
V049-4-A1 (3 SHEETS)	0	ADAPTER A-1 44 5/8 ID x 60 1/2 ID	1	12/13/96	02/07/97
V049-4-A3 (2 SHEETS)	0	ADAPTER A-3 48 1/4 ID x 60 1/2 ID SEE CLEAN AIR PIPE AND VALVE V049-5-014, SECTION C	2	12/13/96	02/07/97
V049-4-A4 (2 SHEETS)	0	60 HAM COVER GROOVED TYPE A4	2	11/01/96	12/13/96
V049-4-A6 (3 SHEETS)	0	ADAPTER A-6 48 1/4 ID x 60 1/2 ID	2	12/13/96	02/07/97
V049-4-A7 (5 SHEETS)	0	ADAPTER A-7 60 1/2 ID x 72 1/4 ID SEE CLEAN AIR PIPE AND VALVE V049-5-019, SECTION E V049-5-023, SECTION E		12/13/96	02/07/97
V049-4-A11 (1 SHEETS)	0	BSC END COVER TYPE A11	1	11/29/96	01/17/97

ATTACHMENT D
TO SPECIFICATION V049-2-009, REV.4
LIGO BAKEOUT BLANKETS
FOR VACUUM EQUIPMENT

DRAWING NUMBER	REV	DESCRIPTION	QTY	ASSEMBLY DWGS REQ'D BY DATE	BLANKETS REQ'D BY DATE
V049-4-A12 (2 SHEETS)	0	ADAPTER A-12 48.25 ID x 60.50 FLANGE	1	12/13/96	02/07/97
V049-4-A13 (2 SHEETS)	0	ADAPTER A-13 60.50 ID x 72.25 ID	1	12/13/96	02/07/97
V049-4-A14 (3 SHEETS)	0	ADAPTER A-14 44 5/8 ID x 60 1/2 ID	1	12/13/96	02/07/97
V049-4-A15 (2 SHEETS)	0	ADAPTER A-15 48 1/4 ID x 60 1/2 ID	2	12/13/96	02/07/97
V049-4-B1 (3 SHEETS)	0	SPOOL B-1 72 1/4 ID	1	02/07/97	03/28/97
V049-4-B2A (4 SHEETS)	0	SPOOL B-2A 30 1/2 ID x 60 1/2 ID SEE CLEAN AIR PIPE AND VALVE V049-5-014, SECTION F	1	12/13/96	02/07/97
V049-4-B2B (4 SHEETS)	0	SPOOL B-2B 30 1/2 ID x 60 1/2 ID	1	12/13/96	02/07/97
V049-4-B3A (4 SHEETS)	0	SPOOL B-3A 30 1/2 ID x 60 1/2 ID SEE CLEAN AIR PIPE AND VALVE V049-5-014, SECTION C	1	02/07/97	03/28/97
V049-4-B4 (2 SHEETS)	0	SPOOL B-4 48 1/4 ID	2	01/17/97	03/07/97
V049-4-B5A (4 SHEETS)	0	SPOOL B-5A 30 1/2 ID x 60 1/2 ID	1	02/07/97	03/28/97
V049-4-B6 (3 SHEETS)	0	SPOOL B-6 48 1/4 ID SEE CLEAN AIR PIPE AND VALVE V049-5-014, SECTION E	1	02/07/97	03/28/97
V049-4-B7 (3 SHEETS)	0	SPOOL B-7 48 1/4 ID	1	02/07/97	03/28/97
V049-4-B8 (3 SHEETS)	0	SPOOL B-8 72 1/4 ID	1	02/07/97	03/28/97
V049-4-B9 (4 SHEETS)	0	SPOOL B-9 72 1/4 ID	1	01/17/97	03/07/97
V049-4-BE2 (3 SHEETS)	0	SPOOL BE-2 60 1/2 ID	2	01/17/97	03/07/97
V049-4-BE3 (2 SHEETS)	0	OFFSET SPOOL BE-3 60 1/2 ID	1	02/07/97	03/28/97
V049-4-BE3A (2 SHEETS)	0	OFFSET SPOOL BE-3A 60 1/4 ID	1	02/07/97	03/28/97
V049-4-BE4 (3 SHEETS)	0	SPOOL BE-4 44 5/8 ID	2	01/17/97	03/07/97
V049-4-BE5 (5 SHEETS)	0	SPOOL BE-5 72 1/4 ID SEE CLEAN AIR PIPE AND VALVE V049-5-014, SECTION D	1	01/17/97	03/07/97
V049-4-BE6 (5 SHEETS)	0	SPOOL BE-6 72 1/4 ID SEE CLEAN AIR PIPE AND VALVE V049-5-014, SECTION D	1	01/17/97	03/07/97
V049-5-002 (1 SHEETS)	0	EQUIP. ARRG ISO CORNER STATION (WA)	-		
V049-5-010 (1 SHEETS)	0	EQUIP. ARRG ISO RT. MID STATION (WA)	-		
V049-5-011 (1 SHEETS)	0	EQUIP. ARRG ISO RT. END STATION (WA)	-		
V049-5-014 (1 OF 2 SHEETS	0	PIPING ARRG SECS CORNER STATION (W SEE CLEAN AIR PIPE AND VALVE SECTION C (WB-3A) SECTION F (WB-2A)	 1 1	 03/28/97 03/28/97	 09/05/97 09/05/97

ATTACHMENT D
TO SPECIFICATION V049-2-009, REV.4
LIGO BAKEOUT BLANKETS
FOR VACUUM EQUIPMENT

DRAWING NUMBER	REV	DESCRIPTION	QTY	ASSEMBLY DWGS REQ'D BY DATE	BLANKETS REQ'D BY DATE
		SECTION D (WBE-5)	1	03/28/97	09/05/97
		SECTION E (WBE-6)	1	03/28/97	09/05/97
		SECTION L (WCP2)	1	03/28/97	09/05/97
		SECTION M (WCP1)	1	03/28/97	09/05/97
V049-5-019 (1 SHEET)	0	PIPE ARRG SECS RIGHT MID STATION (WA			
		SEE CLEAN AIR PIPE AND VALVE			
		SECTION D (WCP5)	2	11/29/96	01/17/97
		SECTION E (ADAPTER A-7)	1	03/28/97	09/05/97
V049-5-023 (1 SHEET)	0	PIPE ARRG SECS RIGHT END STATION (W			
		SEE CLEAN AIR PIPE AND VALVE			
		SECTION D (WCP8)	1	11/29/96	01/17/97
		SECTION E (ADAPTER WA-7C)	1	11/29/97	01/17/97
V049-8-255 (1 SHEETS)	0	ASSEMBLY G48E (48" GATE VALVE)	2	03/28/97	09/05/97
V049-8-228 (1 SHEETS)	9	2500 L/S ION PUMP, QUOTATION DWG.	4	03/28/97	09/05/97
V049-8-249 (1 SHEET)		GATE VALVE 14" ID DIM DWG	1	12/13/96	02/07/97
			2		09/05/97
V049-8-250 (1 SHEETS)		DIMENSIONAL DWG LIGO VALVES (6")	2	03/28/97	09/05/97
V049-8-306 (1 SHEET)		SCHIEBER ND 250 (10" GATE VALVE)	2	11/01/96	12/13/96
			1		09/05/97
V049-8-XXX (NA)		ASSEMBLY G44E (44" GATE VALVE) SIMLAR TO V049-8-255	4	03/28/97	09/05/97
V049-8-XXX (NA)		GAUGE PAIRS	3	03/28/97	09/05/97



NOTES:
1.) THE SMALLEST WIRE SIZE SHALL BE #18 AWG.
2.) THE WIRE SHALL BE RATED 10 AMPS MIN. PER N.E.C.

ITEM	QTY	VENDOR	PART NO.	DESCRIPTION
1	1	AMP	206429-1	PLUG, REVERSE SEX, 600VAC, 10A
2	3	AMP	66361-2	PIN, #14 AWG, 600VAC, 10A
3	1	AMP	54010-1	CABLE ENTRY SEAL, STRAIN RELIEF

REV	DESCRIPTION		CHKD	DRWN	DATE	DED#
2	CHANGED CONNECTOR TYPE	D.McW	DP	BAR	10/2/96	0286
1	REVISED PER DED	D.McW	DP	BAR	6/20/96	0205
	ISSUED FOR RELEASE	D.McW	FAB	BAR	4/2/96	

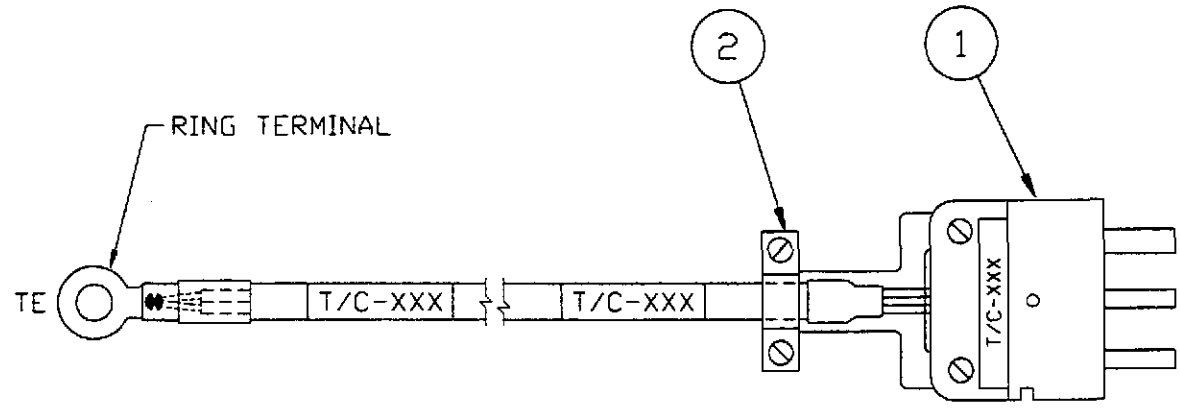
DO NOT SCALE THIS DWG. | USED ON: | NEXT ASS'Y:

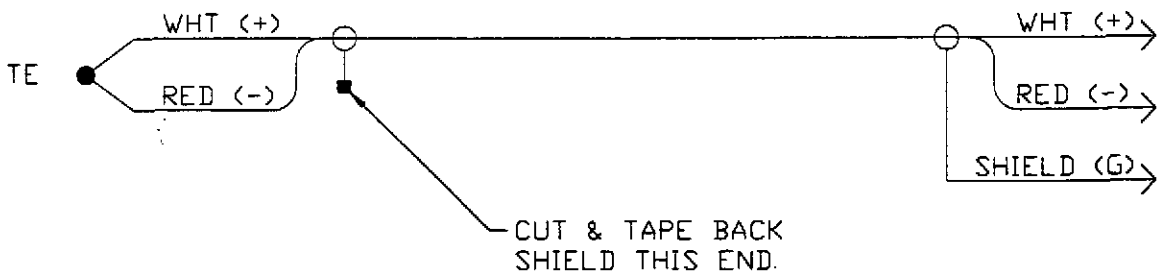
PROCESS SYSTEMS INTERNATIONAL, INC.
20 WALKUP DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

HEATER BLANKET
POWER CABLE END CONNECTOR
LIGO HEATER BAKEOUT SYSTEM

CAD FILE	SIZE	DWG. NO.	REV.
3019S1	A	V049-3-019	2
SCALE NONE		SHEET 1 OF 3	

Oct 02, 1996 - 14:36:05





NOTE:
1.) REFER TO PSI SPEC. V59049-2-009 FOR WIRING REQUIREMENTS.

ITEM	QTY	VENDOR	PART NO.	DESCRIPTION
1	1	OMEGA	OTP-J-M	TYPE "J" T/C CONNECTOR, MALE
2	1	OMEGA	PCLM	CABLE CLAMP

PROCESS SYSTEMS INTERNATIONAL INC.
20 WALKUP DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

HEATER BLANKET
THERMOCOUPLE END CONNECTOR
LIGO HEATER BAKEOUT SYSTEM

CAD FILE	SIZE	DWG. NO.	REV.
3019S2	A	V049-3-019	2

SCALE NONE | SHEET 2 OF 3

Oct 02, 1996 - 14:36:28

SPECIFICATION FOR

CLEAN AIR SUPPLY SYSTEMS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Thomas M. Stein

QUALITY ASSURANCE: Allan L Bradbook

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	TMS 3-5-96	D. McW	REVISED FOR PURCHASE PER DEO 0081
0	TMS 12-14-95	DMcW 12-14-95	REVISED & RELEASED FOR QUOTATION
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	Rev.
	T. Stein	6-14-95	Rcs	9/26/95	V049-2-011	1

SPECIFICATION TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Testing

7.0 Inspection

8.0 Warranty

Attachment A LIGO QA Requirements Summary

Attachment B Other Technical Requirements
PSI Specification V049-2-033, Rev. 2

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 K Bradbrook

TECHNICAL DIRECTOR: D. A. Mueller

PROJECT MANAGER:

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
2	DM 5/20/96	DEO 5/21/96	Revised per DEO #0185 & issued for purchase
1	DM 4/30/96	DEO 4/3/96	Revised per DEO # 0154
ø	DM 3/5/96	D. Mueller	Initial release PER DEO 0083 FOR QUOTE

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

SPECIFICATION TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Cleaning/Testing

7.0 Inspection

8.0 Warranty

Attachment A — LIGO QA Requirements Summary

Attachment B — General Equipment Requirements, PSI Specification V049-2-033, Rev. 2

Attachment C — Vessel Piping & Instrumentation Diagram, V049-0-006, Rev. 2.

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)			V0492013P1
Washington Site:	6	9/1/97	Tag nos. WDW3,WDW4,WDW5, WDW6,WDW7,WDW8
Louisiana Site:	2	3/1/98	Tag nos. LDW3,LDW4
Total Required	8		

Number

Rev.

	Quantity	Date	PSI P/N
12,000 Gallon (minimum net after 90 days)			V0492013P2
Washington Site:	2	9/1/97	Tag nos. WDW1,WDW2
Louisiana Site:	2	3/1/98	Tag nos. LDW1,LDW2
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.

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 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 (PSI drawing V049-0-006).

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 single 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

4.13 A vapor line pressure gauge shall be provided with the dewar.

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:	SPECNO.: 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						PLUS 4 COPIES OF CODE DATA PACKAGE WITH MANUFACTURER'S CODE DATA REPORT	

Attachment A to V049-2-013

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 Bradbrook

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Brian Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	~~DM~~ 10/9/96	DMW10-11-96	General revisions deleting GN_2 lines from VJ requirement. Release for requote per DEO #296
ϕ	~~DM~~ 6/26/96	DMW6-29-96	General revisions. Released for quotation. PER DEO #218
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 T. Stan 6-14-95	APPROVED DATE AES 9/26/95	Number **V049-2-016**	Rev. 1

SPECIFICATION TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Testing

7.0 Inspection

8.0 Warranty

Attachment A LIGO QA Requirements

Attachment B PSI Specification V049-2-033, Rev. 2, Specification for General Equipment Requirements

Attachment C PSI Specification V049-2-034, Rev. 0, Specification for Equipment Purchase, Commercial Requirements

Piping Arrangement Drawings:

V049-6-016-SK1

V049-6-016-SK2

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 (VJ) piping for the LIGO vacuum system. The piping will be used in liquid nitrogen service at the 80 K cryopumps. The cryopumps are identified in the LIGO drawings by the designations, WCPX or LCPX, where X is a numeric identifier of a particular cryopump.

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
Washington Site:		
LN2 Supply Line	8	9/1/97
Louisiana Site:		
LN2 Supply Line	4	3/1/98
Total Required	12	

2.2 At each of the stations along the interferometer arms where a cryopump is located, the lengths of VJ pipe and the number of piping components is the same as every other cryopump station. However, there are different ways in which the piping is routed. The attached sketches, V049-6-016-SK1 and V049-6-016-SK2 define the ways in which the piping is routed.

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 piping will be used in liquid 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 piping arrangement drawings. Vacuum jacketted piping is identified in the drawings with the suffix "VJ".

4.2 The piping shall meet the Vendor's standards. However, the liquid nitrogen process line must be 1/2" NPS SCH 10. No bellows shall be used in the process line supplying liquid nitrogen to the cryopump. If bellows are necessary, they shall be used on the vacuum jacket only. The piping system shall feature intermediate bayonet connections as shown in the attached drawings and wherever else is necessary as determined by the Vendor, so that it can be assembled inside the LIGO vacuum equipment building without resorting to any welding.

4.3 The vacuum jacketted piping shall terminate at the cryopump in male bayonet connections utilizing 1/2" NPS SCH 10 for its process line so that there is a smooth transition in the pipe inner diameter from the supply line through the bayonet to the cryopump. The other end of the piping shall terminate in pant leg/stub end type connections. These connections shall be designed so that the process lines can be butt welded to succeeding runs of pipe which will be covered by mechanical (non VJ) insulation.

4.4 The jacket and process lines shall be grade 304L stainless steel.

4.6 The following paragraphs of Attachment B are not applicable:

5.1.4 5.1.5 5.1.7 14.0

9.4 9.4.1 9.4.2

5.0 REQUIRED DOCUMENTATION

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

1) Isometric drawings of the piping system shall document the design.These drawings shall be updated as necessary and submitted to PSI for approval.

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

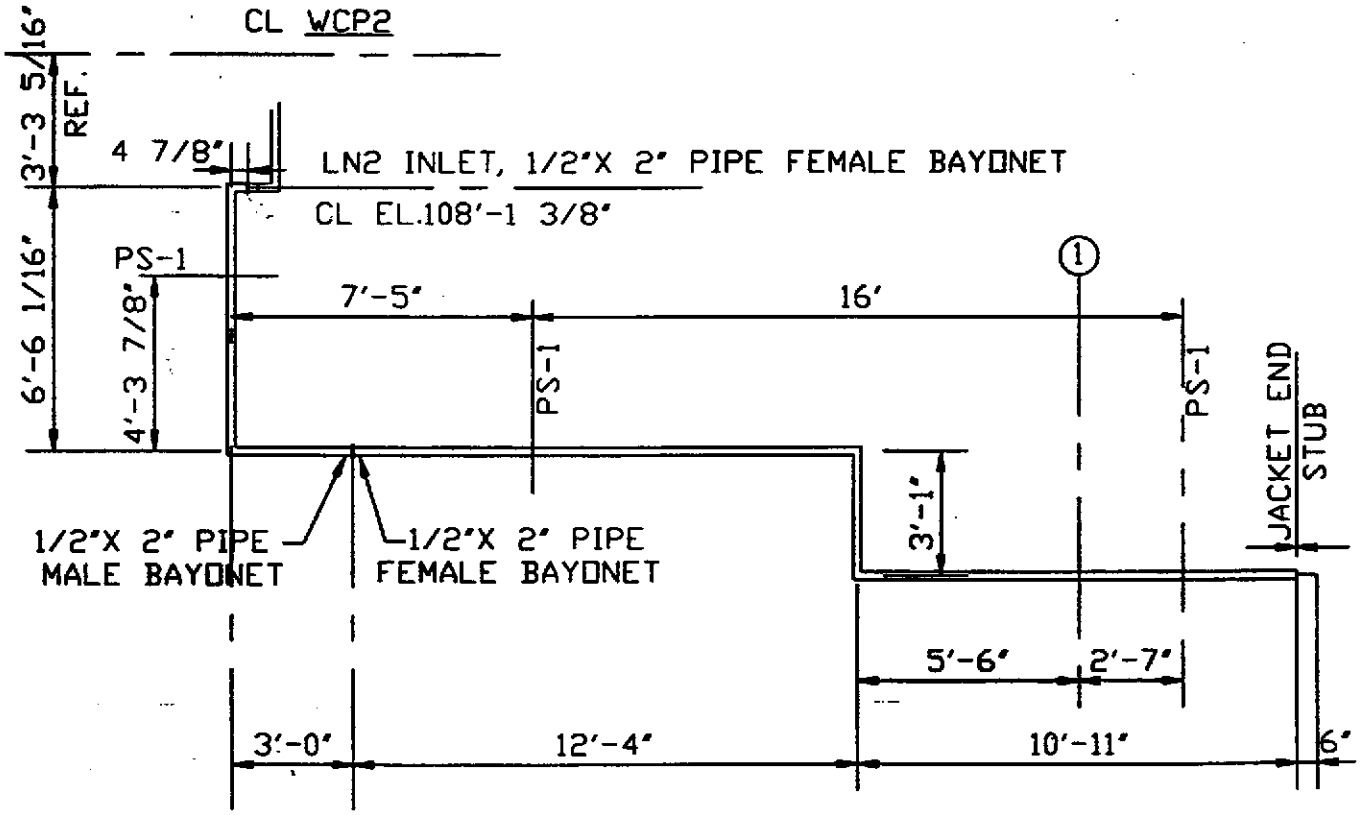
Refer to Attachment A, Section 15.0, and to Attachment B, General Provisions, Article 40 for warranty requirements.

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: VACUUM JACKETTED PIPING	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-016

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		
IN-PROCESS INSPECTIONS	TBD	X		2	X		
OPERATION & MAINTENANCE MANUALS	X			X	X		
SHOP TEST PLAN			X	2	X	Prior to release for fabrication.	
SHOP TEST (WITH REPORT)		X		2	X	Prior to release for shipment.	



PLAN VEW

LN2 SUPPLY LINE FOR CORNER STATION.

V049-2-016-SK1

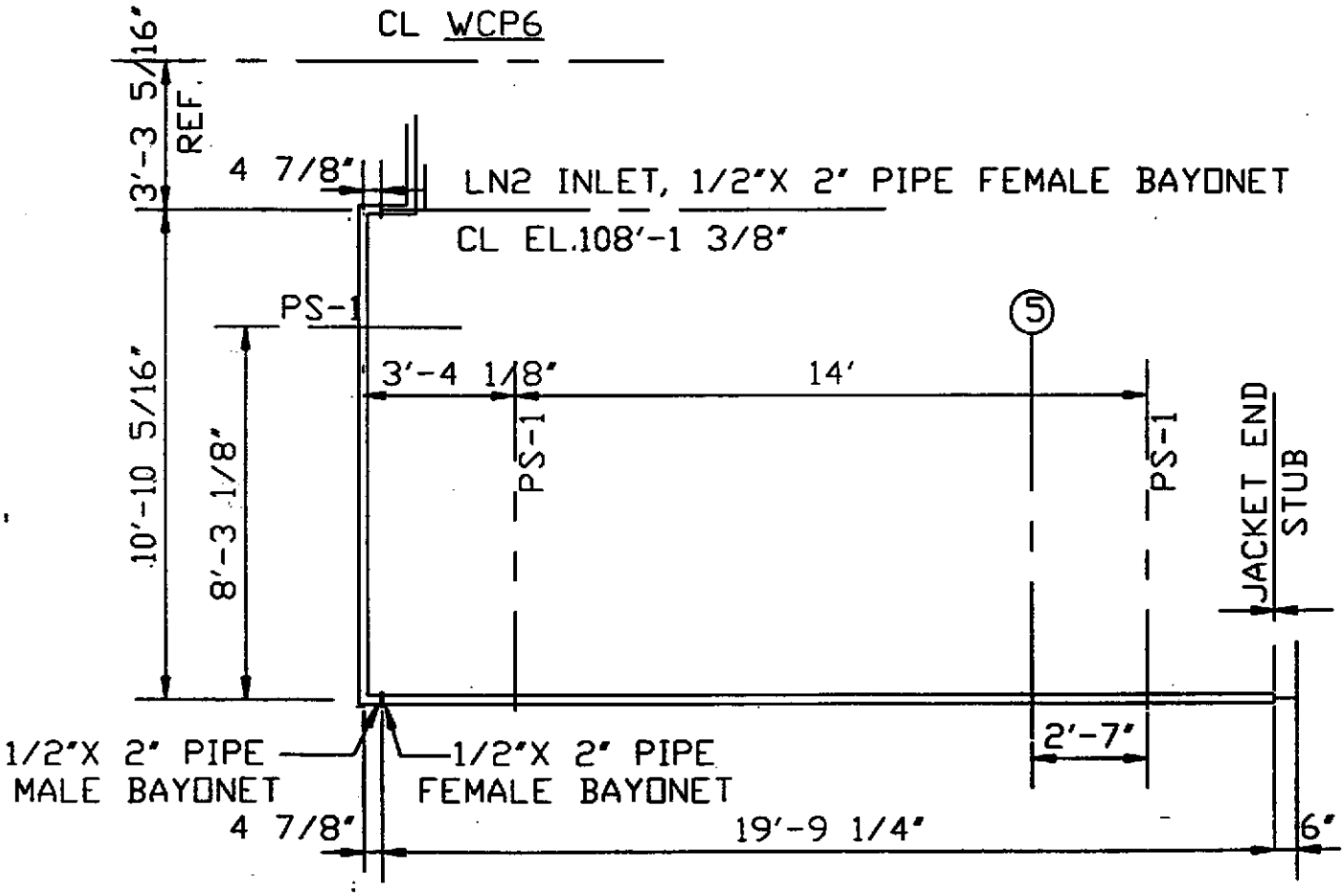
JACKETED LINE: 1/2"IPS X 2"IPS

TOTAL 4 REQ'D

2 - AS SHOWN

2 - OPPOSITE HAND

Oct. 9, 1996



PLAN VEW

LN2 SUPPLY LINE FOR MID AND END STATION.

V049-2-016-SK2

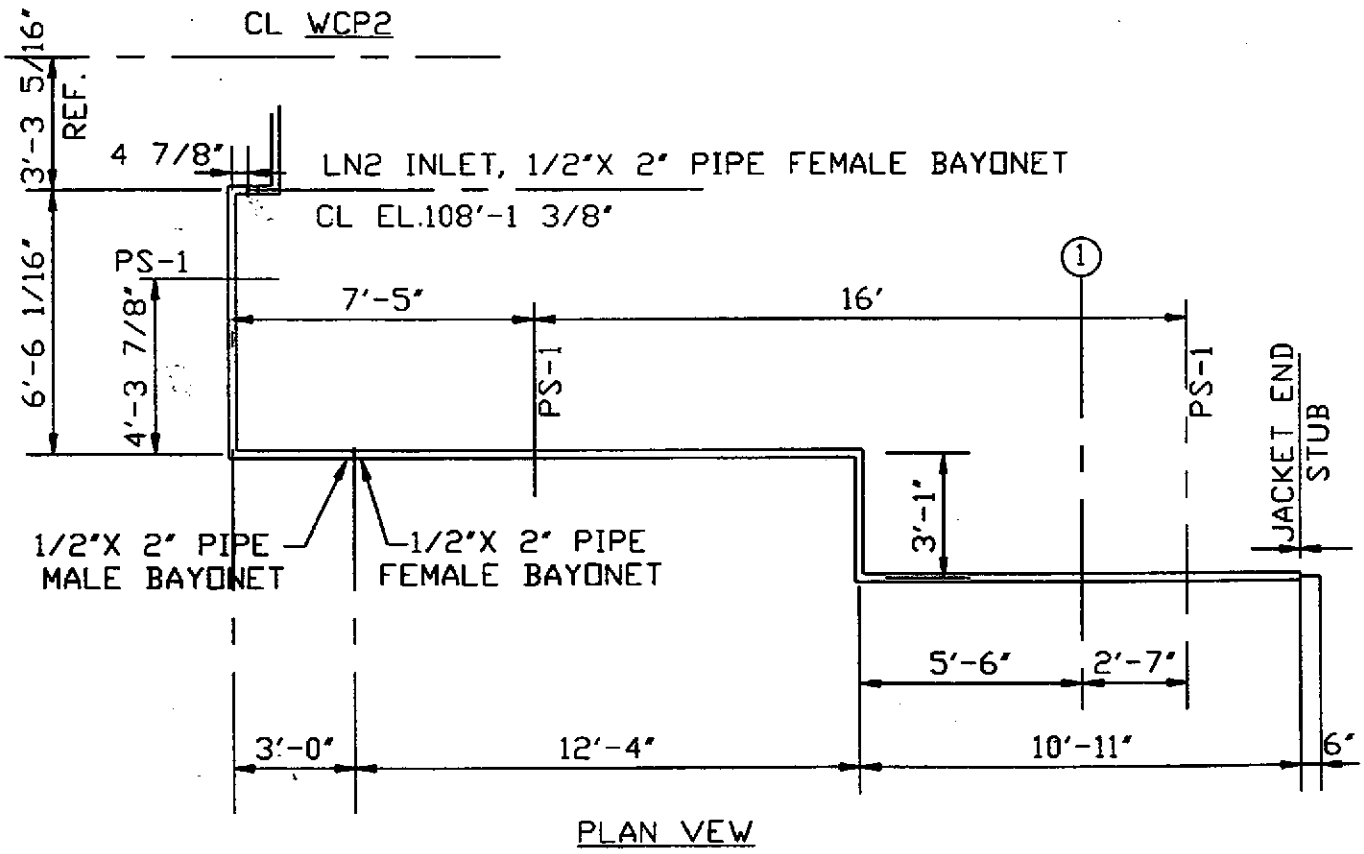
JACKETED LINE: 1/2"IPS X 2"IPS

TOTAL 8 REQ'D

4 - AS SHOWN

4 - OPPOSITE HAND

Oct. 9, 1996



PLAN VEW

LN2 SUPPLY LINE FOR CORNER STATION.

V049-2-016-SK1

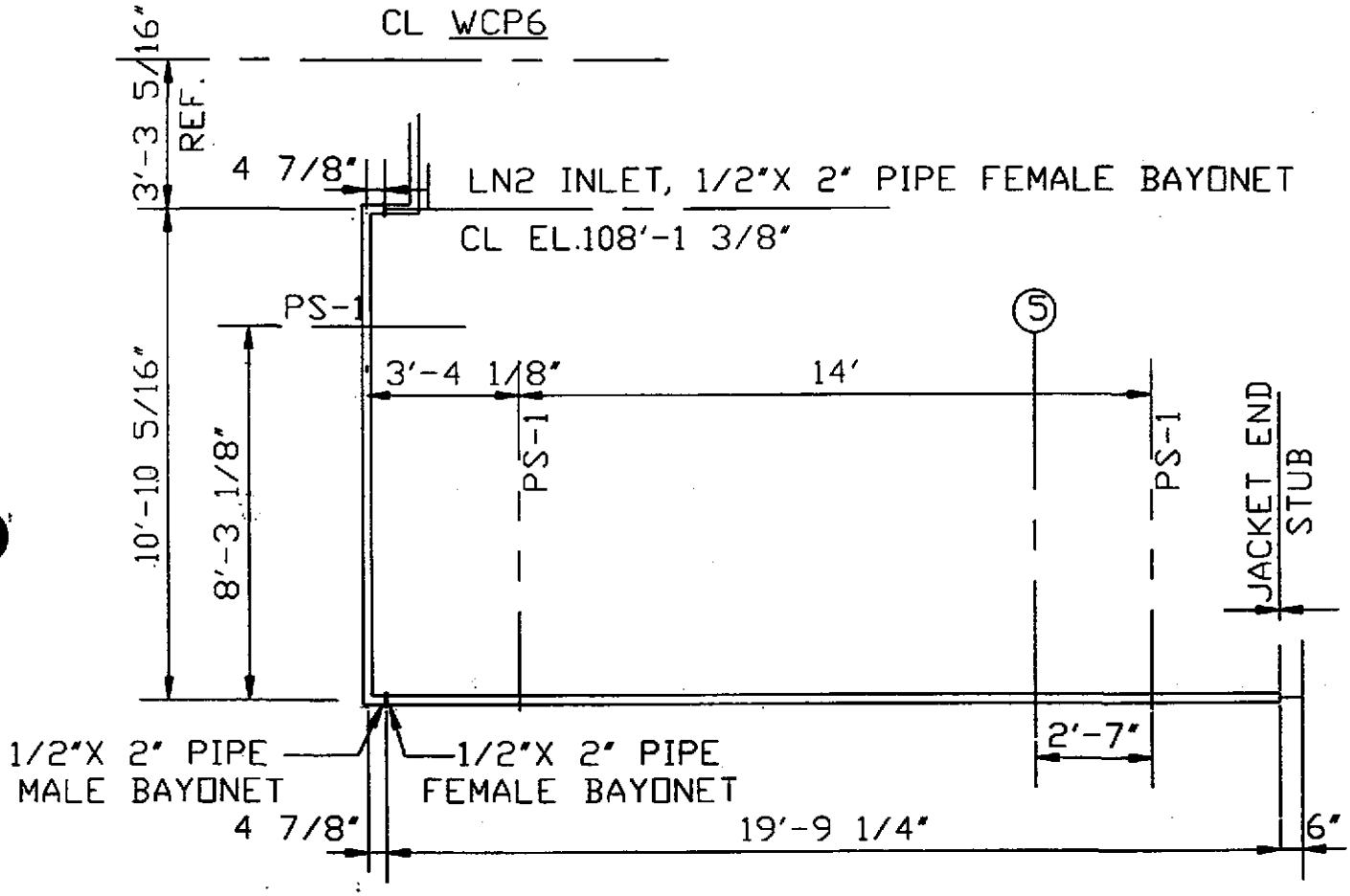
JACKETED LINE: 1/2"IPS X 2"IPS

TOTAL 4 REQ'D

2 - AS SHOWN

2 - OPPOSITE HAND

Oct. 9, 1996



PLAN VEW

LN2 SUPPLY LINE FOR MID AND END STATION.

V049-2-016-SK2

JACKETED LINE: 1/2"IPS X 2"IPS

TOTAL 8 REQ'D

4 - AS SHOWN

4 - OPPOSITE HAND

Oct. 9, 1996

Title: SPECIFICATION FOR BELLOWS EXPANSION JOINTS

SPECIFICATION FOR

BELLOWS EXPANSION JOINTS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: R.E. Curtis 2/7/96

STRUCTURAL ENGINEER: R. D. Ciatto 2/8/96

QUALITY ASSURANCE: A.K. Bradbrook 2/9/96

TECHNICAL DIRECTOR: D.A. McWilliams 2-8-96

PROJECT MANAGER:

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
5	D.M.W 9-17-96	REB 9/15/96	REVISED & ISSUED FOR PURCHASE PER DEO 0266
4	REB 9/11/96	REB 9/11/96	REVISED ATTACHMENT "B" SHT. 1&2. REISSUED FOR PURCHASE DEO 0261

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.

3	FAD 8-16-96	RES 8/19/96	ISSUED FOR PURCHASE PER DEO 0244
2	ROC 6/24/96	D.M.W	REISSUED FOR QUOTES DEO 0210
1	RDC 5/2/96	RES 5/2/96	ISSUED PER DEO 0163 FOR EDR
0	RC 2-7-96	D.M.W 2-8-96	ISSUED FOR QUOTES DEO 0059
P1	10-19-95		RELEASED PER DEO 0005
P1	TS 9-26-95		REVISED FOR UPDATED PRELIMINARY DESIGN

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

INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number A V049-2-017	Rev.
	R.E.C.	2/7/96	D.M.W	2-8-96		5

SPECIFICATION TABLE OF CONTENTS

1.0 Scope

2.0 Material Requirements

3.0 Schedule

4.0 Equipment Requirements

5.0 Design Requirements

6.0 Material Testing

7.0 Fabrication

8.0 Welding

9.0 Cleanliness

10.0 Shop Testing

11.0 Inspection

12.0 Rejections and Repair of Defects

13.0 Identification

14.0 Documentation

15.0 Packing, Storing and Shipping

16.0 Non-Escort Privileges and Inspection Right

17.0 Bellows Design Data

Attachment A	LIGO Quality Assurance Requirements Summary
Attachment B	Drawing List, Schedule of Bellows Assembly Quanitities, and Deliveries
Attachment C	Weld Procedure V049-2-070
Attachment D	Release To Ship Form

NOTE: All Sections Revised

1.0 SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipping, and shipment of bellows expansion joints 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 MATERIAL REQUIREMENTS

2.1 All bellows material provided by the vendor shall conform to the requirements of ASME Specification SA-240 Type 304L with the additional supplementary requirements described in this specification. Other vendor supplied materials shall be provided as required by the drawings and bills of material. The bellows material used shall be hot rolled, annealed and pickled. Bright H_2 annealed material is not permitted. If the bellows material is supplied dual certified to grade 304/304L, this will be acceptable to PSI. Vendor or purchaser supplied material for nipples shall be dual certified to grade 304/304L.

2.2 Applicable Codes

2.2.1 ASME Boiler & Pressure Vessel Code, Section II, "Materials", 1992 Edition through 1994 Addenda.

2.2.2 ASTM A-480, "Standard Specification for General Requirements for Flat-Roll Stainless and Heat-Resisting Steel Plate, Sheet, and Strip".

2.2.3 ASTM A-700, "Standard Packages for Packaging, marking, and Loading Methods for Steel Products for Domestic Shipment".

2.3 Any apparent conflicts between the requirements given herein and the applicable ASME Specification shall be brought to the attention of PSI for clarification.

3.0 SCHEDULE

3.1 See Attachment "B" for bellows assembly quantities and delivery schedule.

3.2 All of the above items shall be shipped to the Buyer directly (Westborough, Massachusetts).

3.3 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.

4.0 EQUIPMENT REQUIREMENTS

4.1 The Vendor shall provide the fabricated items identified on the Buyer's design drawings. The bellows detail is shown on Sketch A included in this specification.

4.2 All Bellows and assemblies shall be designed and fabricated to comply with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Pressure Vessels, latest edition and subsequent addenda, even though vacuum vessels are beyond the scope of this code. Furnished components need not be code "U" stamped.

4.3 Bellows for the "Adapter and Spool Sections" , except those described in 4.4 below, will to be retracted 3" maximum or extended 1" maximum at installation from the shipping length. Also, bellows will be retracted 3" maximum from the installed position for equipment maintenance and "O-Ring" replacement for approximately 200 cycles (total plant life). The shipping length will be the neutral bellows length without any extensions or compressions.

4.4 Bellows for the HAM nozzles and spools BE-3 and BE-3A cannot be extended because of space limitations, hence, they must be designed to allow from 1 1/2" to 2" in compression from the installed position for "O-Ring" replacement. All other requirements stated in this specification apply. Seller must specify the maximum compression allowed for all adapters and spools.

4.5 For normal operating conditions, thermal expansion movements shown in TABLE 1 are from the installed position and shall be designed for the Seller's normal cycle life (1000 cycles min.). Seller shall specify and complete the dimensional information required in Table 1.

4.6 The bellows spring rate shall be such that the total load (spring rate x maximum displacement) shall not exceed 100 #/inch of circumference at the flange I.D.

4.7 Carbon steel parts including but not limited to tie rods, plate washers and nuts shall be finished by the electroless nickel process meeting the requirements of ASTM B733.

5.0 DESIGN REQUIREMENTS

See Attachment "B" for the list of PSI drawings which show bellows spools to be fabricated into bellows assemblies by the Vendor. The bellows shall be provided with end nipples fabricated as shown on PSI drawings, from bulk plate provided by PSI. In addition, jacking lug assemblies and lifting lugs must be installed on each bellows assembly. Design and locations of jacking lug assemblies and lifting lugs will be provided by PSI. Lug & tie-rod material as shown on the PSI drawings shall be provided by Vendor. NOTE: Tie-rod/lifting lugs are to be used as shipping restraints by the bellows vendor.

5.1 "HAM Chamber" bellows shall be provided loose without end nipples.

5.2 Expansion joints shall withstand Ultra-high Vacuum (10E-09 Torr.) at 400 Deg F, bakeout and 2 PSIG internal pressure at room temperature during the purging operation.

5.3 Bellows dimensional limits are shown on PSI drawings. Thermal expansion movements, etc. are shown in Par. 17. The Seller shall provide the actual dimensions and other data requested in the table.

5.3.1 In Par. 17, t is the bellows thickness, O.D. Corr. is the outside diameter of the convolutions, and L is the bellows length. Other dimensions are shown on sketch A.

5.3.2 In addition to the dimensional requirements, the bellows must be capable of permitting a maximum of 1/2 degree of angular offset (bending) while in the installed position.

5.4 Multi-ply bellows are not acceptable for Hi-Vacuum service.

5.5 Except for attachment welds to nipples, circumferential welds in bellows are not permitted under any circumstance.

6.0 MATERIAL TESTING

6.1 One material coupon, 2" x 2" min., from each heat number, lot and thickness of bellows material provided by the vendor must be supplied to PSI for information prior to release for shipment. Each coupon shall be permanently marked/stamped with heat number, lot, etc., for positive identification.

7.0 FABRICATION

7.1 All bellows assemblies shall be furnished complete as shown on the Buyer's drawings, as required by the Purchase Order and as herein noted, and shall include all necessary hardware, such as bolts, washers, and nuts. Tolerances shall be adhered to as specified on the detail drawings.

7.2 For rolling of shells, carbon steel rollers shall be covered with heavy indoor/outdoor carpet or S/S during the rolling process to prevent carbon steel contamination of the stainless steel.

7.3 The seam edges of plates to be rolled are to be preworked to assure roundness of the final cylinder.

8.0 WELDING

8.1 All welding shall be performed in accordance with the ASME Boiler & Pressure Vessel Code, Section IX, Welding and Brazing Qualification, 1992 Edition through 1994 Addenda and other applicable code sections referenced herein.

8.2 All welders shall be certified to ASME Section IX Procedures.

8.3 All vacuum boundary welds shall be continuously welded and shall be on inside per drawing details. Grinding is not permitted; welds shall be smooth but NOT FLUSH & NOT GROUND. Carbide cutting is permitted.

8.4 All welds at vacuum boundaries shall be vacuum tight with a helium leak rate equivalent to a total of 1×10^{-9} torr liters/sec/chamber. PSI will leak test all bellows welds with a helium mass spectrometer. Vendor shall repair all leak areas identified by PSI.

8.5 The Seller's fitup tack welding procedures and procedure qualifications shall be submitted to the Buyer for approval. Approval must be obtained prior to use.

8.6 All weld joint preparation shall be done by tungsten carbide tooling.

8.7 Welding Process

8.7.1. Vacuum boundary and attachment welds shall be gas tungsten arc welds (GTAW) or plasma arc welds (PAW) (see sample Attachment C). The vendor shall submit weld procedures to the Buyer for review and approval prior to fabrication.

8.7.2. All weld repairs shall be performed in accordance with PSI approved procedures.

8.7.3. All weld wire and weld joint preparation areas shall be cleaned with CO_2 scrubbing prior to welding per PSI procedure V049-2-070. Weld wire shall packaged after cleaning to prevent contamination. Weld wire shall be handled only with clean gloves after CO_2 cleaning.

8.8 Backing strips or rings shall not be used.

8.9 Longitudinal seams of the bellows and spools shall be offset.

8.10 Welding shall be done in an area that is separate from dirty processes (MIG welding, grinding, blasting, painting, etc.).

9.0 CLEANLINESS

9.1 This material is intended for use in a high vacuum application. Potential hydrocarbon contamination shall be prevented. Also, the material shall be wrapped and covered at all times the material is not being processed to minimize possible exposure to contaminants.

9.2 No iron, carbon steel or other contaminants (such as grease, oil or hydrocarbons) are to come in contact with the shells. Machining fluids shall be water soluble and free of oil and sulfur. All fluids that come in contact with bellow shall not exceed the contaminant levels permitted as stated below.

Maximum Concentration Limits

Contaminant	Limit
Water Leachable Chlorides	100 ppm
Total Halogens (including Water Leachable Chlorides)	1000 ppm
Total Sulfur	1000 ppm

9.3 Bellows shall be cleaned and dried (air dried) prior to wrapping. The bellows shall be free of all surface contaminants, forming lubricants, free from residue from forming rolls, tools etc. and standing water. The Seller shall submit all cleaning procedures and methods for Buyers approval.

10.0 SHOP TESTING

The Seller shall submit all test methods and procedures that are to be used to verify the leak tightness of the expansion joints (bellows and weld nipples) or bellows (after forming) for the buyers approval. The Seller shall submit the documented results of the tests to the Buyer for his records. The Buyer reserves the right to witness the tests on-site. The vendor shall notify the buyer 5 working days before each lot is leak tested.

Bellows shall be helium leak checked per ASTM E498 to less than 1×10^{-9} Torr l/sec.

Liquid penetrant testing shall not be used for testing.

11.0 INSPECTION

11.1 The responsibility for all inspections rests with the Seller, however, the Buyer reserves the right to inspect the components and/or final assemblies at any time during or after fabrication to assure that the workmanship and materials are in compliance with this specification.

11.2 The purchaser shall have the right to witness all manufacturing processes.

11.3 The purchaser shall be informed 5 working days before the scheduled ship date of each lot. A signed release for ship form is required from the purchaser to release each shipment.

11.4 Purchaser supplied material must be inspected by the purchaser before use. (Direct shipment from mills.)

12.0 REJECTIONS AND REPAIR OF DEFECTS

12.1 No weld splices or repair welding is permitted to the formed bellows. The only exception is at the bellows to nipple circumferential seal welds.

12.2 If a weld defect is found in the bellows to nipple weld during PSI's leak test, the weld will be repaired by PSI and the cost back charged to the vendor.

12.3 If a weld or metal defect is found in the metal bellows during PSI's leak test, the bellows unit will be returned to the vendor, and a replacement bellows assembly will be sent to PSI at no cost to PSI.

13.0 IDENTIFICATION

13.1 Identification of the nipple and bellows material shall be maintained and documented through all manufacturing processes (i.e. restamping material heat numbers after each cut).

13.2 If material identity of the bellows or nipples is lost, they shall be requalified by making all tests that were required for the material or as indicated in this specification.

13.3 Marking the finished bellows 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 only the outside of the attached shells (when applicable). All other marking methods must be approved by the purchaser prior to use. All attached nipples shall be marked 2" from the edge. Material heat numbers shall be marked on the outside of all bellows and nipples.

13.4 All bellows and bellows assemblies shall be marked with the Buyer's drawing number plus "P1" and a unique serial number for each assembly (1, 2, 3, etc.) Example: V0494A1P1 Serial No. 1. All quality assurance documentation shall reference this number.

14.0 DOCUMENTATION

14.1 The Certified Material Test Reports (CMTRs) for vendor purchased material shall be provided to the purchaser with the shipment of the assemblies, and be available for review during inspection visits prior to shipment. See Attachment A for other required documentation.

14.2 Design calculations and fabrication drawings shall be submitted to the purchaser for approval prior to fabrication.

15.0 PACKAGING, STORING AND SHIPPING

15.1 Temporary shipping supports, as required, shall be of the same material as the nipple and attached so that they may easily be removed without damage to the assemblies. All temporary devices shall be clearly marked and tagged "to be removed prior to operation".

15.2 All material and parts shall be covered with a tarp immediately after each processing operation has 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.

15.3 After final cleaning, bellows/assemblies shall be packaged for shipping. All bellows/assemblies shall be wrapped in polyethylene and placed in closed wooden crates with proper supports to prevent shipping damage.

15.4 The bellows shall be shipped as specified in the purchase order (TBD).

15.5 The purchaser shall approve each lot of bellows/bellows assemblies prior to shipment. A signed off (by purchaser) release to ship form shall be included with each shipment.

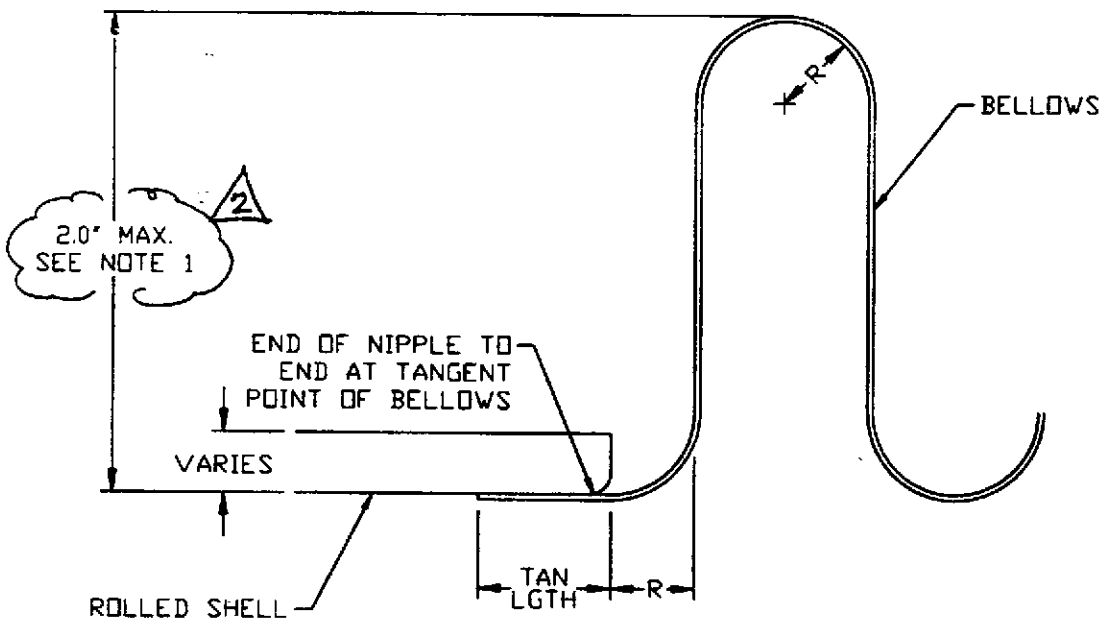
16.0 NON-ESCORT PRIVILEGES AND INSPECTION RIGHT

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.

17.0 BELLOWS DESIGN DATA
SPEC. V049-2-017

REV	ITEM	BELLOWS ID	QTY	MAINT. COMPR.	THERMAL AXIAL COMPR.	MAX. O.D. CORR	"t" (INCHES)	TAN LGTH.	SELLER TO PROVIDE ACT. O.D. CORR	ACT. "L"	NO. OF CORR.	CYCLE LIFE
	V049-4-053 (HAM)	60 1/2"	18	2"	1/2"	63 1/2"						
	ADAPTER -A1	44 5/8"	10	3"	7/16"							
	ADAPTER -A3	48 1/4"	4	3"	9/16"							
	ADAPTER -A6	48 1/4"	2	3"	3/8"							
	ADAPTER -A12	48 1/4"	2	3"	5/8"							
	ADAPTER -A13	60 1/2"	2	3"	9/16"							
	ADAPTER -A14	44 5/8"	2	3"	5/8"							
	SPOOL BE-2	60 1/2"	4	3"	1/2"							
	SPOOL BE-3	60 1/2"	3	2"	1/2"							
	SPOOL BE-3A	60 12"	3	2"	1/2"							
	SPOOL BE-1	72 1/4"	2	3"	5/8"							
	SPOOL BE-4	44 5/8"	12	3"	11/16"							
	SPOOL BE-5	72 1/4"	2	3"	2"							
	SPOOL BE-6	72 1/4"	2	3"	2							
	SPOOL B2A	30 1/2"	1	3"	1"							
	SPOOL B2B	30 1/2"	1	3"	1"							
	SPOOL B3A	30 1/2"	2	3"	1"							
	SPOOL B5A	30 1/2"	2	3"	1"							

NOTE 1: TYPICAL FOR ALL BELLOWS EXCEPT HAM. FOR HAM BELLOWS, THIS DIMENSION SHALL BE 1.5" MAX.



REV.	DESCRIPTION	DATE	BY	CHK.	APP.

PROCESS SYSTEMS INTERNATIONAL INC.
20 WALKUP DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

SKETCH A
BELLOWS DETAIL

CAD FILE NO.	SIZE	DWG. NO.	REV.
V0492017	A	V049-2-017	4

SCALE: NONE | DRAWN: | SHEET: 11 OF 11

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT:BELLOWS EXPANSION JOINTS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPECNO: V049-2-017

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	9/13		X	2	X		
VENDOR Q.A. PLAN	9/13		X	2	X		
CLEANING PROCEDURE	9/13		X	2	X		
PREP FOR SHIPMENT PROCEDURE	9/13		X	2	X		
WELDING PROCEDURES			X	2	X		
ASSEMBLY DRAWINGS			X	2	X		
DESIGN REVIEW							
CERTIFIED MATERIAL TEST REPORTS				2	X		
IN-PROCESS INSPECTIONS		X		2	X		
BELLOWS DESIGN DATA				2	X		
SHOP TEST PLAN (LEAK CHECK, ETC.)			X	2	X		
SHOP TEST (WITH REPORT)		X		2	X		
SHOP DIMENSIONAL INSPECTION		X		2	X		

ATTACHMENT "B"

Drawing List, Schedule of Bellows Assembly Quantities, and Deliveries.

PSI Dwg No.	PSI Part No.	Rolled Nipple I.D.	Quantity (Wash.)	Date	Quantity (LA)	Date	Make From PSI Part No.
V049-4-A1	V0494A1P1	44.63	6	10/25/96	4	2/1/97	V049M159-1
V049-4-A3	V0494A3P1	48.25	2	10/25/96	2	2/1/97	V049M163-1
V049-4-A6	V0494A6P1	48.25	2	10/25/96	0	2/1/97	V049M163-1
V049-4-A12	V0494A12P1	48.25	2	10/25/96	0	2/1/97	V049M163-1
V049-4-A13	V0494A13P1	60.5	2	10/25/96	0	2/1/97	V049M163-1
V049-4-A14	V0494A14P1	44.63	2	11/25/96	0	2/1/97	V049M178-1
V049-4-B2A	V0494B2AP1	30.5	1	11/25/96	0	2/1/97	V049M157-1
V049-4-B2B	V0494B2BP1	30.5	1	11/25/96	0	2/1/97	V049M157-1
V049-4-B3A	V0494B3AP1	30.5	1	11/25/96	1	2/1/97	V049M157-1
V049-4-B5A	V0494B5AP1	30.5	1	11/25/96	1	2/1/97	V049M157-1
V049-4-BE1	V0494BE1P1	72.25	0	11/25/96	2	2/1/97	V049M154-1
V049-4-BE2	V0494BE2P1	60.5	2	10/25/96	2	2/1/97	V049M153-1
V049-4-BE3	V0494BE3P1	60.5	2	11/25/96	1	2/1/97	V049M177-1
V049-4-BE3A	V0494BE3AP1	60.5	2	11/25/96	1	2/1/97	V049M177-1
V049-4-BE4	V0494BE4P1	44.63	8	11/25/96	4	2/1/97	V049M158-1
V049-4-BE5	V0494BE5P1	72.25	1	11/25/96	1	2/1/97	V049M155-1
V049-4-BE6	V0494BE6P1	72.25	1	11/25/96	1	2/1/97	V049M155-1
V049-4-053	V0494053	60.5	12	11/25/96	6	2/1/97	
		Total	**48**	**Total**	**26**		

NOTE: Partial deliveries in advance of above dates are acceptable only with PSI approval.

ATTACHMENT "B"

List of PSI Purchased Plate To Be Sent To Bellows Vendor

Plate P/N	Size	WA	LA	Total PLS
V049M159-1	1/4 x 96 x 142	3	2	5
V040M163-1	1/4 x 72 x 154	4	1	5
V049M178-1	1/4 x 88 x 142	2	---	2
V049M157-1	1/4 x 90 x 98	2	1	3
V049M154-1	1/4 x 120 x 229	---	2	2
V049M153-1	1/4 x 62 x 192	2	2	4
V049M177-1	3/8 x 96 x 192	1	1	2
V049M158-1	1/4 x 66 x 142	4	2	6
V049M155-1	3/8 x 96 x 230	1	1	2

ATTACHMENT "D"

LIGO Project **Release to Ship Form** **Date:**_____

Purchase Order No.: Lot:
Vendor Name:
PSI Part Number:
Description:
Manufacturers' Model Number:
Manufacturers' Serial Number:
Specification Number: V049- Rev.:
Packaging Requirements: Per V0492017
Ship Via:
Bill of Lading:
Ship to Address: Process Systems International 20 Walkup Drive Westborough, MA 01581 (508) 366-9111
FOB:
Attention of: Receiving Department
Operating Manuals: with Equipment ; to PSI
Documentation Package: To be sent to PSI; Attention: Mr. Ronald Bento
Authorized Signature:

Number

Rev.

SPECIFICATION FOR

AMBIENT AIR VAPORIZERS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE: C.A. Bradbrook

TECHNICAL DIRECTOR: DAVE McWILLIAMS/RSB

PROJECT MANAGER: Richard Bayer

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	DM 7/22/96	RSB	Revised per DEO #225 & released for purchase
ϕ	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.
	DM	2/20/96	D. Miller	2-23-96		1

TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Testing

7.0 Inspection

8.0 Warranty

Attachment A LIGO QA Requirements Summary

Attachment B General Equipment Requirements
PSI Specification V049-2-033, Rev. 2

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 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.: V049-2-062

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						PRIOR TO RELEASE FOR FABRICATION.	
IN-PROCESS INSPECTIONS						PRIOR TO RELEASE FOR FABRICATION.	
OPERATION & MAINTENANCE MANUALS	12Wk			5	X		
SHOP TEST PLAN	8 Wk		X	2	X	PRIOR TO RELEASE FOR FABRICATION.	
SHOP TEST (WITH REPORT)				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: Dave Moore

QUALITY ASSURANCE: A R Braddock

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Richard Boyle

ELECTRICAL/ INSTRUMENTATION Fadi Kanh

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	DM	AEB	Released for purchase per DEO 226. No spec. changes
Ø	DM	DMcW	Initial release

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number A V049-2-056	Rev. 1
	DMoore 2/23/96	D. McW		

TABLE OF CONTENTS

1.0 Scope
2.0 Schedule
3.0 Equipment Requirements
4.0 Design Requirements
5.0 Required Documentation
6.0 Shop Testing
7.0 Inspection
8.0 Warranty

Attachment A LIGO QA Requirements Summary

Attachment B General Equipment Requirements
PSI Specification V049-2-033, Rev. 2

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.

Number

Rev.

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							

Title: SPECIFICATION FOR SMALL VACUUM VALVES

SPECIFICATION FOR

SMALL VACUUM VALVES

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Thomas M. Stam

PROCESS ENGINEER: Roberto Thom.

QUALITY ASSURANCE: [signature]

TECHNICAL DIRECTOR: D. C. McWilliams

PROJECT MANAGER: [signature]

1	TMS 7-19-96	D. McW	REVISED FOR PURCHASE PER DEO 0224
0	TMS 2-29-96	D. McW	RELEASED FOR QUOTE PER DEO 0075
REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE

PROCESS SYSTEMS INTERNATIONAL, INC.					SPECIFICATION	
INITIAL APPROVALS	PREPARED T. Stam	DATE 2-29-96	APPROVED KZB	DATE 2/21/96	Number V049-2-059	Rev. 1

SPECIFICATION TABLE OF CONTENTS

1.0 Scope
2.0 Schedule
3.0 Design Requirements
4.0 Required Documentation
5.0 Shop Testing
6.0 Inspection

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 Part No.
1 1/2" High Vac	137	9/30/96	V049AVHV15
2 1/2" High Vac	70	9/30/96	V049AVHV25
1 1/2" Ultra High Vac	77	9/30/96	V049AVUV15
2 1/2" Ultra High Vac	26	9/30/96	V049AVUV25

2.2 All valves shall be delivered to Process Systems International, Inc. at 20 Walkup Drive, Westboro, Massachusetts, 01581.

2.3 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.

SPECIFICATION FOR

CLEAN QUARTER-TURN VALVES

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Thomas M. Stan

PROCESS ENGINEER: Roberto Thom

QUALITY ASSURANCE: Alan L Bradbrook

TECHNICAL DIRECTOR: D C. McWilliams

PROJECT MANAGER: Rob Bayless

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	TMS 9-25-96	DMcW 9-26-96	REVISED FOR PURCHASE PER DEO 0274
0	TMS 3-1-96	D.McW 9-5-96	RELEASED FOR QUOTE PER DEO 077

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number V049-2-060	Rev.
	T. M. Stan 3-1-96	RBS	A	1

SPECIFICATION TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Design Requirements

4.0 Required Documentation

5.0 Shop Testing

6.0 Inspection

Attachment MDC Catalog Cut

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	PSI Part No.
PSI, Westboro, MA:	21	11/29/96	V049BVCA20

2.2 Deleted

3.0 DESIGN REQUIREMENTS

3.1 The valves shall be either butterfly style, MDC Model No. BFV-200, MDC Part No. 360002.

3.2 The valves shall be 304 stainless steel.

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 visually inspected for cleanliness prior to shipment. Valves shall be recleaned if any contamination is found.

ATTACHMENT

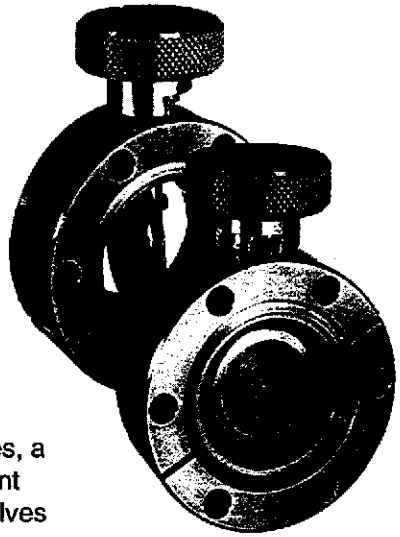
Butterfly Valves

Del•Seal Metal Seal Flange

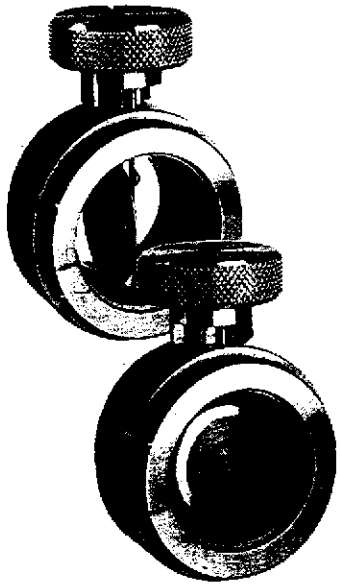
Kwik•Flange ISO O-Ring Flange

FEATURES

- Quick open/Quick close
- Positive lock both positions
- Positive Viton® O-Ring vacuum seal
- High conductance
- Choice of *Del-Seal* or *Kwik-Flange*



Del-Seal Flange
BFV-150



Kwik-Flange Flange
KBFV-150

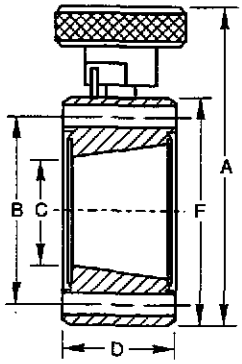
DESCRIPTION

MDC Butterfly Valves require only one-quarter turn rotation of the handle to go from fully open to the fully closed position. In the 1-1/3 Mini *Del-Seal* flange series, a spring loaded ball bearing becomes seated in an indent providing a positive mechanical stop. All other size valves employ a roll pin stop method.

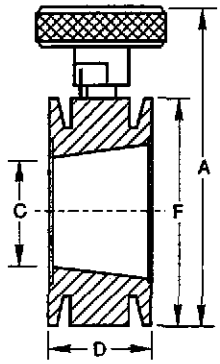
These quick-acting Butterfly Valves feature an improved sealing action. The opening in the body of the valve has been machined at a slight angle to the plane of the flapper. The flapper is set to rotate slightly off-center. On closure, this causes the sealing pressure to be applied more uniformly all around the O-ring. A reliable, positive seal is made and the tendency of previous designs to roughen the surface of the O-ring and eject it from its groove is eliminated.

MDC Butterfly Valves are low outgassing. All internal surfaces are machined from solid stainless steel bar stock. The handle is made of aluminum. A small O-ring on the stem prevents shaft leakage.

The valves are offered with a choice of *Del-Seal* ultra-high vacuum metal-seal flanges or ISO *Kwik-Flange* O-ring seal flanges.



Del-Seal Flange



Kwik-Flange Flange

ORDERING INFORMATION

Please order by Part Number

Valve Nom I.D. Size	Reference	Part Number	Flange F	Flange O.D.	Bolt Holes No.	Ref ISO	Height A	Bolt Circle B	C	Thickness D	Wt Lbs	Unit Price
3/4	BFV-075	360000	*Del-Seal* 1-1/3	1.33	6	-	1.96	1.062	.60	.75	1	$250
3/4	KBFV-075	360010	*Kwik-Flange*	1.18	-	NW16	1.81	-	.56	1.25	1	$250
1	KBFV-100	360011	*Kwik-Flange*	1.57	-	NW25	2.32	-	.87	1.25	1	$255
1-1/2	BFV-150	360001	*Del-Seal* 2-3/4	2.73	6	-	3.81	2.312	1.33	1.00	1	$260
1-1/2	KBFV-150	360012	*Kwik-Flange*	2.16	-	NW40	3.81	-	1.31	1.34	1	$260
2	BFV-200	360002	*Del-Seal* 3-3/8	3.37	8	-	4.46	2.850	1.84	1.00	2-1/2	$360
2	KBFV-200	360013	*Kwik-Flange*	2.95	-	NW50	4.46	-	1.87	1.68	2-1/2	$360

Dimensions are in inches

SPECIFICATION FOR

LIGO CRYOGENIC CONTROL VALVES

FOR

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

Job No. V59049

INSTRUMENTATION/ ELECTRICAL ENGINEER: F. Bartle

PROJECT ENGINEER: David Moore

TECHNICAL DIRECTOR: D. G. McWilliams

PROJECT MANAGER: Bartle Bayle

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
2	DM 9/17/96	D. McW 10-8-96	Revised per DEO #267
1	DM 7/2/96	D. McW 7-2-96	Revised per DEO #217 & released for purchase
Ø	DM 2/29/96	D. McW	Initial release PER DEO 076 FOR QUOTE

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE: DMoore 2/29/96	APPROVED DATE: D. McW 3-11-96	Number V049-2-062	Rev. 2

TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Testing

7.0 Inspection

8.0 Warranty/Performance

Attachment A LIGO QA Requirements Summary

Attachment B PSI Valve Data Sheets

Attachment C General Equipment Requirements
PSI Specification V049-2-033, Rev. 2

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 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 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	Cryogenic Control Valve	PSI	12	11/30/96

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 cabable of being mechanically insulated (a layer of fiberglass insulation with foam insulation around the fiberglass).

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. Airsets shall be provided with the valves.

4.8 The following paragraphs of Attachment C are not applicable:

5.1.1	5.1.5	5.1.6	5.1.7
5.1.11	5.2.1.3	6.3	6.4
8.1	8.2	8.4	9.4.1
9.4.2	9.6.1	9.6.4	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).

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 C are not applicable:

5.1.1	5.1.5	5.1.6	5.1.7
5.1.11	5.2.1.3	6.3	6.4
8.1	8.2	8.4	9.4.1
9.4.2	9.6.1	9.6.4	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 C (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

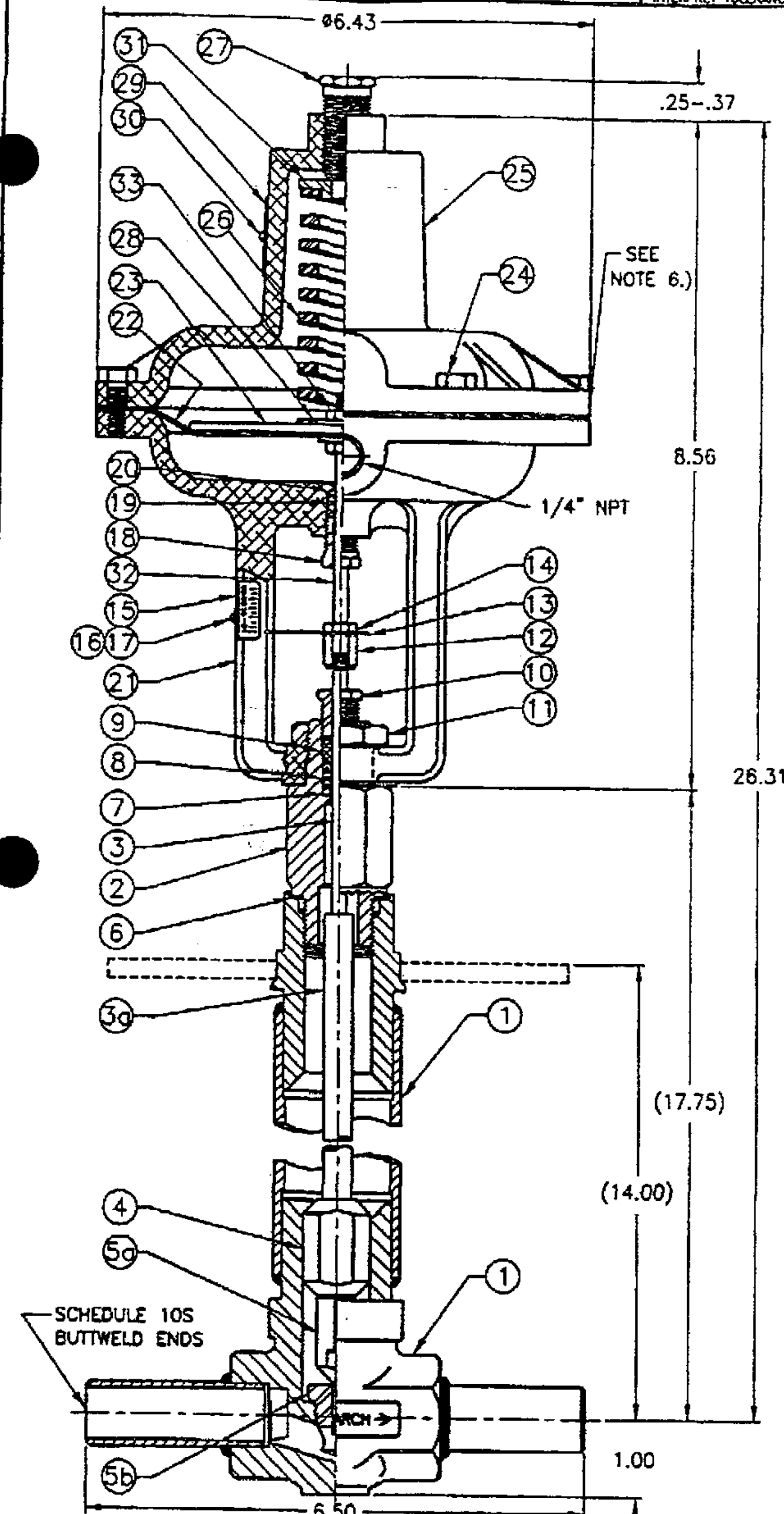
LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT:CRYOGENIC CONTROL VALVES	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-062

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	N/A		X		X		
VENDOR Q.A. PLAN	2		X	2	X		
CLEANING PROCEDURE	2		X	2	X		
PREP FOR SHIPMENT PROCEDURE	N/A		X		X		
ASSEMBLY DRAWINGS	4		X	2	X		
VALVE SIZING CALCULATION	*	X			X	PRIOR TO SHIPMENT.	
IN-PROCESS INSPECTIONS	*			2	X		
OPERATION & MAINTENANCE MANUALS	8			5	X		
SHOP TEST PLAN	N/A		X	2	X	PRIOR TO RELEASE FOR FABRICATION.	
SHOP TEST (WITH REPORT)	*			2	X	PRIOR TO RELEASE FOR SHIPMENT.	
SHOP DIMENSIONAL INSPECTION	*			2	X		
WELDING PROCEDURES	4 WK		X	2	X		
* PER APPROVED VENDOR SCHEDULE							

Attachment B

PSI Valve Data Sheets

CD-952106 | 1.1 | TOLERANCE ON 1-PLACE DIMENSIONS ±.030 | ALL DIMENSIONS ARE IN INCHES
INTERPRET TOLERANCES PER ANSI Y14.5-1982 | PROPERTY OF BADGER METER INC.



PARTS & MATERIAL LIST

QUANTITIES ARE FOR ONE (1) UNIT ONLY

ITEM NO.	PART NO.	QTY	DESCRIPTION	MATERIAL
1	527467-0001	1	BODY	316L SST
2	527338-0001	1	BONNET	316 SST
3	525614-0001	1	STEM	316 SST
3a	522759-0001	1	STEM	316 SST
4	525613-0001	1	CONNECTOR	316 SST
5a	SEE NOTE 1	1	INNERVALVE	316 SST
5b	SEE NOTE 1	1	SEAT	316 SST
6	500240-0001	1	GASKET	316 SST
7	520755-0017	1	ADAPTOR	PFA
8	541548	1	PACKING SET	TFE
9	520754-0001	1	FOLLOWER	PFA
10	520794-0001	1	GLAND	316 SST
11	520749	1	LOCKNUT	303 SST
12	520391	1	CONNECTOR	303 SST
13	510157	1	TRAVEL POINTER	300 SER SST
14	410011	1	STEM NUT	316 SST
15	520985-0002	1	TRAVEL SCALE	300 SER SST
16	400001-0072	1	SCREW	300 SER SST
17	430002-0022	1	FLAT WASHER	300 SER SST
18	525026-0001	1	O-RING GLAND	316 SST
19	522768	1	O-RING FOLLOWER	TFE
20	490002-0001	1	O-RING	SILICONE RUBBER
21	520987-0002	1	PRESS CASE & YOKE	ALUMINUM
22	510154-0003	1	DIAPHRAGM	BUNA/ NYLON
23	520386-0002	1	DIAPHRAGM PLATE	STEEL/ ZINC PL
24	400029-0001	6	HEX HD.RIM SCREW	300 SER SST
25	520988-0002	1	SPRING CASE	ALUMINUM
26	510031-0107	1	SPRING	STEEL
27	522785-0001	1	SPRING ADJUSTOR	300 SER SST
28	430002-0020	2	WASHER	300 SER SST
29	512416-0002	1	NAMEPLATE	300 SER SST
30	400018-0012	2	DRIVE SCREW	300 SER SST
31	520388-0001	1	SPRING SEAT	ALUMINUM
32	520993	1	TOPWORKS STEM	316 SST
33	410030-0002	2	LOCKNUT	300 SER SST

NOTES:

1.) TRIM ASS'Y P/N: 540366-0001
INNERVALVE TO SIZE AND CHARACTERISTIC SPECIFIED.
(SIZE J Cv 0.05 CHAR. LINEAR)
ITEM 5a & 5b SOLD AS A SINGLE TRIM SET. TRIM SET & GASKET ITEM#6 ARE OPTIONAL SPARE PARTS.

2.) NOMINAL STROKE - .562

3.) INSTRUMENT SIGNAL RANGE 3-15 PSI

4.) RECOMMENDED SPARE PARTS ARE ITEMS 20, 22 & 26. ADDITIONAL RECOMMENDED SPARE PART IS PACKING KIT PART NO. 543801-0001 (INCLUDES ITEMS 7, 8 & 9)

5.) WHEN ORDERING SPARE OR REPLACEMENT PARTS, PROVIDE FACTORY THE VALVE ASSEMBLY SERIAL NUMBER AND ALL OTHER NAMEPLATE DATA.

6.) FURNISHED WITH ECKARDT 4-20 mA POSITIONER & GO SWITCH (MODEL# 7G-23523-A1) TO INDICATE CLOSED PER DWG CD-952107.

V049-1-062, Rev 2 Attachment B Pg 2 of 8

PRINT CERTIFIED FOR: PROCESS SYSTEMS INTERNATIONAL
P.O. : 555761-00
LOCATION: WESTBOROUGH, MA
SERIAL NUMBER: 223915 THRU 223926 TAG NO: NONE
BADGER BY: [signature] DATE: 2-20-96

ISSUE	CHANGE	BY	DATE
1.1	926908	DPD	10-9-96

BADGER METER
RESEARCH CONTROL® VALVES

DWG. NAME: 1/2" BODY/ BONNET CBX STYLE ASSEMBLY 14" EXTENSION WITH SCHEDULE 10S BUTT WELD NIPPLES & ATO TOPWORKS
DRAWN DESVIGNES | DATE 2-20-96 | SCALE NONE | SHT 1 OF 1 | ISSUE
MATERIAL AS SPECIFIED | DWG. NO. CD-952106 | 1.1

OCT-17-96 THU 13:38 BADGER METER P.02

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.)	31.41				9.00	
3	Inlet Pressure	5-13 psig						
4	Outlet Pressure	0.5 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 fiberglass liner with foam outer covering

VALVE BODY/BONNET:

16 *Type Globe
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: See attached for further info.

32 *Type ____
33 *Size J Rated Travel ____
34 *Characteristics linear
35 *Balanced/Unbalanced ____
36 *Rated Cv .05 Fl ____ Xt ____
37 *Plug/Ball Material 316 S.S. / ____
37 *Disk Material ____
38 *Seat Material 316 S.S.
39 *Cage/Guide Material ____
40 *Stem Material 316 S.S.
41
42

SPECIALS/ACCESSORIES:

43 NEC Class ____ Group ____ Div ____
44 NOTES:
45 1. Flashing service
46
47
48
49
50
51
52

53 ACTUATOR:
54 * Type Cylinder
55 *Mfr & Model ____
56 * Size ____ Eff Area ____
57 On/Off ____ Modulating YES
58 Spring Action Open/Close F.C.
59 *Max Allowable Pressure ____
60 *Min Required Pressure ____
61 Available Air Supply Pressure:
62 Max 80 psig Min ____
63 *Bench Range ____ / ____
64 Act Orientation ____
65 Handwheel Type ____
66 Air Failure Valve ____ Set at ____
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 Conoflow GFH85
80 *Set Pressure ____
81 Filter ____ Gauge ____
82

TESTS:

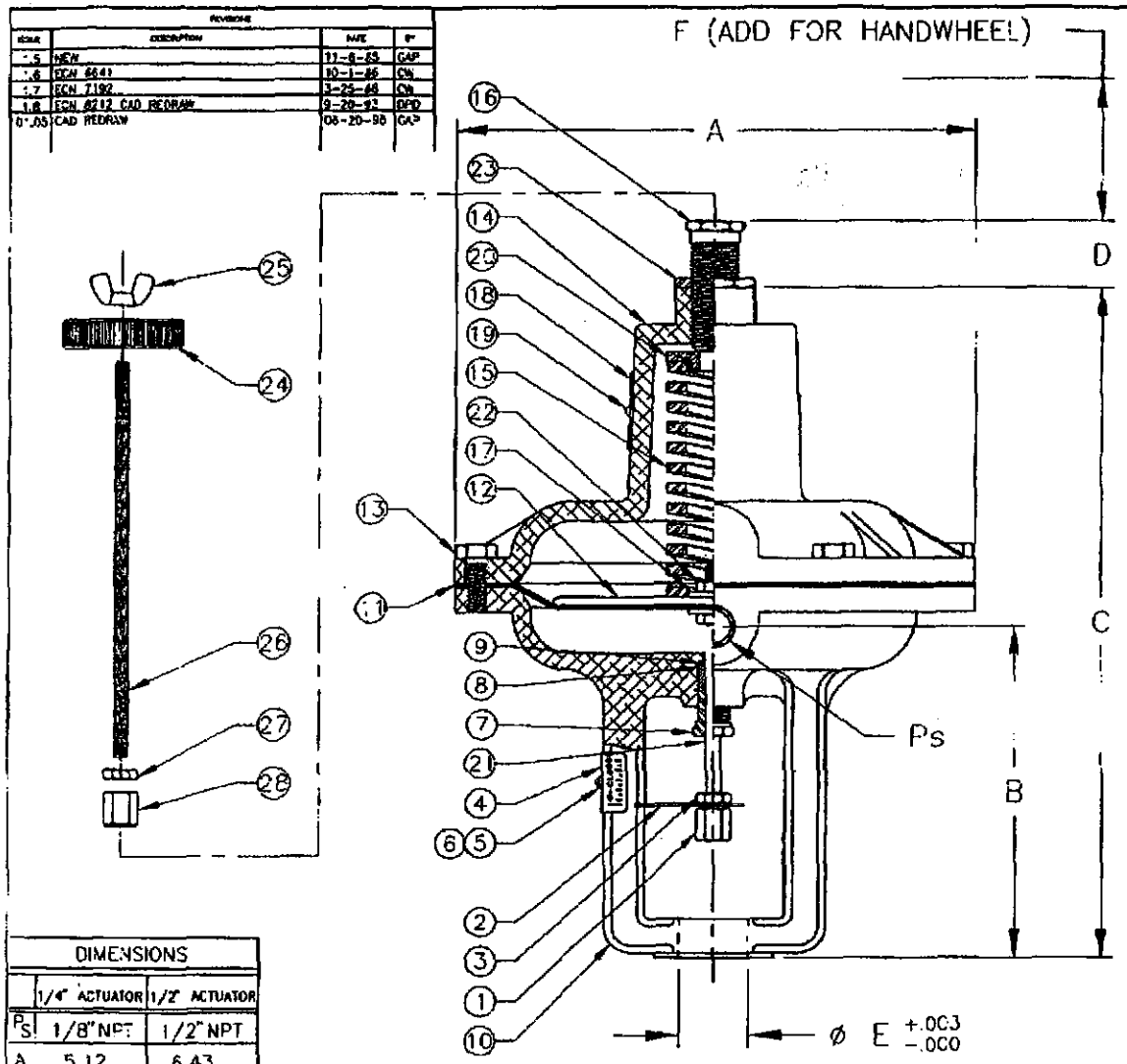
83 *HydroPressure ____
84 ANSI/FCI Leakage Class ____
85 Max. Shutoff Diff. Press. ____ (psi) ____
86

Rev.	Date	Revision	Orig.	App.
Ø	2/28/96		DM	
1	9/19/96		DM	

V049-2-062, Attachment B
Rev 2
Pg 2 of 8

* Information supplied by manufacturer unless already specified.

REVISIONS			
REV#	DESCRIPTION	DATE	BY
-.5	NEW	11-6-85	GAP
-.6	ECN 6641	10-1-86	CVL
-.7	ECN 7192	3-25-88	CVL
-.8	ECN 8212 CAD REDRAW	9-20-93	DPD
01.05	CAD REDRAW	06-20-96	GAP



DIMENSIONS		
	1/4" ACTUATOR	1/2" ACTUATOR
Ps	1/8" NPT	1/2" NPT
A	5.12	6.43
B	3.34	4.29
C	6.59	8.56
D	.18-.31	.25-.37
E	.625	.875
F	1.00	1.18

CD-950754 | 01.05

PARTS & MATERIAL LIST

QUANTITIES ARE FOR ONE (1) UNIT ONLY

ITEM NO.	1/4" PART NO.	1/2" PART NO.	QTY	DESCRIPTION	MATERIAL
-	520997	520391	1	CONNECTOR	300 SER SST
2	510252	510157	1	TRAVEL POINTER	300 SER SST
3	410009	410011	1	STEM NUT	300 SER SST
4	520986-0002	520985-0002	1	TRAVEL SCALE	300 SER SST
5	400C01-0072	400001-0072	1	SCREW	300 SER SST
6	430C02-0022	430002-0022	1	WASHER	300 SER SST
7	525025-0001	525026-0001	1	GLAND	300 SER SST
8	522761	522768	1	FOLLOWER	TFE
9	511828	490002-0001	1	O-RING	SILICONE RUBBER
10	520995-0002	520987-0002	1	PRESS CASE & YOKE	ALUMINUM
11	510261-0001	510154-0003	1	DIAPHRAGM	BUNA/ NYLON
12	520994-0001	520386-0002	1	DIAPHRAGM PLATE	STEEL ZAC P.
13	430029-0003	400029-0001	6	RIM SCREWS	300 SER SST
14	520996-0002	520988-0002	1	SPRING CASE	ALUMINUM
15	510031-0040	510031-0107	1	SPRING	STEEL
16	520990-0002	520390-0003	1	SPRING ADJUSTOR	300 SER SST
17	430002-0037	430002-0020	2	WASHER	300 SER SST
18	512416-0002	512416-0002	1	NAMEPLATE	300 SER SST
19	400018-0012	400018-0012	2	DRIVE SCREW	300 SER SST
20	520931-0001	520366-0001	1	SPRING SEAT	ALUMINUM
21	520932	520993	1	STEM	316 SST
22	410030-0001	410030-0002	2	LOCKNUT	300 SER SST
23	410001-0052	522615	1	LOCKNUT, ADJUSTOR	300 SERIES SST
24	5227C2-0002	522702-0001	1	HANDWHEEL	BRASS
25	410004-0004	410004-0005	1	WINGNUT	300 SERIES SST
26	521271	520389-0001	1	STEM, HANDWHEEL	300 SERIES SST
27	410009	410011	1	NUT	300 SERIES SST
28	520997	520391	1	CONNECTOR	300 SERIES SST

NOTES:

1. RECOMMENDED SPARE PARTS ARE ITEMS 8, 11 & 15.
2. WHEN ORDERING REPLACEMENT PARTS, PROVIDE FACTORY THE VALVE SERIAL NUMBER FROM THE NAMEPLATE ON THE ACTUATOR.
3. ITEMS 23 THRU 28 ARE OPTIONAL EQUIPMENT AVAILABLE AT EXTRA COST - SPECIFY MANUAL HAND-WHEEL WHEN DESIRED.

THIS PRINT CERTIFIED FOR: _____

P.O.: _____

LOCATION: _____

SERIAL NUMBER: _____ TAG NO. _____

BADGER BY: _____ DATE: _____

DRAWN	G.PRICE	5-9-83
CHECKED	W. Hall	6-21-96
ENGINEER	W. Mallett	6-21-96

BADGER METER

RESEARCH CONTROL® VALVES

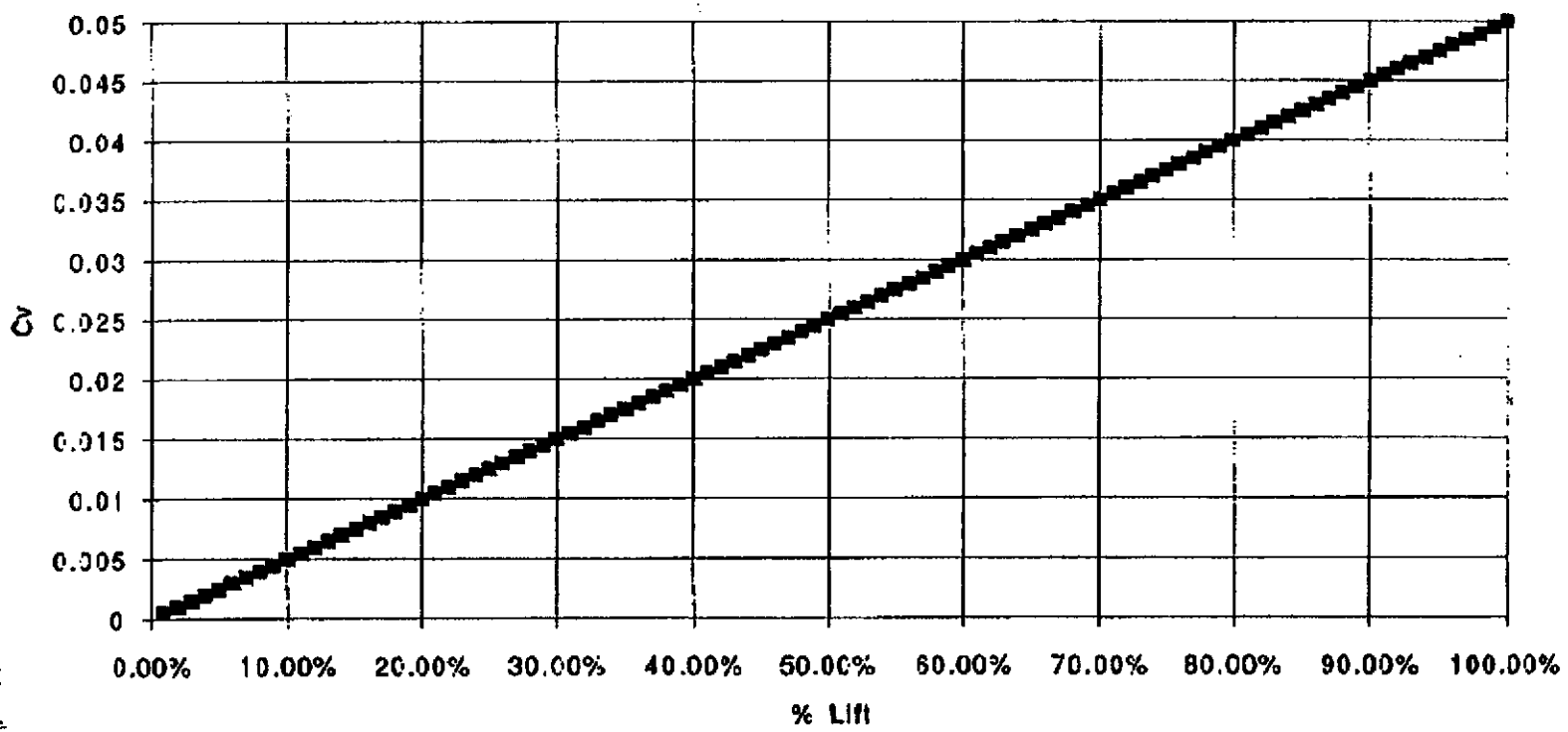
1/4" & 1/2" STANDARD ATO TOPWORKS

SIZE	PRODUCT NO.	DWG. NO.	REV.
C	29	CD-950754	01.05

SCALE 1/1 | MATERIAL PCR 941312 | SHEET 1 OF 1

V049-2-062, Rev 2
Attachment B
Page 4 of 6

"J" LINEAR



V049-2-062, Rev 2
Attachment B,
Pg 5 of 8

"J" LINEAR

.05 Cv MAX.

CV%	TRAVEL %	CV
1.00%	1.00%	0.0005
2.00%	2.00%	0.001
3.00%	3.00%	0.0015
4.00%	4.00%	0.002
5.00%	5.00%	0.0025
6.00%	6.00%	0.003
7.00%	7.00%	0.0035
8.00%	8.00%	0.004
9.00%	9.00%	0.0045
10.00%	10.00%	0.005
11.00%	11.00%	0.0055
12.00%	12.00%	0.006
13.00%	13.00%	0.0065
14.00%	14.00%	0.007
15.00%	15.00%	0.0075
16.00%	16.00%	0.008
17.00%	17.00%	0.0085
18.00%	18.00%	0.009
19.00%	19.00%	0.0095
20.00%	20.00%	0.01
21.00%	21.00%	0.0105
22.00%	22.00%	0.011
23.00%	23.00%	0.0115
24.00%	24.00%	0.012
25.00%	25.00%	0.0125
26.00%	26.00%	0.013
27.00%	27.00%	0.0135
28.00%	28.00%	0.014
29.00%	29.00%	0.0145
30.00%	30.00%	0.015
31.00%	31.00%	0.0155
32.00%	32.00%	0.016
33.00%	33.00%	0.0165
34.00%	34.00%	0.017
35.00%	35.00%	0.0175
36.00%	36.00%	0.018
37.00%	37.00%	0.0185
38.00%	38.00%	0.019
39.00%	39.00%	0.0195
40.00%	40.00%	0.02
41.00%	41.00%	0.0205

42.00%	42.00%	0.021
43.00%	43.00%	0.0215
44.00%	44.00%	0.022
45.00%	45.00%	0.0225
46.00%	46.00%	0.023
47.00%	47.00%	0.0235
48.00%	48.00%	0.024
49.00%	49.00%	0.0245
50.00%	50.00%	0.025
51.00%	51.00%	0.0255
52.00%	52.00%	0.026
53.00%	53.00%	0.0265
54.00%	54.00%	0.027
55.00%	55.00%	0.0275
56.00%	56.00%	0.028
57.00%	57.00%	0.0285
58.00%	58.00%	0.029
59.00%	59.00%	0.0295
60.00%	60.00%	0.03
61.00%	61.00%	0.0305
62.00%	62.00%	0.031
63.00%	63.00%	0.0315
64.00%	64.00%	0.032
65.00%	65.00%	0.0325
66.00%	66.00%	0.033
67.00%	67.00%	0.0335
68.00%	68.00%	0.034
69.00%	69.00%	0.0345
70.00%	70.00%	0.035
71.00%	71.00%	0.0355
72.00%	72.00%	0.036
73.00%	73.00%	0.0365
74.00%	74.00%	0.037
75.00%	75.00%	0.0375
76.00%	76.00%	0.038
77.00%	77.00%	0.0385
78.00%	78.00%	0.039
79.00%	79.00%	0.0395
80.00%	80.00%	0.04
81.00%	81.00%	0.0405
82.00%	82.00%	0.041
83.00%	83.00%	0.0415
84.00%	84.00%	0.042
85.00%	85.00%	0.0425
86.00%	86.00%	0.043
87.00%	87.00%	0.0435

V049-2-062, Rev. 2
Attachment B
Pg 7 of 8

88.00%	88.00%	0.044
89.00%	89.00%	0.0445
90.00%	90.00%	0.045
91.00%	91.00%	0.0455
92.00%	92.00%	0.046
93.00%	93.00%	0.0465
94.00%	94.00%	0.047
95.00%	95.00%	0.0475
96.00%	96.00%	0.048
97.00%	97.00%	0.0485
98.00%	98.00%	0.049
99.00%	99.00%	0.0495
100.00%	100.00%	0.05

V099-2-062
Rev. 2
Attachment B
Pg 8 of 8

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: [illegible signatures]

ELECTRICAL : [illegible signature]

QUALITY ASSURANCE: [illegible signature]

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: [illegible signature]

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
5	BAR 10/14/96	[illegible] 10/31/96	CHANGED DWG. REVISION NUMBERS. DEO 0304
4	BAR	[illegible] 9-27-96	[illegible] DEO 0291
3	BAR 7/30/96	[illegible] 8-1-96	ISSUED FOR "AS-BUILT" CHANGES DEO #0231
2	BAR 5/9/96	[illegible] 5-13-96	ISSUED FOR DESIGN/BUILD CHANGES DEO #0181
1	PPS	[illegible] 3-26-96	Issued for Purchase, DEO #095
Ø		—	Issued for Bid DEO #089

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED PPS	DATE 3/12/96	APPROVED DAM	DATE 3.12	Number V049-2-068	Rev. 5

TABLE OF CONTENTS

1 SCOPE OF WORK 3
2 DRAWING AND SPECIFICATION INTENT 3
3 DEFINITIONS 3
4 EXCEPTIONS 4
5 CODES AND STANDARDS 4
6 LABELED EQUIPMENT 4
7 INSTALLATION RESTRICTIONS 4
8 SPECIFIED EQUIPMENT AND SUBSTITUTIONS 4
9 WIRING SYSTEMS 5
10 TESTING 7
11 INSPECTION 7
12 RELEASE FOR SHIPMENT 7
13 WARRANTY 8
14 RECORD DRAWINGS 8
15 EQUIPMENT DELIVERY SCHEDULE 8

— APPENDIX I–DRAWING LIST / CART 9
— APPENDIX II–ITEMS FURNISHED BY BUYER / CART 10
— APPENDIX III–BILL OF MATERIALS / CART 11

— ATTACHMENT A: PAINTING REQUIREMENTS

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 2	PLC/PC/Data Acquisition Layout

CABINET LAYOUT DRAWINGS

V049-3-013	Rev 5	Assembly, Heater Control Cart (7 sheets)

CABINET SCHEMATIC DRAWINGS

V049-3-011	Rev 2	Elect Schematic, Control System (9 sheets)
V049-3-012	Rev 3	Elect Schematic, Heater Power (2 sheets)

APPENDIX II

ITEMS FURNISHED BY BUYER / CART

Allen-Bradley PLC Equipment

(1)	1771-A3B1	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
(8)	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
(7)	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

Miscellaneous

(1)		Bakeout cart nametag

APPENDIX III

BILL OF MATERIALS / CART

BILL OF MATERIALS (DWG V049-3-013)

PAINT SPEC	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-PD31123	ALLEN BRADLEY	POWER DISTRIBUTION BLOCK
	5	12 EA	199-DR1	ALLEN BRADLEY	1 METER SYMMETRICAL DIN RAIL
	6	114 EA	1492-UF8	ALLEN BRADLEY	FUSE BLOCK, 30A, 600VAC
	7	448 EA			RHMS, #4-40 X 3/8" LG.
	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
PTHALO BLUE	13	1 EA	ER-16823	BUD INDUSTRIES	24" RACK ENCLOSURE
PTHALO BLUE	14	1 EA	ER-16873	BUD INDUSTRIES	24" ADD-A-RACK ENCLOSURE
PTHALO BLUE	15	2 EA	ER-16833	BUD INDUSTRIES	24" RACK STEEL DOOR
CARBIDE BLACK	16	2 PR	PMR-9451	BUD INDUSTRIES	RACK PANEL MOUNTING RAILS
CARBIDE BLACK	17	1 PR	AB-1854	BUD INDUSTRIES	19" TO 24" X 7" ADAPTER
CARBIDE BLACK	18	1 PR	AB-1855	BUD INDUSTRIES	19" TO 24" X 8 3/4" ADAPTER
CARBIDE BLACK	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
CARBIDE BLACK	21	1 EA	SH-2488	BUD INDUSTRIES	24" SLIDING SHELF
CARBIDE BLACK	22	1 EA	PA-2405 MG	BUD INDUSTRIES	24" X 8 3/4" BLANK RACK PANEL
	23	112 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	8 EA	MDA-1/2	BUSS	FUSE, 1/2A, 250V, 1/4 X 1 1/4
PTHALO BLUE	29	1 EA	874-N5	EDWARDS	ALARM HORN, SURFACE MOUNT, 120VAC
	30	1 EA	52R-N5	EDWARDS	ALARM BEACON, RED, 120VAC
	31	16 EA	199 095.13	ENTRELEC	FUSE HOLDER, 25A, 600VAC
	32	1 EA	199 635.24	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
	37	2 EA	234 030.27	ENTRELEC	MARKING TAGS, 8MM, 1-100
	38	16 EA	167 075.25	ENTRELEC	FUSE BLOWN INDICATOR

PAINT SPEC	ITEM	QTY	P/N	VENDOR	DESCRIPTION
	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
CARBIDE BLACK	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	1897A41	McMASTER-CARR	OVAL HANDLE, 9" X 1 3/4"
PTHALO BLUE	51	4 EA	8890T14	McMASTER-CARR	LIFTING EYE, 3/8"-16
	52	112 EA	206430-1	AMP	RECPT., SQ. FLNG., REVERSE SEX, 10A
	53	224	66360-2	AMP	SOCKET, #14 AWG., 600VAC, 10A
	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	ABM25-AT-CO	PANDUIT	TY-RAP BASE, BLACK
	63	113 EA	K10P-11A15-120	POTTER & BRUMFIELD	RELAY,120VAC, 277VAC 10A CONTACT
	64	113 EA	27E895	POTTER & BRUMFIELD	RELAY SOCKET
	65	113 EA	20C297	POTTER & BRUMFIELD	HOLD DOWN SPRING
CARBIDE BLACK	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
PTHALO BLUE	71	1 EA	A-VK44	HOFFMAN	LOUVER PLATE KIT
	72	1 EA	VY20/D/011/ST	ENTRELEC	CAM SWITCH, 20A, 90 DEG. ACTUATOR
	73	18 EA	93N1004	NEWARK	1/4" X #6 CPVC SPACER
	74	1 EA	800MR-P16AS	ALLEN BRADLEY	PILOT LIGHT, AMBER, 120VAC
	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
CARBIDE BLACK	78	1 PR	SA-1349	BUD INDUSTRIES	CHASSIS SUPPORT ANGLE

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.

PAINT SPEC	ITEM	QTY	P/N	VENDOR	DESCRIPTION
CARBIDE BLACK	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
	82	5 FT			ANGLE, 1 1/2" EQUAL LEG X 3/16" THK.
	83	2.5 FT			ANGLE 1" EQUAL LEG X 3/16" THK.
	84	1.5 FT			COPPER BAR, 1" WIDE X 1/4" THK.
5	85	4.25 FT			SHEET STEEL, #16 GA. X 5" WIDE CRS

SPECIFICATION FOR 80K PUMP BURST DISC FOR LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Dave Moore

QUALITY ASSURANCE: R R Bradbrook

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: REB

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	DM 12/9/96	RGS 12/9/96	Released for purchase with revisions per DEO # 0384
0	DM 9/11/96		Released for requote & purchase on DEO # 0260

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number A V049-2-138	Rev. 1
	DM	9/11/96	REB	9/16/96		

TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Equipment Requirements

4.0 Design Requirements

5.0 Required Documentation

6.0 Shop Testing

7.0 Inspection

8.0 Warranty

Attachment A — LIGO QA Requirements Summary

Attachment B — General Equipment Requirements
PSI Specification V049-2-033, Rev. 2

Attachment C — Hydrodyne drawing no. 48-6759, Burst Disc Assembly, LIGO 80K Cryopump

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 burst disc 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 Part No.	Quantity	Delivery
V049-2-138-P1	14	

3.0 EQUIPMENT REQUIREMENTS

3.1 The burst discs will be used to protect the LIGO 80K cryopump vacuum chamber shell from overpressure in the event of a break in the liquid nitrogen circuitry within the chamber. The burst discs shall be purchased from the following supplier:

Hydrodyne Division of F.P.I. Incorporated
3125 Damon Way
Burbank, California 91505

4.0 DESIGN REQUIREMENTS

4.1 Mechanical Requirements

4.1.1 The helium leak rate, burst pressure, temperature range, and materials of construction of the burst disc shall conform to Attachment C, Hydrodyne drawing no. 48-6759. The inlet and outlet flanges, however, shall be a 4-1/2" rotatable Conflat flange, and a 4" ASA 150 lb. pipe flange, respectively. The burst disc is required to relieve a 70 deg. F gaseous nitrogen flow rate of 6524 lb_m /hr. at its set pressure(set pressure = 11psig +0/-10 %). This requires a minimum relieving area of 3.36 $in.^2$ to assure adequate protection of the 80K pump chamber.

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:

5.1.5	5.1.4	5.2
6.4	8.1	8.2
8.4	8.6	9.3
9.4		

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).
- A Certificate of Compliance must be furnished for materials used in the construction of the device.

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

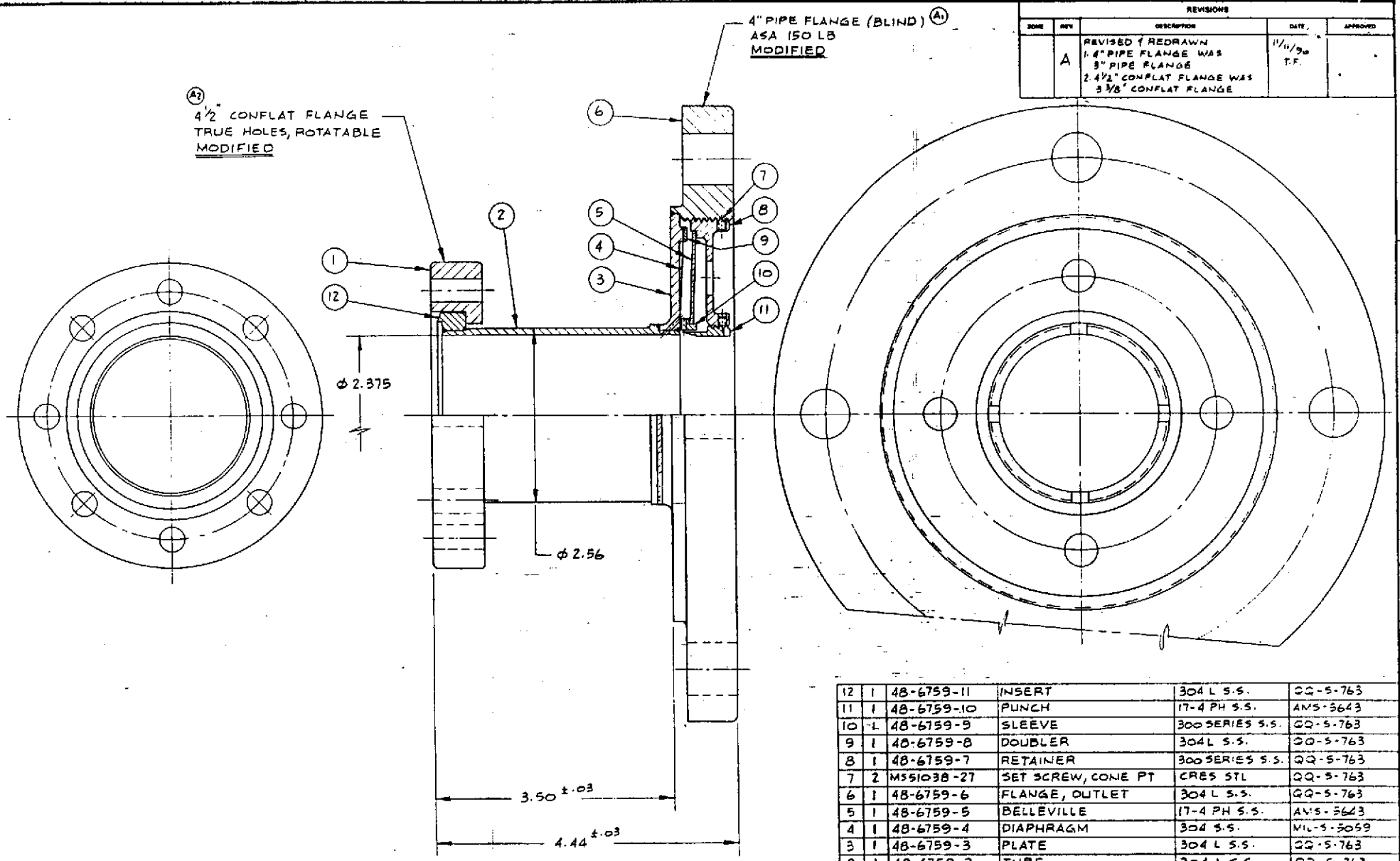
Refer to Specification V049-2-034, Purchased Equipment Commercial Requirements (attached to the Request for Quotation), for warranty requirements.

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT:80K PUMP BURST DISCS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-138

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			PRIOR TO RELEASE FOR FABRICATION.	
IN-PROCESS INSPECTIONS						PRIOR TO RELEASE FOR FABRICATION.	
SHOP TEST PLAN	8 Wk		X	2	X	PRIOR TO RELEASE FOR FABRICATION.	
SHOP TEST (WITH REPORT)				2		PRIOR TO RELEASE FOR SHIPMENT.	
WELDING PROCEDURES	4 Wk		X	2	X		
* PER APPROVED VENDOR SCHEDULE							



REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	A	REVISED & REDRAWN 1. 4" PIPE FLANGE WAS 3" PIPE FLANGE 2. 4½" CONFLAT FLANGE WAS 3⅜" CONFLAT FLANGE	11/11/96 T.F.	

FIND NO.	QTY REQD	FSCM NO	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION
12	1		48-6759-11	INSERT	304 L S.S.	QQ-S-763
11	1		48-6759-10	PUNCH	17-4 PH S.S.	AMS-5643
10	1		48-6759-9	SLEEVE	300 SERIES S.S.	QQ-S-763
9	1		48-6759-8	DOUBLER	304L S.S.	QQ-S-763
8	1		48-6759-7	RETAINER	300 SERIES S.S.	QQ-S-763
7	2		MS51038-27	SET SCREW, CONE PT	CRES STL	QQ-S-763
6	1		48-6759-6	FLANGE, OUTLET	304 L S.S.	QQ-S-763
5	1		48-6759-5	BELLEVILLE	17-4 PH S.S.	AMS-5643
4	1		48-6759-4	DIAPHRAGM	304 S.S.	MIL-S-5059
3	1		48-6759-3	PLATE	304 L S.S.	QQ-S-763
2	1		48-6759-2	TUBE	304 L S.S.	QQ-S-763
1	1		48-6759-1	FLANGE, INLET	304 L S.S.	QQ-S-763
—	BSC		48-6759	ASSEMBLY	———	———

PARTS LIST

4. LEAKAGE: THRU & EXTERNAL 1×10^{-9} SCCS MAX/GHe
3. BURST PRESSUPE: 11.0 PSID +0, -10%
2. TEMPERATURE RANGE: -320°F TO 302°F
1. FLUID MEDIUM: GN_2

NOTES:

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: FRACTIONS /, DECIMALS .XX ±.01 .XXX ±.005, ANGLES ±0.5°. MATERIAL ——— FINISH ———. DO NOT SCALE DRAWING

CONTRACT NO.

APPROVALS	DATE
DRAWN R. VISKET	4/30/96
CHECKED	
ISSUED	

hydrodyne Burbank, CA 91505

BURST DISK ASSEMBLY - LIGO, 80K PUMP

SIZE C | FSCM NO. 07107 | DWG. NO. 48-6759 | REV. A

SCALE 1:1 | SHEET 1

DWG NO 48-6759 | SH 1 | REV A

Attachment C to V049-2-138

SPECIFICATION FOR

GENERAL EQUIPMENT REQUIREMENTS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Thomas R. Stein

QUALITY ASSURANCE: Alan L Bradbrook ALB

TECHNICAL DIRECTOR: D.A. McWilliams

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
2	JM 12/26/95		REVISED ATTACH. A PARA C.5.1 ECO 0034
1	TMS 11-9-95	D. McW 11-9-95	REVISED PER CUSTOMER COMMENTS / ECO 0019
0	TMS 10-14-95	D. McW 10-28-95	REVISED AND ISSUED FOR QUOTATION AND APPROVAL / ECO 0004

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION		
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number V049-2-033	Rev.
	TMS	10-26-95	RCB	10/27/95	A	2

SPECIFICATION TABLE OF CONTENTS

1.0 Definitions
2.0 Deleted
3.0 General Requirements
4.0 Codes and Standards
5.0 Design Requirements
6.0 Materials
7.0 Utilities
8.0 Welding
9.0 Required Documentation
10.0 Nameplates
11.0 Cleaning and Painting
12.0 Quality Assurance Requirements
13.0 Preparation for Shipment
14.0 Startup Assistance
15.0 Deleted

Attachment A Other Electrical Requirements

Number | Rev.

SPECIFICATION

Number A V049-2-033 | Rev. 2

1.0 DEFINITIONS

1.1 The "Vendor" is defined as the successful bidder accepting responsibility for meeting all requirements of this specification.

1.2 The "Owner" is defined as the California Institute of Technology (Caltech) in partnership with the Massachusetts Institute of Technology (MIT), under a grant from the National Science Foundation.

1.3 The "Buyer" is defined as Process Systems International, Inc. (PSI).

1.4 The "sites" are located on the Hanford reservation near Richland, Washington and in Livingston, Louisiana.

2.0 DELETED

3.0 GENERAL REQUIREMENTS

3.1 The Vendor shall be responsible for coordination of all subsuppliers and for overall warranty and guarantees of all equipment, including their compatibility. The Vendor shall comply with all applicable referenced specifications and standards and invoke them on each subsupplier purchase order.

3.2 Equipment will be installed at Hanford (near Richland), Washington and in Livingston, Louisiana. Unless otherwise indicated, equipment shall be capable of continuous service in an indoor location with a controlled temperature of 23 ± 1.5 C and a relative humidity controlled at 40 ± 5%. The equipment will, however, be exposed to diurnal and seasonal ranges during shipment, construction and power loss. It shall, therefore, not be damaged by exposure to temperature in the range of -20 to +40 C, or a humidity of 100%.

3.3 The Buyer shall be notified at least 10 working days prior to the start of major fabrication, assembly or testing.

3.4 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.

4.0 CODES AND STANDARDS

4.1 Priority of Codes and Standards

1. Codes
2. Standards
3. Data Sheets
4. This Specification

4.2 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.

4.3 Applicable Codes and Standards:

American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code
Pressure Vessels: Section VIII, Division 1
Welding and Brazing Qualifications: Section IX

American National Standards Institute (ANSI)
ANSI A58.1: ASCE Minimum Design loads for Buildings and Other Structures

International Standards Organization
ISO Standard 2861: Flange Standards

Expansion Joint Manufacturers' Association (EJMA)
EJMA Standards

Government Standards
Building and safety codes: local, state and federal, including OSHA
Federal Standard 209 for Cleanrooms

5.0 DESIGN REQUIREMENTS

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 design, materials and workmanship as required elsewhere in the Contract.

5.1 Mechanical Requirements

5.1.1 Equipment feet or mounting plates shall have machined surfaces. Shim stock used shall be stainless steel.

5.1.2 Each vacuum element greater than 12" in diameter shall be designed, fabricated and tested in accordance with the latest edition of the ASME B&PV Code, Section VIII, Division 1, and subsequent addenda (except as noted under section 8.0, Welding), even though vacuum chambers lie outside of the scope of that document..

5.1.3 Bolt holes in flanges shall straddle natural centerlines.

5.1.4 Reasonable measures shall be taken to minimize noise. The goal is for acoustic noise to not exceed NC-15 when measured at any point within 1' of the equipment.

5.1.5 Reasonable measures shall be taken to minimize vibration. The goal is for the vibration of any item of equipment not to induce motion of the walls of any vacuum chamber or of the facility floor within 1 meter of any chamber which exceeds the following spectral density limits:

Frequency Band, Hz	Vibration Limit, m/√Hz
0.1 - 10	3×10^{-11}
10 - 1000	$3 \times 10^{-9} \times (1/f)^2$
1000 - 10000	3×10^{-15}

The above limits apply when all simultaneously operating equipment is running, and in the absence of vibration from other sources. Limited narrow band exceptions may be permitted, subject to Buyer's acceptance. Compliance with this requirement may be demonstrated by any combination of measurements and analysis, subject to Buyer's acceptance.

5.1.6 ANSI Standard A58.1 shall be applied to determine the probability of earthquakes and seismic coefficients at the two sites.

5.1.7 No equipment shall emit or harbor particulates at a level inconsistent with maintenance of a clean environment conforming to Federal Standard 209 Class 50,000.

5.1.8 The equipment shall be designed for a minimum serviceable life of 20 years.

5.1.9 Exposure of the equipment to ambient conditions during construction, power failure or control failure shall not result in damage.

5.1.10 Separable parts shall be fully interchangeable between assemblies.

5.1.11 Adequate clearance shall be provided for assembly of mating flanges and for handles. External access shall be provided to all vacuum seams for leak checking.

5.1.12 Elements heavier than 50 pounds shall have lifting lugs installed.

5.1.13 Vendor shall specify all bolt torque requirements in the equipment operating and maintenance manual.

5.2 Electrical Requirements

5.2.1 General Electrical Requirements

5.2.1.1 Electrical equipment and wiring shall conform to the National Electric Code.

5.2.1.2 All electrical equipment shall meet commercial standards for EMI (see Attachment A).

5.2.1.3 Electrical equipment shall meet the acoustic noise and vibration requriements of Sections 5.1.4 and 5.1.5, above.

5.2.1.4 See Attachment A for other electrical requirements.

5.2.2 Instrumentation Requirements

5.2.2.1 Instrumentation shall be of industrial quality and shall be subject to the acceptance of the Buyer.

5.2.2.2 Vibration monitoring is not a requirement of this specification.

5.2.2.3 Unless otherwise indicated, analog instrument signals shall be 4-20 ma or 0-10 VDC.

5.2.3 Controls Requirements

Control signals shall be 24 VDC.

5.2.4 Power Requirements

5.2.4.1 Motors shall comply with the Vendor's standard specifications, unless otherwise required by this specification. The minimum service factor of motors shall be 1.15. Motors shall be sized so that they can start and accelerate their loads to design speed at 90% voltage, and shall be energy efficient, if required by local or state codes.

5.2.4.2 Motors less than 3/4 HP shall be 120 VAC, 1 phase, 60 Hz. Those 3/4 HP to 200 HP shall be 460 VAC, 3 phase, 60 Hz.

6.0 MATERIALS

6.1 Materials used for pressure or vacuum retaining parts, nuts, bolts and studs shall be new. Where practicable, materials shall be of US origin; where not, materials from Canada, the European Community or Japan may be used. The Vendor's quotation shall identify the country of origin and how he intends to establish material traceability and conformance of composition and properties to applicable codes.

6.2 Copies of mill test reports of chamber and flange materials shall be furnished. Other nozzles, small parts, small flange nozzles, and bolting materials shall be furnished with a Certificate of Compliance.

6.3 Fabricated components exposed to vacuum shall be made from type 304L or 316L stainless steel using low carbon weld filler wire, where required. Standard catalog items of 304 or 316 stainless steel are acceptable if not available in 304L or 316L. Copper, aluminum and prebaked Viton (Dupont Type E-60C, manufactured by Parker or Buyer-accepted equal) must be used for seals. Vacuum feedthroughs must utilize UHV compatible glass or ceramic. All other materials are subject to Buyer's acceptance.

6.4 Vacuum surfaces shall not be allowed to come into contact with carbon steel or oil, including during forming, handling or manufacture. Machining fluids shall be water soluble and free of oil and sulfur.

6.5 When manufacturing materials are marked for material identification or traceability, marking shall be done on the outside, and not on surfaces that will be exposed to vacuum.

7.0 UTILITIES

The following utilities are available. The vendor shall state in his proposal the usage of each utility.

7.1 Electric Power

120 VAC, 1 phase, 60 Hz
480 VAC, 3 phase, 60 Hz or 208/120 VAC, 3 phase, 60 Hz

7.2 Instrument Air: 80 psig, -60 C Dew Point

7.3 Deleted.

8.0 WELDING

8.1 Welding exposed to vacuum shall be done by the gas tungsten arc inert gas (GTAW) process, with a 100% Argon shield and purged back gas.

8.2 Welding techniques shall deviate from the ASME Code in accordance with the best ultra high vacuum practice to eliminate any "virtual leaks" in the welds. Wherever practicable, welds shall be internal and continuous. External welds for structural purposes shall be intermittent to eliminate trapped volumes.

8.3 Defective welds shall be repaired by removal to sound metal and rewelding.

8.4 Vacuum weld procedures shall include steps to avoid contamination of the heat affected zone with air, hydrogen, hydrocarbons or water. This requires that inert purge gas, such as argon, be used to flood the vacuum side of heated portions. All vacuum surfaces and weld wire shall be cleaned prior to welding

8.5 The finished product shall be free of weld spatter, cutoff spatter, free iron, weld oxidation and defects. There shall be no grinding or abrasion of completed welds or internal vacuum surfaces. Completed welds shall only be cleaned with SS wire brushes that have not previously come in contact with carbon steel.

8.6 All welding procedures, procedure qualifications and welders employed on this job shall be qualified in accordance with ASME Section IX, latest edition.

9.0 REQUIRED DOCUMENTATION

9.1 Drawings

9.1.1 Assembly drawings shall be submitted for the Buyer's review prior to fabrication. They shall include all pertinent design data and calculations, including design pressures and temperatures.

9.1.2 Drawing acceptance must be obtained from the Buyer prior to the start of fabrication. Drawing acceptance does not constitute acceptance of any errors or of any deviation from these specifications or any instructions relating to the work. The Vendor shall call attention to any such deviations by separate written notice. Unless specific written acceptance is obtained from the Buyer, deviations are not acceptable.

9.1.3 If changes are made to any drawing subsequent to acceptance, drawings shall be resubmitted with all changes clearly identified. "As-Built" drawings shall be submitted.

9.1.4 Drawings in AutoCad, Release 12.0 are preferred. All documents stored electronically (procedures and CAD drawings) shall be backed up daily and the back-up tape shall be stored in a fire-proof safe.

9.2 Mechanical Data

9.2.1 Dimensioned outline drawings (indicating weights and center of gravity). These shall be submitted with the Vendor's proposal.

9.2.2 Connection sizes and ratings, design and test pressures and temperatures.

9.2.3 Cross-section drawings of all seals identifying all seal parts and materials.

9.2.4 Allowable nozzle loads, if applicable.

9.2.5 All procedures to be utilized shall be submitted for acceptance prior to use. This includes welding, QA, cleaning, testing, welding, Heat Treating, leak testing, etc.

9.3 Electrical Data

9.3.1 Electrical schematics and wiring diagrams

9.3.2 Control logic documentation

9.3.3 Instrument data sheets

9.3.4 Motor data sheets

9.4 Acoustic Noise and Vibration (See Sections 5.1.4 and 5.1.5)

9.4.1 A plan describing how the Vendor will address the design issues associated with acoustic noise and vibration is to be submitted.

9.4.2 An analysis of the equipment's design dynamic characteristics (mass, center of gravity, isolator stiffness, transmissibility). The analysis shall support the Vendor's claim of meeting or not meeting the specification requirements. In the case that the requirements are not met, the Vendor shall show that all reasonable engineering attempts have been made to meet them, and the design will be subject to the Buyer's written acceptance prior to the start of manufacturing.

9.5 Test and QA Data

The following shall be submitted where applicable:

9.5.1 Manufacturer's Code Data Report

9.5.2 Nameplate facsimile

9.5.3 Hydrotest results (Deleted)

9.5.4 Performance and leak test procedures and results

9.5.5 Mill test reports and certificates of conformance per Section 6.2

9.6 Other Documentation

9.6.1 Schedule, including design, material procurement and fabrication activities

9.6.2 Priced spare parts list with recommended spares

9.6.3 Installation, Operation and Maintenance Manual, including drawings

9.6.4 A status report with updated schedule shall be submitted monthly

10.0 NAMEPLATES

10.1 Each separable part (except fasteners, seals and interchangeable, standard blank flanges) shall be permanently marked with a unique identification number in a location readily viewable.

10.2 Each item shall have a stainless steel nameplate (permanently attached if practical). Nameplates shall include the Vendor's standard data. Where provided, each motor shall also have a nameplate.

11.0 CLEANING AND PAINTING

11.1 Equipment internals shall be cleaned and free of all foreign materials.

11.2 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.

11.3 Surfaces exposed to vacuum shall be cleaned in accordance with procedures accepted by the Buyer prior to fabrication and installation. Surface recontamination during subsequent processes shall be prevented. Cleaning procedures for ultra high vacuum service shall be required.

11.4 Items shall be wrapped or sealed after cleaning to maintain cleanliness through handling, transportation and storage. Care shall be taken to minimize exposure to corrosive environments, such as those containing chloride compounds.

12.0 QUALITY ASSURANCE REQUIREMENTS

The responsibility for inspection and testing rests with the Vendor. However, the Buyer reserves the right to review equipment at any time during the fabrication to assure that the work performed is in accordance with this contract. The Vendor shall give the Buyer 10 working days notice prior to the start of major fabrication, assembly or testing so that his representative may witness these tests.

The vendor shall have implemented inspection system in effect at all times during this contract. The inspection system shall comply with the following:

Design Control And Change Control
Provide a system to control the issuance of documents and drawings including changes to the locations where the work is being performed. The system shall address both electronic files and hard copies.

Material Control
Provides system that controls materials from receipt through the finished product. This system shall assure that only accepted items are used and installed. Physical identification shall be used to the maximum extent possible.

Quality Planning (Traveler)
A system of shop travelers shall be established for all work in process. The traveler shall contain Hold/Witness points of the Vendor, the Buyer and the Owner. All planning documents shall be submitted to the buyer for acceptance prior to fabrication.

Receiving Inspection
Measures shall be established to inspect incoming materials to the applicable procurement documents. Status of materials shall be visible, by tagging or marking.

In-Process And Final Inspection
A system of inspection and test status shall be maintained using tags, markings, shop travelers, stamps or inspection records.

Control Of Special Process' And Testing
A system shall be established to assure that welding, heat treatment, cleaning and NDE are accomplished under controlled conditions, in accordance with written procedures, using qualified personnel, to the applicable codes and standards.

Calibration Of Measuring And Test Equipment
A system shall be established and documented to assure that tools, gages, instruments and other inspection, measuring, and testing equipment are of the proper range, type and accuracy. The above shall be controlled, calibrated, and certified against nationally known standards (NIST).

Control Of Non-Conformances
A system shall be established and documented to control items or services which do not conform to requirements. The system shall include appropriate procedures for identification, documentation, segregation, disposition and notification.

Documentation And Records
Sufficient records shall be prepared as work is performed to furnish documentary evidence of the quality of items and activities affecting quality.

13.0 PREPARATION FOR SHIPMENT

13.1 Items shall be completely drained and dried.

13.2 Bolted connections shall be made up before shipment.

13.3 Aluminum plate shipping covers shall be attached with bolts to flanged connections, and with suitable attachments to other connections.

13.4 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.

13.5 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.

13.6 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.

13.7 Surfaces that will see vacuum shall be further protected by, after final cleaning, sealing openings with oil-free heavy duty aluminum foil, attaching the nozzle cover and applying shrink wrapped plastic.

14.0 STARTUP ASSISTANCE

The services of a qualified startup assistant shall be provided on request of the Buyer or the Owner to provide operator training and startup assistance at the sites.

15.0 DELETED

ATTACHMENT A

OTHER ELECTRICAL REQUIREMENTS

1.0 Definitions
2.0 Exceptions
3.0 Codes and Standards
4.0 Labeled and Listed Equipment
5.0 General Assembly Requirements
6.0 Wiring
7.0 Field Connection Boxes
8.0 Testing
9.0 Deleted
10.0 Motor Data Sheets

1.0 DEFINITIONS

Indicated	Shown or noted.
Labeled	Approved by nationally recognized testing company.
Permitted	As by code, Contract Documents, or Buyer.
Provide	Furnish and assemble.
Buyer	Process Systems International (PSI)
Required	As by Contract Documents and/or applicable codes and standards.
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.

2.0 EXCEPTIONS

If the Vendor cannot meet requirements established under this specification and its attachments, provide a list of deviations with your proposal. In the absence of a list of deviations, it shall be deemed that the Vendor's product is fully in compliance with this specification.

3.0 CODES AND STANDARDS

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

4.0 LABELED AND LISTED EQUIPMENT

Provide UL label (or that of other nationally recognized testing company) or listed components where such standards exist.

5.0 GENERAL ASSEMBLY REQUIREMENTS

5.1 Arrange and assemble components in accordance with their manufacturers' specifications.

5.2 Label components with the equipment designation as indicated using adhesive backed labels with 1/8" high lettering.

5.3 Label terminal strips as indicated using printed manufacturer's labels.

5.4 Where air-actuated valves require pilot solenoids, mount the solenoid valves on the air operated valves.

6.0 WIRING

Install wiring in raceways, wireways, or neatly tirewrapped wire bundles. Provide product data for all cables.

6.1 Power Wire

6.1.1 Provide #12 AWG or larger single, stranded copper conductors with Type THHN-THWN or MTW insulation rated 90 C, 600 volts.

6.1.2 Use black colored insulation, except green for equipment grounding conductors.

6.2 Control Wire (Discrete Signals)

6.2.1 120 VAC: Provide #14 AWG, stranded copper, multiconductor cable with Type THHN-THWN or MTW insulation rated 90 C, 600 volts.

6.2.2 24 VDC: provide #16 AWG stranded copper, twisted pairs, single or multipair cables rated 90 C and 300 volts.

6.2.3 Color code conductors as follows:

120 VAC—Line	Red
120 VAC—Neutral	White
24 VDC	Blue
External Source	Yellow
Ground	Green

6.2.4 Identify each single conductor at each end with wire number or designation. Use printed, sleeve type wire marker.

6.3 Instrument Wire (Analog Signals)

6.3.1 4-20 mA: Provide #16 AWG or larger, stranded copper, individually shielded twisted pairs, single or multipair cables rated 90 C, 300 volts unless otherwise indicated. Where practicable, install cables spaced at least 12 inches away from power and control wiring.

6.3.2 Provide shielded twisted pair cables with one black and one white conductor.

6.4 Thermocouple Wire

6.4.1 Provide #16 AWG solid thermocouple extension cable shielded, rated 105 C, 300 volts of type required.

6.4.2 Provide thermocouple extension wire in accordance ISA color coding standards.

6.5 Wire and Cable Installations

6.5.1 Identify each cable end with cable number or designation. Use printed sleeve wire marker.

6.5.2 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. Do not 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.

6.6 Wiring Terminations and Connectors

6.6.1 Control Wiring

6.6.1.1 To terminate #10 AWG and smaller conductors to buses, enclosures, and similar applications, provide compression (crimp) terminals.

6.6.1.2 To terminate #8 AWG and larger conductors, provide either compression (crimp) connectors using matching installing tool or mechanical screw type connectors.

6.6.1.3 Where more than one conductor requires termination, provide screw or pressure type insulated terminal blocks.

6.6.2 Instrument Wire

6.6.2.1 Use insulating sleeve to secure shielding at instrument end of cable. Clip shields to avoid protruding from insulating sleeve.

6.6.2.2 Coil, insulate, and label ends of spare conductors.

6.6.2.3 Remove insulation from ends of conductors using mechanical or electric heat type stripper.

6.7 Equipment Grounding

6.7.1 Bond motors, heaters, and other electrical equipment to skid base. Weld to diagonal corners of skid base a 4 by 6 by 1/2 inch steel plate with two 3/8"-16 tapped holes spaced two inches apart, or if steel base is at least 1/2 inch thick, tap holes directly into steel base.

6.7.2 Do not ground instrument shielding. Use insulating tape or heat shrink to secure shielding at instrument end of cable. Connect shielding at other end of cable to junction box terminal. (Shielding connects to a single ground reference point at Owner's controller or I/O rack.)

6.7.3 Completely remove paint, dirt, and corrosion down to bare metal where connectors, lugs, and other metal components are attached to mounting panels and enclosures to assure grounding continuity.

6.7.4 Where a grounding stud or existing panel mounting bolt is used, the Vendor may provide the grounding conductor with a ring-tongue terminal and a "star" type washer installed between the panel and terminal. Use hexagon nut to secure tightly.

7.0 FIELD CONNECTION BOXES

7.1 To facilitate field wiring, provide separate power, control, and instrument NEMA 4 or 12 type enclosures, unless otherwise required, with terminals and a minimum of 20 percent spare terminals.

7.2 Arrange surrounding work and location of boxes to permit box accessibility and to permit (bottom, sides, top, and rear) entrance of field conduits.

7.3 In power box, segregate voltage systems using barriers or separate boxes. Use box to terminate motors, heaters, and other branch circuits with #8 AWG and small wiring. PSI will field wire larger circuits directly to equipment junction boxes.

7.4 In instrument box, segregate temperature element wiring using barriers or separate boxes.

8.0 TESTING

It is the Vendor's responsibility to conduct the following tests without damage to equipment.

8.1 Wire Testing

8.1.1 Check point-to-point continuity of each conductor to ensure that wiring is intact and terminated at the proper place at both ends.

8.1.2 Verify wire connections are made in accordance with terminal wiring diagrams and schedules.

8.1.3 Deleted

8.1.4 All defective wiring shall be replaced and the unit retested.

8.2 Motors

8.2.1 Before connecting motor, measure motor winding resistance in accordance with manufacturer's recommendations.

8.3 Test each three-phase motor for proper rotary direction.

8.4 Submit a signed test report for each electrical test conductor.

9.0 Deleted

10.0 MOTOR DATA SHEETS

The attached motor data sheets shall be completed by the Vendor and submitted to the Buyer with the Vendor's proposal.

Title

MOTOR DATA SHEET - DESIGN PARAMETERS

ITEM	DESIGN PARAMETERS	MOTOR DATA	MOTOR DATA	MOTOR DATA	MOTOR DATA
1	Motor Identification (tag)				
2a	Volts				
2b	Phases				
2c	Hertz				
3	Synchronous RPMs				
4	Efficiency (premium/energy/norm)				
5	Service Factor				
6	Load Brake Horse Power				
7	Starting Torque				
8	Type Load (fan/pump/comp)				
9	Drive (belt/direct couple)				
10	Rotation (CW/CCW)				
11	Enclosure				
12	Mounting (horz/vert)				
12a	NEMA Type Flange				
12b	Vertical Trust (up/down)				
13	Indoor/Outdoor Use				
14	Space Heater, 120V (no/watts)				
15	Winding Temp Sensor (yes/no)				
16	Bearing Temp Sensor (yes/no)				

Number

Rev.

SPECIFICATION

Number A V049-2-033 Attach. A

Rev. 2

11/88

PS-997

Title

MOTOR DATA SHEET - MANUFACTURER'S NAMEPLATE

ITEM	MANUFACTURER'S NAMEPLATE	MOTOR DATA	MOTOR DATA	MOTOR DATA	MOTOR DATA
1	Motor Identification (tag)				
2a	Mfr:				
2b	Type				
2c	Frame Size				
3	Horsepower Output				
4	Time Rating (NEMA MG1-10.35)				
5	Max Ambient Temperature				
6	Insulation System				
7	RPM @ Rated Load				
8	Frequency				
90	Phases				
10	Rated Load Amps				
11	Voltage				
12	Locked Rotor Amps or NEMA Code Ltr				
13	NEMA Design Letter				
14	Efficiency				
15	Service Factor				
16	Thermal Protectors				

ITEM	MANUFACTURER'S DATA	MOTOR DATA	MOTOR DATA	MOTOR DATA	MOTOR DATA
1	Motor Identification (tag)				
2	Bearing Type				
3	Bearing Lub				
4	Efficiency @ Full Load				
5	Efficiency @ 3/4 Load				
6	Efficiency @ 1/2 Load				
7	Power Factor @ Full Load				
8	Power Factor @ 3/4 Load				
9	Power Factor @ 1/2 Load				
10	Space Heater Voltage				
11	Space Heater Watts				

Number

Rev.

SPECIFICATION

Number	Rev.
A V049-2-033 Attach. A	2

SPECIFICATION FOR 80K PUMP MANUAL REGENERATION VALVE FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE: N/A

TECHNICAL DIRECTOR: D.A. McWilliams

PROJECT MANAGER: Bill Bayless

REV LTR	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	DM 10/7/96	DAMcW 10-7-96	Changed butt weld ends to socket weld DEO # 0295
0	DM 9/12/96	DAMcW 9-17-96	Released for purchase on DEO # 0263

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number A V049-2-140 / Rev. 1
	DM	9/12/96	AB	9/17/96	

Title: SPECIFICATION FOR 80K PUMP MANUAL REGENERATION VALVE

Manufacturer:	The William Powell Company
Type:	2400 series globe valve
Size:	1-1/2"
Quantity:	12
Rating:	150 lb. class
Model Number:	2475SWE
Body/Bonnet Material:	Stainless steel, A-351, A-276
Handwheel Material:	Carbon steel
End Connections:	socket weld ends to mate to sch. 10S pipe
Packing:	teflon
Disc Material:	Stainless steel, A-276
Identification:	V049HV-190, HV-192, HV-290, HV-292, HV-390, HV-392, V049HV-490, HV-590, HV-690, HV-692, HV-790, HV-890

SPECIFICATION	
Number A **V049-2-140**	Rev. 1

SPECIFICATION FOR
80K PUMP VENT HEATER
FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

ELECTRICAL ENGINEER: Daniel J. Parenti Jr.

TECHNICAL DIRECTOR: J. McWilliams

PROJECT MANAGER: RICHARD BAGLEY

Ø	D Moore 9/16/96	RGB 10/4/96	Issued for purchase, DEO # 0264
REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED D Moore	DATE 9/16/96	APPROVED RGB	DATE 10/4/96	Number A V049-2-141	Rev. Ø

Title: **SPECIFICATION FOR 80K PUMP VENT HEATER**

Supplier:	McMaster-Carr Supply Co.
Description:	Constant-Output Heat Cable, with power connection kit and temperature switch
Size:	PSI P/N V049-2-141-P1: 92' long cable PSI P/N V049-2-141-P2: 50' long cable
Rating:	12 watts/ft, 400° F max. exposure temperature
Model Number:	35535K76 (cable) 35535K52 (power conn. kit) 3599K34 (temp. switch)

SPECIFICATION		
Number A	V049-2-141	Rev. ϕ

Title: SPECIFICATION FOR CLEAN ROOM FAN/FILTER MODULES AND FLOURESCENT LIGHTING FIXTURES

SPECIFICATION FOR

CLEAN ROOM FAN/FILTER MODULES AND FLOURESCENT LIGHTING FIXTURES

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: BAK

ELECTRICAL: FADI BAAK

QUALITY ASSURANCE: GENE SENECAL

TECHNICAL DIRECTOR: D. A. McIW

PROJECT MANAGER: R. A. Bayley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
2	BAK 10/9/96		REVISED FOR PURCHASE. DEO #0305
1	D.M.W	REB 9/30/96	REVISED PER DEO 0279
0	D.M.W	REB 9/19/96	ISSUED FOR QUOTE PER DEO 0265

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

INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number	Rev.
	BAK	9/19/96	REB	9/19/96	V049-2-142	2

TABLE OF CONTENTS

1.0	Scope	3
2.0	Testing	3
3.0	Drawings	3
4.0	Delivery	3
5.0	Equipment	3

ATTACHMENTS

A. LIGO Quality Assurance Requirements Summary

Title: **SPECIFICATION FOR CLEAN ROOM FAN/FILTER MODULES AND FLOURESCENT LIGHTING FIXTURES**

1.0 SCOPE

This equipment will be used to fabricate cleanroom for use with ultra high vacuum equipment.

2.0 TESTING

HEPA filter units (or of each type) shall be tested to verify particulate removal. A test report shall be provided to the Buyer.
The HEPA filter assemblies shall be protected from hydrocarbon contamination throughout manufacture and testing. No hydrocarbon vapors shall be used for testing.

3.0 DRAWINGS

Bidder shall submit outline drawing for HEPA filter units and lighting units with their proposal.

4.0 DELIVERY

Delivery is required as soon as possible. Bidders to state their delivery schedule with the proposal.

5.0 EQUIPMENT DATA

1. 2 ft. x 4 ft. Fan/Filter Module for class 100 cleanroom system. 16 Units Required.
   PSI part number V0492142P1.

   A. Fan/Filter Module to have prefilter section. Ductwork collars are not permitted.
   B. Filter to be HEPA type, with 99.99% efficiency on 0.3µm particle size.
   C. Fan motor to be wired for 277 VAC.
   D. Fan motor to have local speed control mounted on Fan/Filter Module. Speed control to have adjustment range of 50% of fan speed to 100% of fan speed or better.
   E. Fan/Filter Module to have 10' extension cord with NEMA L7-15P twist-lock male plug.
   F. Fan/Filter Module to be constructed of either aluminum or stainless steel, or both.
   G. Fan/Filter Module shall work in conjunction with Gordon Inc. CG-15 clean room grid-system.
   H. Fan/Filter Module shall have a capacity of 415 to 730 CFM.
   I. Tag or permanantly mark the PSI part number on the fan/filter module.

2. 2 ft. x 3 ft. Fan/Filter Module for class 100 cleanroom system. 208 Units Required.
   PSI part number V0492142P2.

   A. Fan/Filter Module to have prefilter section. Ductwork collars are not permitted.
   B. Filter to be HEPA type, with 99.99% efficiency on 0.3µm particle size.
   C. Fan motor to be wired for 277 VAC.
   D. Fan motor to have local speed control mounted on Fan/Filter Module. Speed control to have adjustment range of 50% of fan speed to 100% of fan speed or better.
   E. Fan/Filter Module to have 10' extension cord with NEMA L7-15P twist-lock male plug.
   F. Fan/Filter Module to be constructed of either aluminum or stainless steel, or both.
   G. Fan/Filter Module shall work in conjunction with Gordon In. CG-15 clean room grid systems.
   H. Fan/Filter Module shall have a capacity of 415 to 730 CFM.
   I. Tag or permanantly mark the PSI part number on the fan/filter module..

3. 2 ft. x 3 ft. Fluorescent Lighting Fixture for class 100 cleanroom system. 68 Units Required. PSI part number V0492142P3.

   A. Lighting Fixture to be wired for 277 VAC.
   B. Fixture to have Energy saving lights.
   C. Lighting Fixture shall work in conjunction with Gordon Inc. CG-15 clean room grid systems.
   D. Lighting fixture to have 10' extension cord with NEMA L7-15P twist-lock male plug.
   E. Tag or permanantly mark the PSI part number on the lighting fixture.

Title: SPECIFICATION FOR SOFTWALL CLEAN ROOM PANELS FOR HORIZONTAL ACCESS MODULE

SPECIFICATION FOR

SOFTWALL CLEAN ROOM PANELS
HORIZONTAL ACCESS MODULE

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: [illegible]

QUALITY ASSURANCE: Alan L Bradbrook

TECHNICAL DIRECTOR: D. C. McWilliams

PROJECT MANAGER: [illegible signature]

0	BAL 10/2/96	KEB 10/4/96	[illegible]
REV	BY - DATE	APPD. - DATE	DESCRIPTION OF CHANGE

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED BAL DATE 10/2/96	APPROVED RES DATE 10/7/96	NUMBER A V049-2-144	REV 0

TABLE OF CONTENTS

1.0 SCOPE 3

2.0 SCHEDULE 3

3.0 GENERAL REQUIREMENTS 3

4.0 REQUIRED DOCUMENTATION 4

5.0 SHOP TESTING 4

6.0 INSPECTION 4

7.0 WARRANTY 4

8.0 Q.A. REQUIREMENTS 4

9.0 APPENDIX: DWG. V049-2-144 5
HAM CLEAN ROOM SYSTEM
SOFTWALL PANEL DETAILS

ATTACHMENT A: LIGO QA REQUIREMENT SUMMARY

ATTACHMENT B: GENERAL EQUIPMENT REQUIREMENTS
PSI SPECIFICATION V049-2-033, REV 2

Title: SPECIFICATION FOR SOFTWALL CLEAN ROOM PANELS FOR HORIZONTAL ACCESS MODULE

1.0 SCOPE

1.1 This specification covers the minimum requirements for the design, materials, fabrication, inspection, testing, preparation for shipping, and shipment of softwall panels for portable softwalled 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 **L**aser **I**nterferometer **G**ravity wave **O**bservatory (LIGO). LIGO, which is operated by Caltech & MIT under a NSF contract, includes two installations at widely seperated 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.

1.2 This specification covers the requirements for one Horizontal Access Module (hereinafter called HAM) clean room softwall panel set. Refer to section 2.0 delivery schedule for quantities.

1.3 These panels shall be used in a portable class 100 clean room system.

2.0 SCHEDULE

The deliverary schedule shall be as follows:

Washington Site:	qty of 1	12/1/96
Lousiana Site:	qty of 1	12/1/96

Total required: 2

3.0 GENERAL REQUIREMENTS

2.1 Panels shall be constructed of transparent 40mil fire-retardant PVC with weighted bottoms.

2.2 Panels shall be attached to structural framework (by PSI) via non-particulating "Dual Lock" or equivalent attachment strips along the top edge of the panel, or such attachment as suggested by manufacturer. The mating piece of "Dual Lock", or other attachment method, shall be supplied with the appropriate panel.

Attachment method shall be suitable for supporting the weight of the panels during normal operation without sagging or pulling free.

2.3 Panels intersecting beam tubes shall have a closable "Dual Lock" seam to enable setting panel in place around beam tube. Refer to appendix A, dwg. #v049-2-144 for arrangement of beam tubes.

2.4 Panels intersecting beam tubes shall have a method of cinching panel tube around circumference of the beam tube. Beam tube diameters vary from 68.25" to 30". Panel must accomodate varying diameters. Refer to appendix A, dwg. #v049-2-144 for arrangement of beam tubes.

2.5 Panels intersecting beam tubes shall have a method of closing beam tube opening for use when beam tube is not installed.

2.6 Adjacent panels shall overlap by 3" min. each side, or as suggested by manufacturer.

4.0 REQUIRED DOCUMENTATION

The documentation called for in Attachment A shall be supplied by the vendor.

5.0 SHOP TESTING

The Vendor shall perform his standard testing.

6.0 INSPECTION

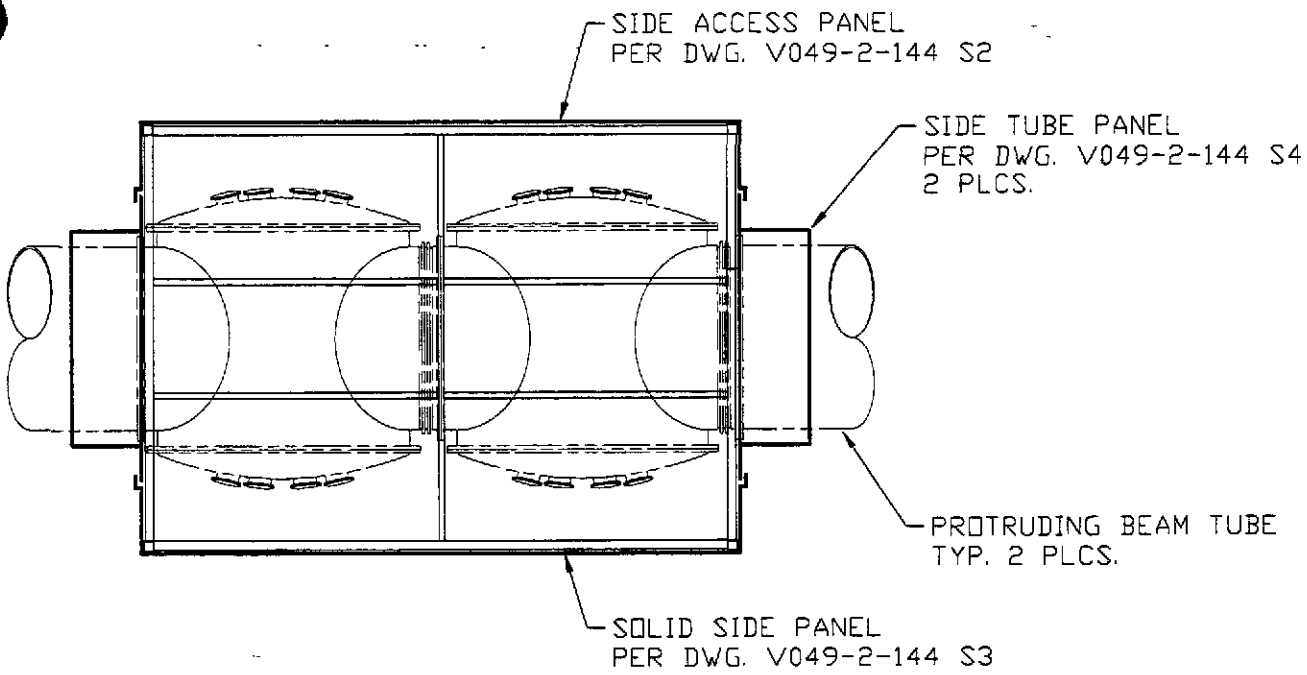
The inspections called for in Attachment A shall be performed by the vendor.

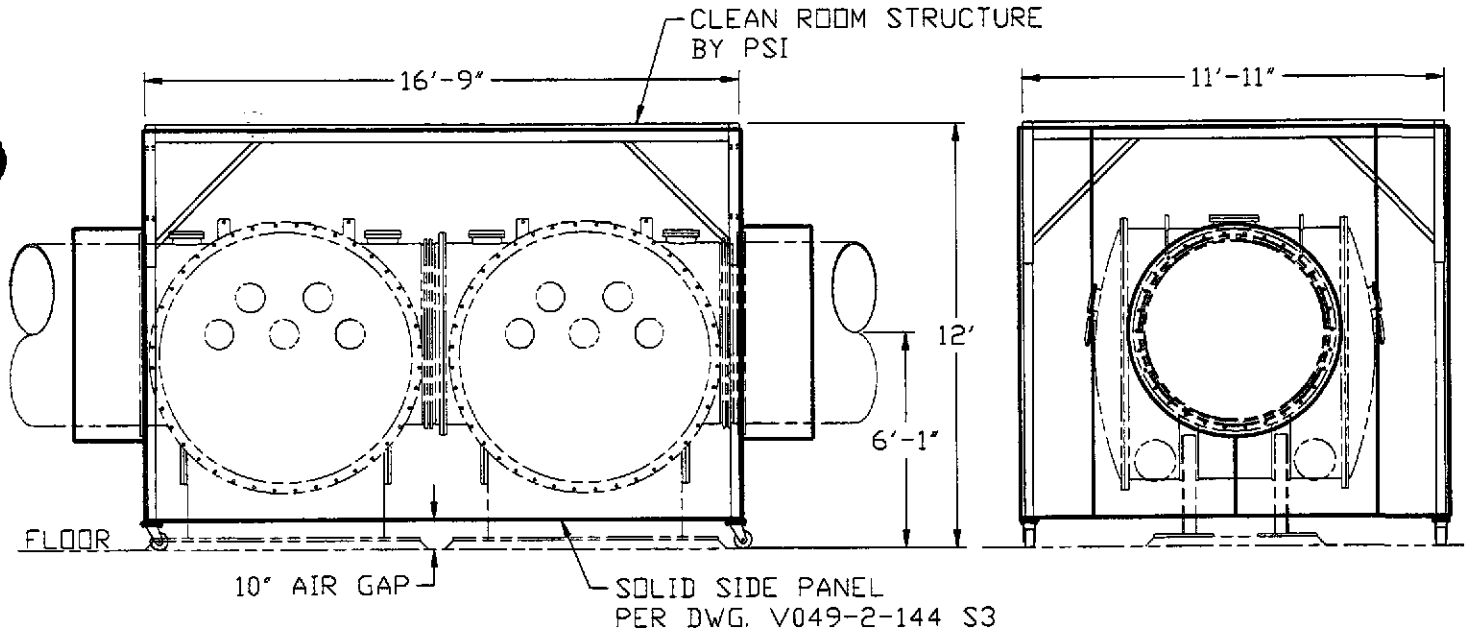
7.0 WARRANTY

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

8.0 Q.A. REQUIREMENTS

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





NOTE:
SIDE PANELS WILL OVERLAP ADJACENT
SIDE TUBE PANELS BY 3".

REV.	DESCRIPTION	DATE	BY	CHK.	APP.

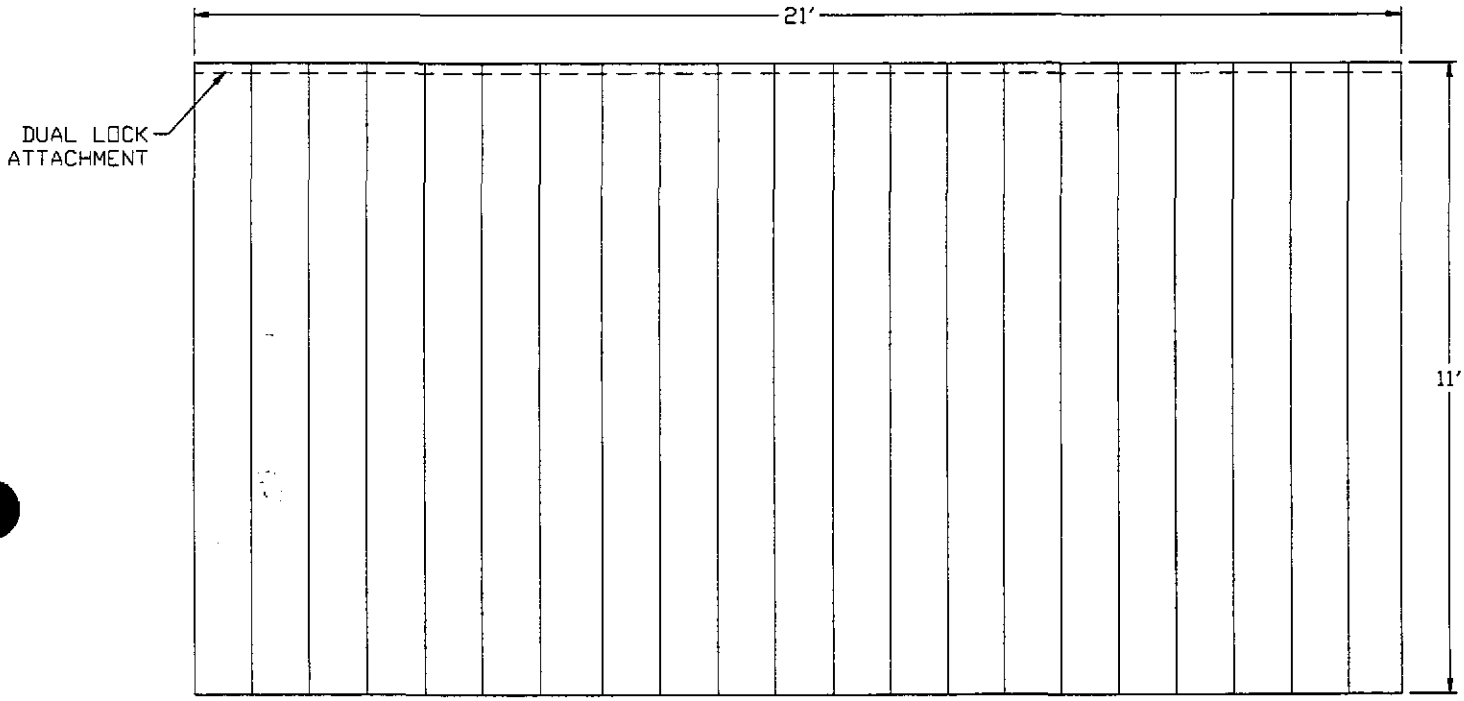
PROCESS SYSTEMS INTERNATIONAL INC.
20 WALKUP DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

H.A.M. CLEAN ROOM SYSTEM
CLEAN ROOM SOFTWALL PANELS

CAD FILE NO.	SIZE	DWG. NO.	REV.
2144S1	A	V049-2-144	0

SCALE: NONE | DRAWN: BAR | SHEET: 1 OF 4

Sept 25, 1996 - 13:27:09



CORNER ACCESS PANEL
40 MIL SOFTWALL PANEL STRIPS
1 REQ'D

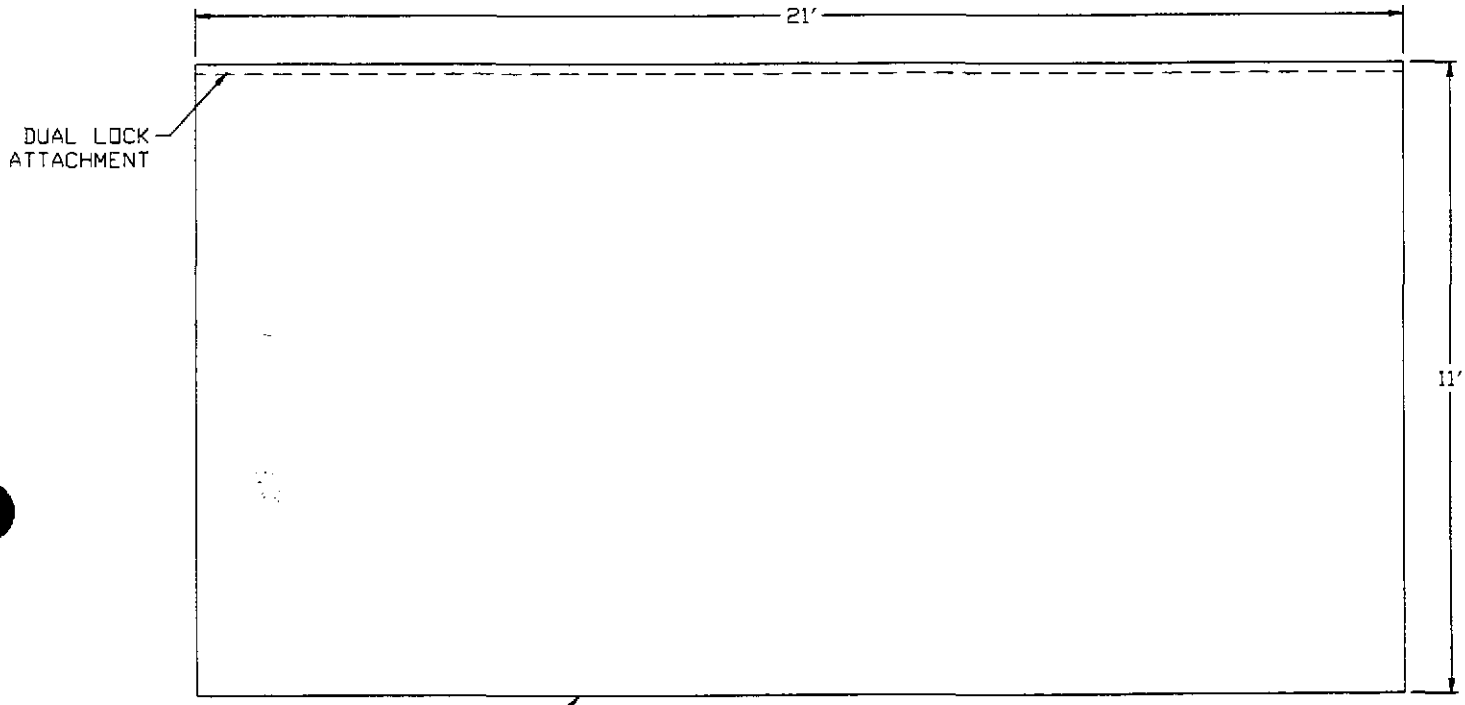
PROCESS SYSTEMS INTERNATIONAL INC.
20 WALKUP DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

H.A.M. CLEAN ROOM SYSTEM
SIDE ACCESS PANEL

CAD FILE NO.	SIZE	DWG. NO.	REV.
2144S2	A	V049-2-144	0

SCALE: NONE	DRAWN: BAR	SHEET: 2 OF 4

Sept 25, 1996 - 09:37:34



MAY BE CONSTRUCTED OF SEVERAL DIFFERENT OVERLAPPING PANEL LENGTHS.

CORNER ACCESS PANEL
40 MIL SOFTWALL PANEL
1 REQ'D

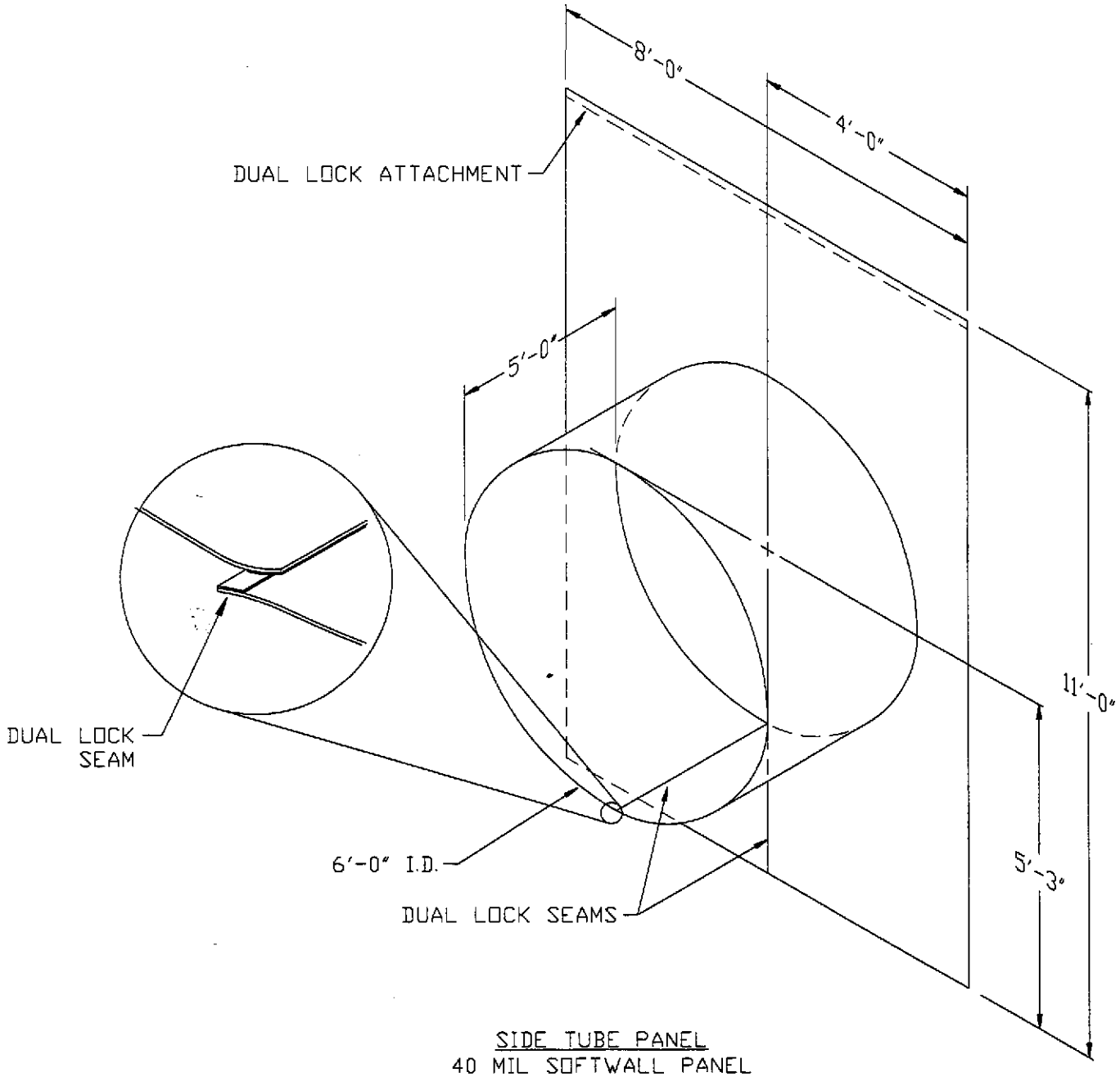
PROCESS SYSTEMS INTERNATIONAL INC.
20 WALKUP DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

H.A.M. CLEAN ROOM SYSTEM
SOLID SIDE PANEL

CAD FILE NO.	SIZE	DWG. NO.	REV.
2144S3	A	V049-2-144	0

SCALE: NONE	DRAWN: BAR	SHEET: 3 OF 4

Oct 04, 1996 - 15:22:22



SIDE TUBE PANEL
40 MIL SOFTWALL PANEL
2 REQ'D.

PROCESS SYSTEMS INTERNATIONAL INC.
20 WALKUP DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

H.A.M. CLEAN ROOM SYSTEM
SIDE TUBE PANEL

CAD FILE NO.	SIZE	DWG. NO.	REV.
2144S4	A	V049-2-144	0
SCALE: NONE	DRAWN: BAR	SHEET: 4 OF 4	

Oct 04, 1996 - 15:39:12

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: SOFTWALL CLEAN ROOM PANELS FOR HORIZONTAL ACCESS MODULE	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-144

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		
OPERATION & MAINTENANCE MANUALS	TBD			5	X		

Title: SPECIFICATION FOR SOFTWALL CLEAN ROOM PANELS FOR BEAM SPLITTER CHAMBER

SPECIFICATION FOR

SOFTWALL CLEAN ROOM PANELS
BEAM SPLITTER CHAMBER

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: [signature]

QUALITY ASSURANCE: Alan L Bulbrook

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: [signature]

ϕ	[illegible] 10/2/96	AES 10/4/96	ISSUED FOR [illegible] DCC 0275
REV	BY - DATE	APPD. - DATE	DESCRIPTION OF CHANGE

PROCESS SYSTEMS INTERNATIONAL, INC.					SPECIFICATION	
INITIAL APPROVALS	PREPARED [illegible]	DATE 10/2/96	APPROVED AES	DATE 10/4/96	NUMBER A V049-2-145	REV 0

TABLE OF CONTENTS

1.0 SCOPE	3
2.0 SCHEDULE	3
3.0 GENERAL REQUIREMENTS	3
4.0 REQUIRED DOCUMENTATION	4
5.0 SHOP TESTING	4
6.0 INSPECTION	4
7.0 WARRANTY	4
8.0 Q.A. REQUIREMENTS	4
9.0 APPENDIX: DWG. V049-2-145 BSC CLEAN ROOM SYSTEM SOFTWALL PANEL DETAILS	5

ATTACHMENT A: LIGO QA REQUIREMENT SUMMARY

ATTACHMENT B: GENERAL EQUIPMENT REQUIREMENTS PSI SPECIFICATION V049-2-033, REV 2

Title: SPECIFICATION FOR SOFTWALL CLEAN ROOM PANELS FOR BEAM SPLITTER CHAMBER

1.0 SCOPE

1.1 This specification covers the minimum requirements for the design, materials, fabrication, inspection, testing, preparation for shipping, and shipment of softwall panels for portable softwalled 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 Gravity wave Observatory (LIGO). LIGO, which is operated by Caltech & MIT under a NSF contract, includes two installations at widely seperated 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.

1.2 This specification covers the requirements for one Horizontal Access Module (hereinafter called HAM) clean room softwall panel set. Refer to section 2.0 delivery schedule for quantities.

1.3 These panels shall be used in a portable class 100 clean room system.

2.0 SCHEDULE

The deliverary schedule shall be as follows:

PSI (Westborough Ma.)	qty of 1	12/1/96
Washington Site:	qty of 6	5/1/97
Lousiana Site:	qty of 3	12/1/97

Total required: 10

3.0 GENERAL REQUIREMENTS

2.1 Panels shall be constructed of transparent 40mil fire-retardant PVC with weighted bottoms.

2.2 Panels shall be attached to structural framework (by PSI) via non-particulating "Dual Lock" or equivalent attachment strips along the top edge of the panel, or such attachment as suggested by manufacturer. The mating piece of "Dual Lock", or other attachment method, shall be supplied with the appropriate panel.

Attachment method shall be suitable for supporting the weight of the panels during normal operation without sagging or pulling free.

2.3 Panels intersecting beam tubes shall have a closable "Dual Lock" seam to enable setting panel in place around beam tube. Refer to appendix A, dwg. #v049-2-145 for arrangement of beam tubes.

2.4 Panels intersecting beam tubes shall have a method of cinching panel tube around circumference of the beam tube. Beam tube diameters vary from 68.25" to 30". Panel must accomodate varying diameters. Refer to appendix A, dwg. #v049-2-145 for arrangement of beam tubes.

2.5 Panels intersecting beam tubes shall have a method of closing beam tube opening for use when beam tube is not installed.

2.6 Adjacent panels shall overlap by 3" min. each side, or as suggested by manufacturer.

4.0 REQUIRED DOCUMENTATION

The documentation called for in Attachment A shall be supplied by the vendor.

5.0 SHOP TESTING

The Vendor shall perform his standard testing.

6.0 INSPECTION

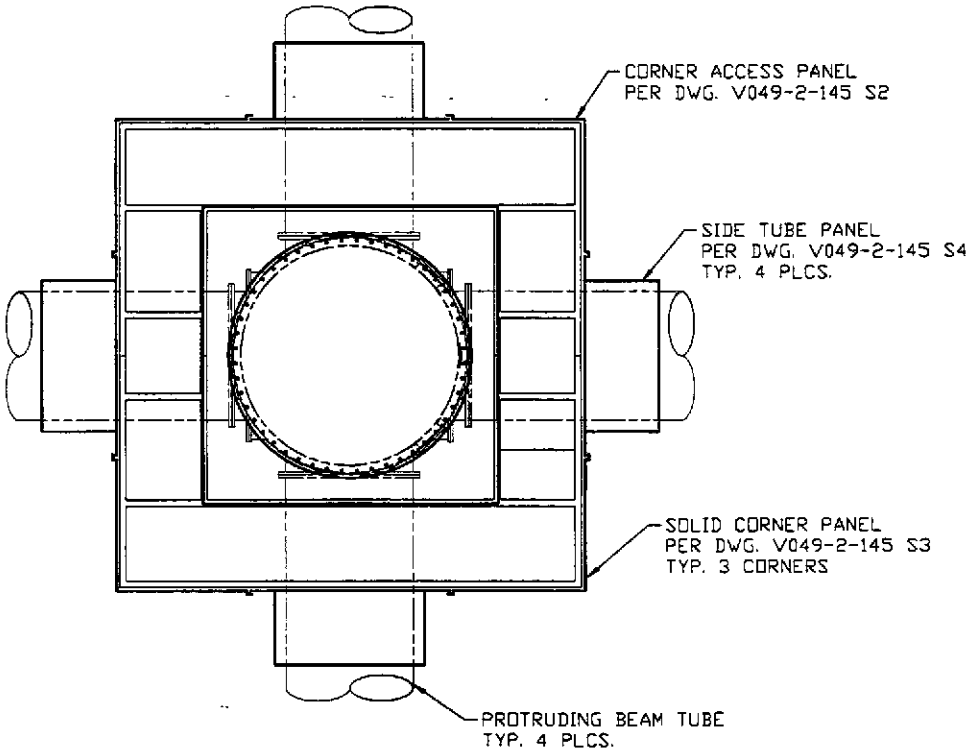
The inspections called for in Attachment A shall be performed by the vendor.

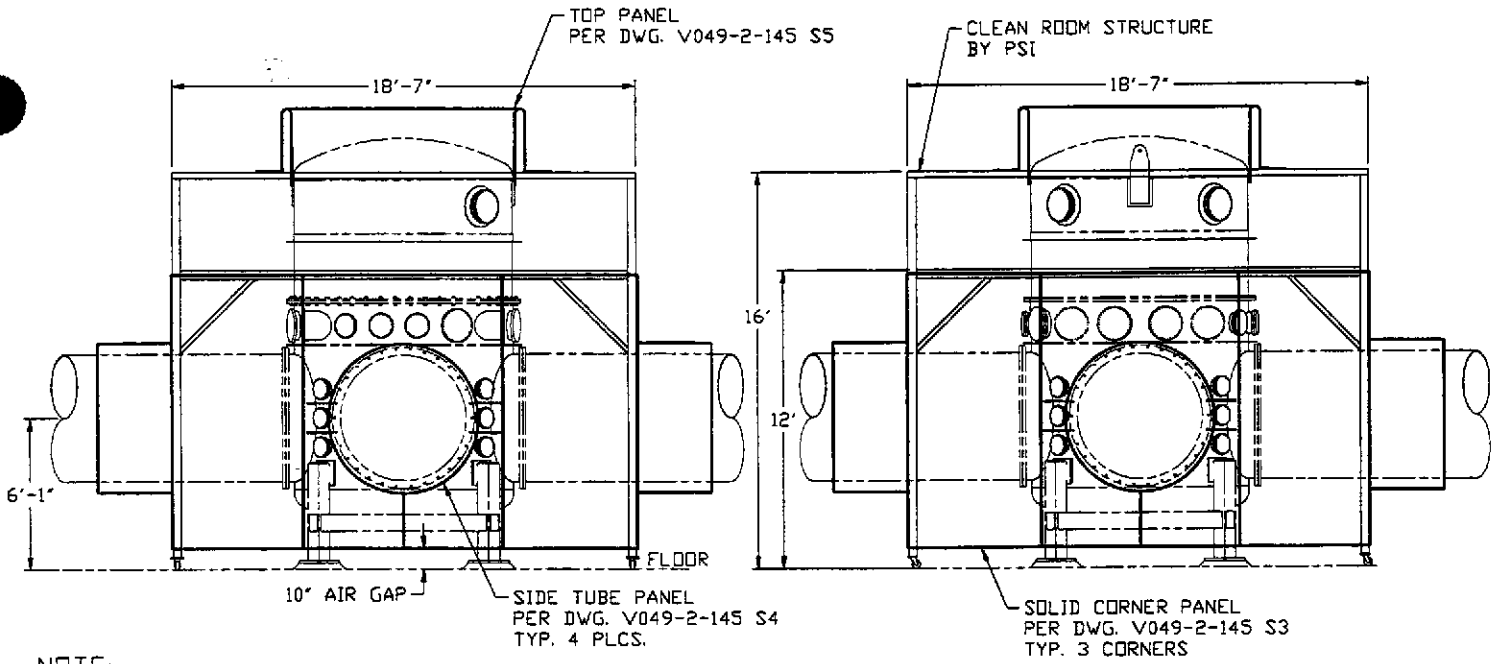
7.0 WARRANTY

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

8.0 Q.A. REQUIREMENTS

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





NOTE:
CORNER PANELS WILL OVERLAP
ADJACENT SIDE TUBE PANELS BY 3".

REV.	DESCRIPTION	DATE	BY	CHK.	APP.

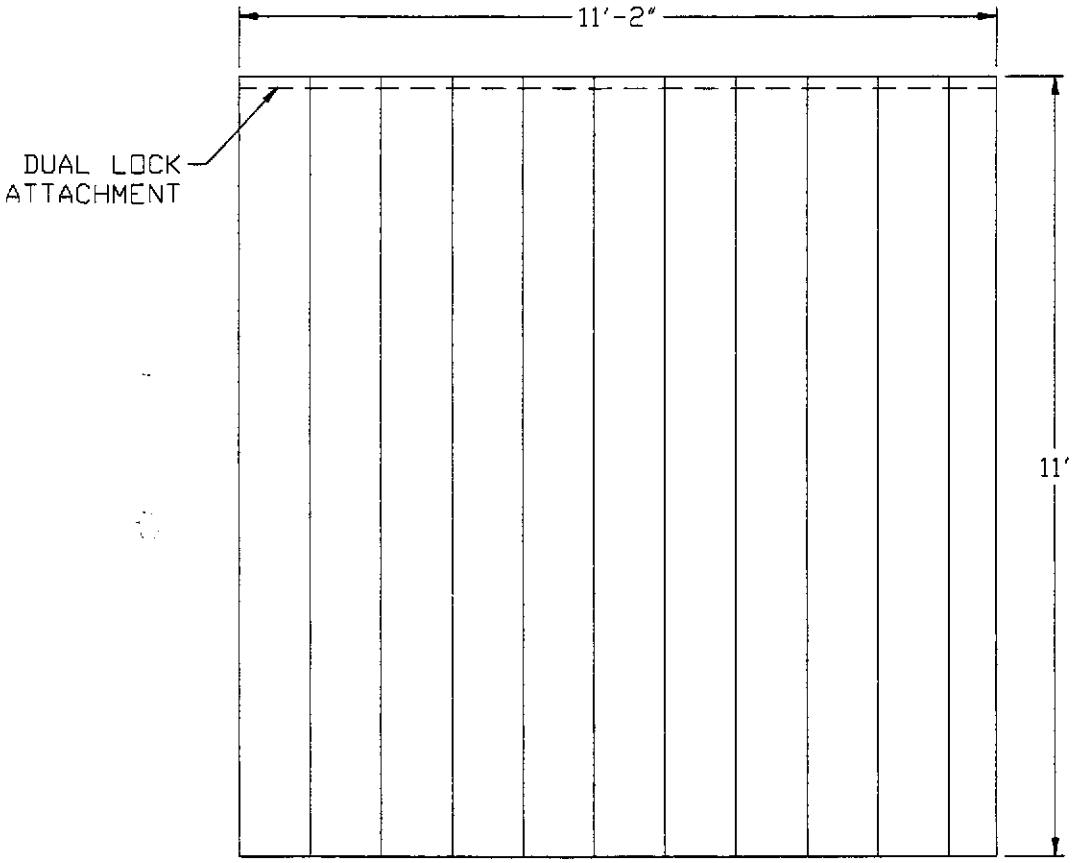
PROCESS SYSTEMS INTERNATIONAL INC.
20 WALKUP DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

B.S.C. CLEAN ROOM SYSTEM
CLEAN ROOM SOFTWALL PANELS

CAD FILE NO.	SIZE	DWG. NO.	REV.
2145S1	A	V049-2-145	0

SCALE: NONE | DRAWN: BAR | SHEET: 1 OF 5

Oct 04, 1996 - 15:49:28



CORNER ACCESS PANEL
40 MIL SOFTWALL PANEL STRIPS
1 REQ'D

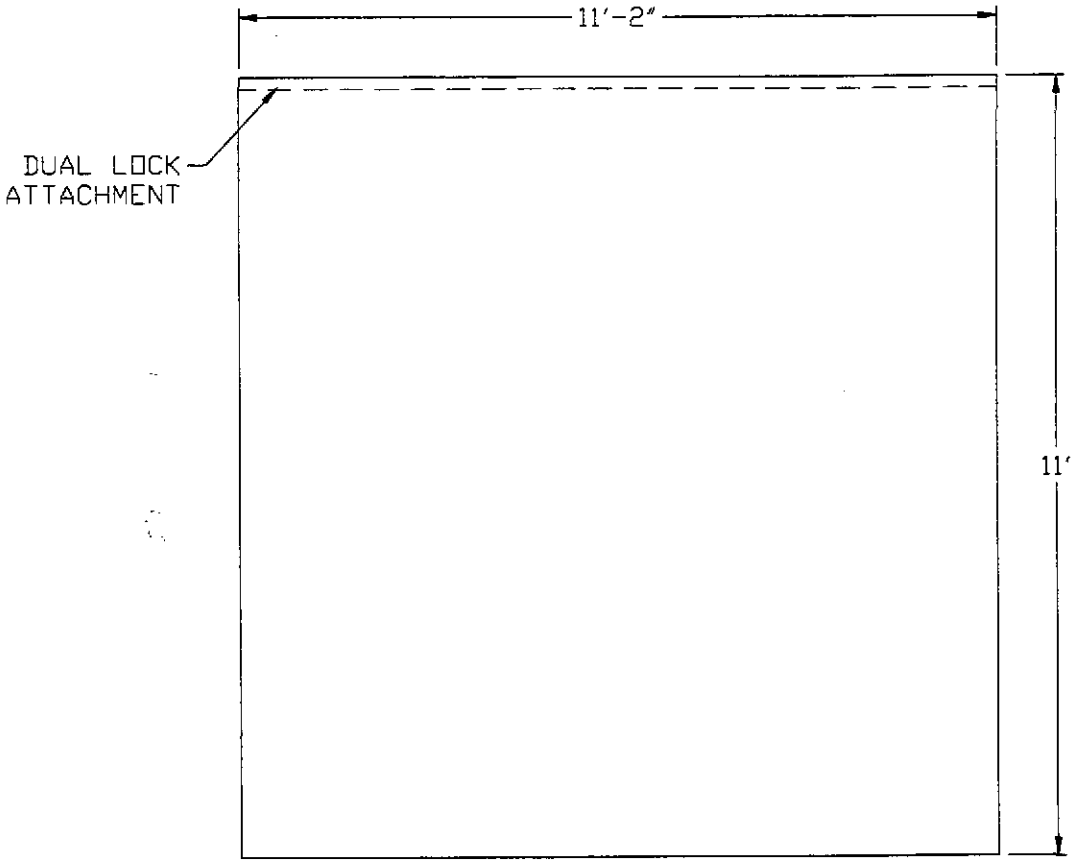
PROCESS SYSTEMS INTERNATIONAL INC.
20 WALKUP DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

B.S.C. CLEAN ROOM SYSTEM
CORNER ACCESS PANEL

CAD FILE NO.	SIZE	DWG. NO.	REV.
2145S2	A	V049-2-145	0

SCALE: NONE	DRAWN: BAR	SHEET: 2 OF 5

Oct 04, 1996 - 15:49:51



SOLID CORNER PANEL
40 MIL SOFTWALL PANEL
3 REQ'D

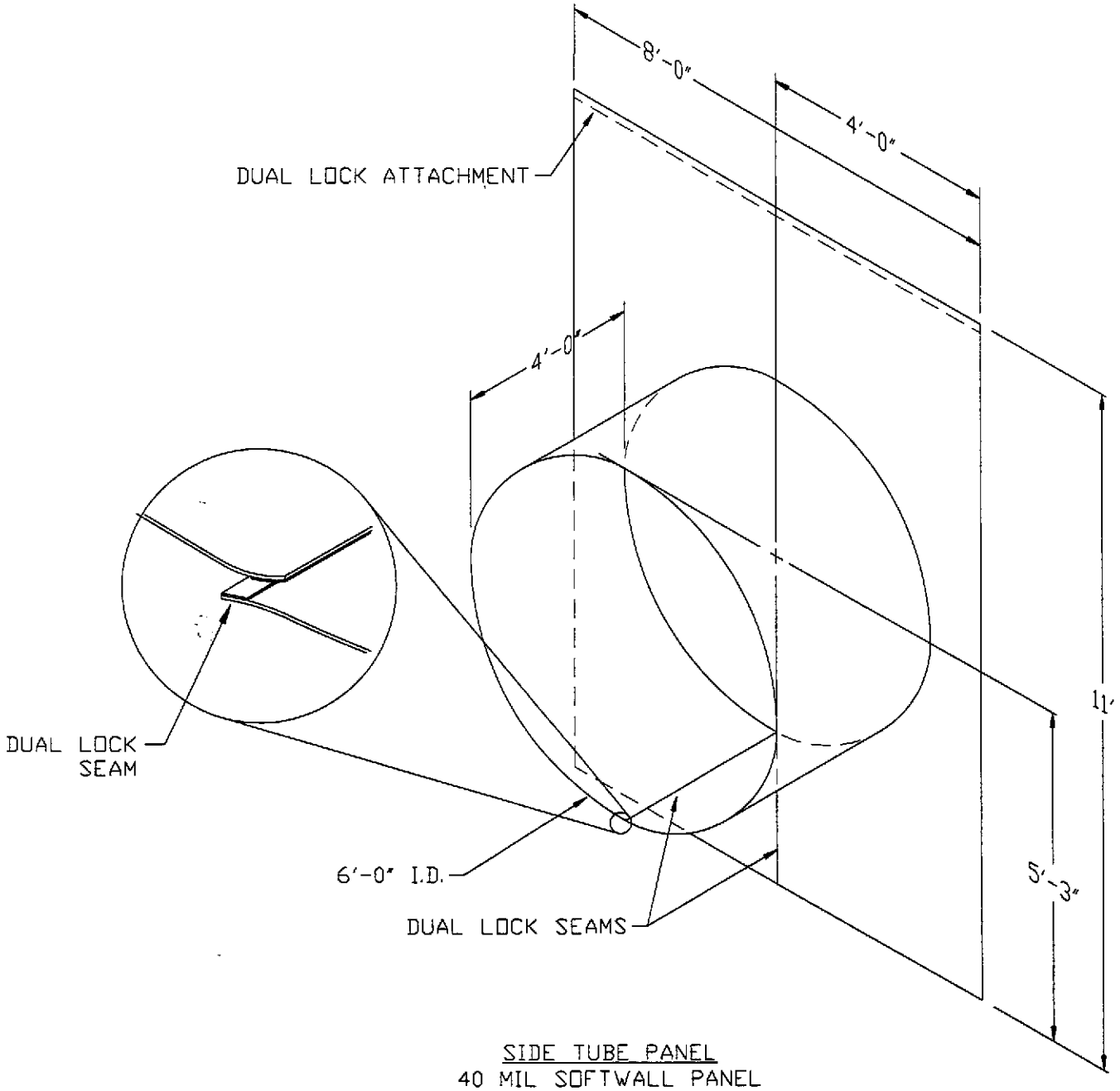
PROCESS SYSTEMS INTERNATIONAL INC.
20 WALKUP DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

B.S.C. CLEAN ROOM SYSTEM
SOLID CORNER PANEL

CAD FILE NO.	SIZE	DWG. NO.	REV.
2145S3	A	V049-2-145	0

SCALE: NONE	DRAWN: BAR	SHEET: 3 OF 5

Oct 04, 1996 - 15:50:09



SIDE TUBE PANEL
40 MIL SOFTWALL PANEL
4 REQ'D.

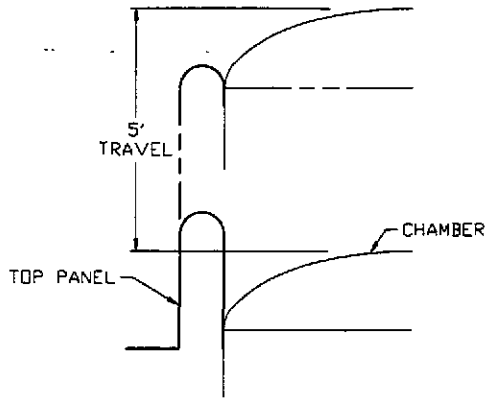
PROCESS SYSTEMS INTERNATIONAL INC.
20 WALKUP DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

B.S.C. CLEAN ROOM SYSTEM
SIDE TUBE PANEL

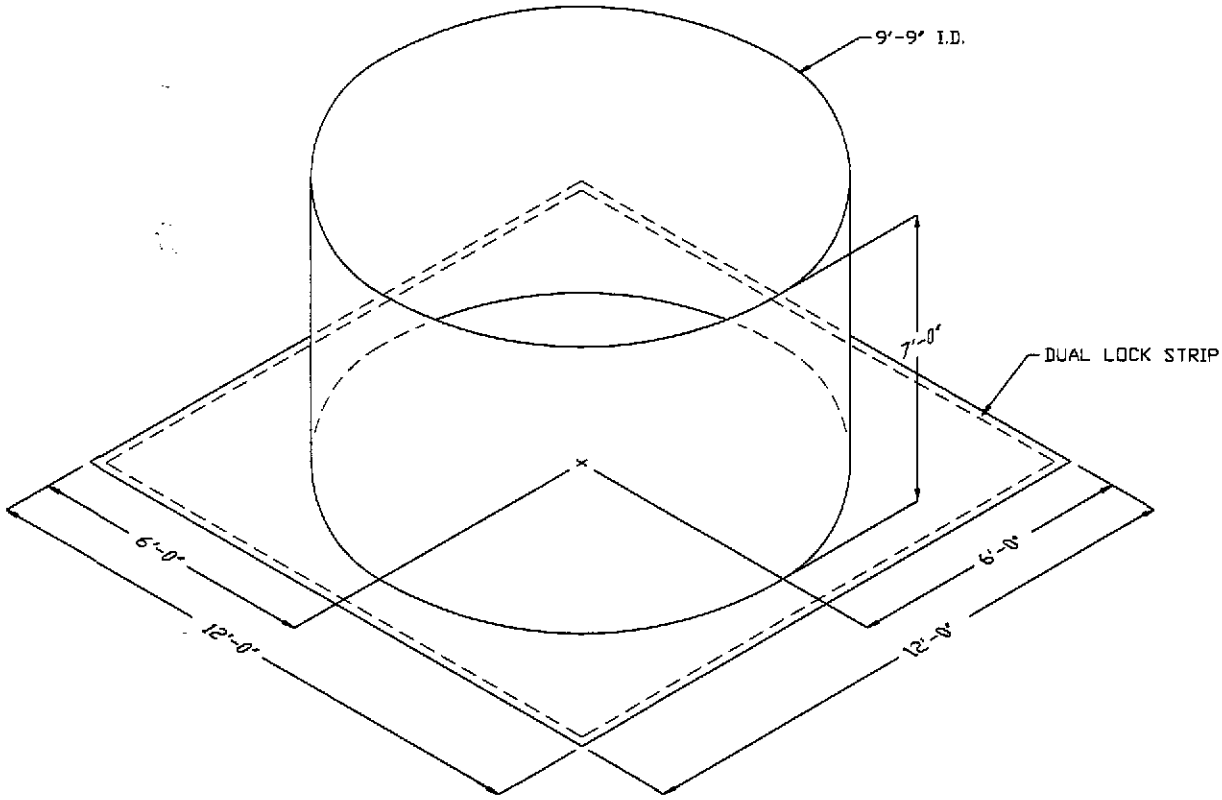
CAD FILE NO.	SIZE	DWG. NO.	REV.
2145S4	A	V049-2-145	0

SCALE: NONE	DRAWN: BAR	SHEET: 4 OF 5

Oct 04, 1996 - 155028



DETAIL
INSTALLATION OF TOP PANEL
ON BSC CHAMBER & TRAVEL
REQUIREMENTS.



TOP BSC PANEL
40 MIL SOFTWALL PANEL
1 REQ'D

PROCESS SYSTEMS INTERNATIONAL INC.
20 WALKUP DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

B.S.C. CLEAN ROOM SYSTEM
TOP PANEL

CAD FILE NO.	SIZE	DWG. NO.	REV.
2145S5	A	V049-2-145	0
SCALE: NONE	DRAWN: BAR	SHEET: 5 OF 5	

Oct 04, 1996 - 15:50:46

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: SOFTWALL CLEAN ROOM PANELS FOR BEAM SPLITTER CHAMBER	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-145

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		
OPERATION & MAINTENANCE MANUALS	TBD			5	X		

Title:	SPECIFICATION FOR CLASS 100 PORTABLE CLEAN GOWNING ROOMS

SPECIFICATION FOR

PORTABLE CLASS 100

CLEAN GOWNING ROOMS

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: BAR

QUALITY ASSURANCE: G. SEMECAL

TECHNICAL DIRECTOR: D. M. Williams 10-16-96

PROJECT MANAGER: Barry Barish

REV	BY - DATE	APPD. - DATE	DESCRIPTION OF CHANGE
Ø	BAR 10/15/96	RES 10/16/96	RELEASED PER DCO 0306

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	NUMBER REV: A V049-2-157	0
	BAR	10/15/96	RES	10/16/96		

TABLE OF CONTENTS

1.0 SCOPE 3

2.0 SCHEDULE 3

3.0 GENERAL REQUIREMENTS 3

4.0 REQUIRED DOCUMENTATION 4

5.0 SHOP TESTING 5

6.0 INSPECTION 5

7.0 WARRANTY 5

8.0 Q.A. REQUIREMENTS 5

ATTACHMENT A: LIGO QA REQUIREMENT SUMMARY

ATTACHMENT B: GENERAL EQUIPMENT REQUIREMENTS
PSI SPECIFICATION V049-2-033, REV 2

1.0 SCOPE

1.1 This specification covers the minimum requirements for the design, materials, fabrication, inspection, testing, preparation for shipping, and shipment of portable softwall gowning rooms 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 Gravity wave Observatory (LIGO). LIGO, which is operated by Caltech & MIT under a NSF contract, includes two installations at widely seperated 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.

1.2 This specification covers the requirements for 4'L x 4'W x 8'H gowning room and the 4'L x 8'W x 8'H gowning room. Refer to section 2.0 delivery schedule for quantities.

1.3 These gowning room will be used in conjunction with larger portable clean room systems.

2.0 SCHEDULE

The delivery schedule shall be as follows:

4'L x 4'W x 8'H gowning room:

Washington Site:	qty of 4	8/1/97
Lousiana Site:	qty of 2	3/1/98

Total required: 6

4'L x 8'W x 8'H gowning room:

Washington Site:	qty of 1	8/1/97
Lousiana Site:	qty of 1	3/1/98

Total required: 2

3.0 GENERAL REQUIREMENTS

3.1 4'L x 4'W x 8'H Gowning Room

3.1.1 Frame shall be constructed of 2" x 2" structural tube steel, or such material as deemed appropriate by the manufacturer to satisfy conditions of use. Frame shall further contain such supports and bracing as required to maintain structural integrity.

3.1.2 Frame shall be painted with a white epoxy finish.

3.1.3 Casters with a foot actuated locking mechanism shall be attached to the support legs to facilitate placement of gowning room.

3.1.4 Lifting lugs shall be attached to the top of the frame to enable lifting of gowning room via a single hook crane. Lugs shall be designed to support finished weight of gowning room.

3.1.5 Wall material shall be 16mil or 20mil clear vinyl, or such thickness as deemed appropriate by the manufacturer. Wall material shall be attached to frame as required by manufacturer.

3.1.6 A strip door shall be placed on one side of the gowning room. The side opposite the strip door shall not have a soft wall, but shall be left open. The other 2 sides shall have solid clear vinyl walls attached as described in 3.1.5. The open side of the gowning room shall be placed against an existing softwall strip door.

3.2.7 The gowning room shall be suitable for class 100, using air flow from adjacent class 100 clean room softwall strip door.

3.2.8 The ceiling or top panel of the gowning room shall be of transparent material suitable for use in a class 100 cleanroom environment.

3.2 4'L x 8'W x 8'H Gowning Room

3.2.1 Frame shall be constructed of 2" x 2" structural tube steel, or such material as deemed appropriate by the manufacturer to satisfy conditions of use. Frame shall further contain such supports and bracing as required to maintain structural integrity.

3.2.2 Frame shall be painted with a white epoxy finish.

3.2.3 Casters with a foot actuated locking mechanism shall be attached to the support legs to facilitate placement of gowning room.

3.2.4 Lifting lugs shall be attached to the top of the frame to enable lifting of gowning room via a single hook crane. Lugs shall be designed to support finished weight of gowning room.

3.2.5 Wall material shall be 16mil or 20mil clear vinyl, or such thickness as deemed appropriate by the manufacturer. Wall material shall be attached to frame as required by manufacturer.

3.2.6 A strip door shall be placed on one 8'W side of the gowning room. The side opposite the strip door shall not have a soft wall, but shall be left open. The other two 4'L sides shall have solid clear vinyl walls attached as described in 3.2.5. The open side of the gowning room shall be placed against an existing softwall strip door.

3.2.7 The gowning room shall have one HEPA blower/filter unit required to maintain a class 100 environment, with an attached flow-through flourescent lighting fixture. The HEPA blower/filter and lighting fixture shall be wired for 120vac, with an extension cord. The extension cord shall be attached to one leg the gowning room at approximately 10" from the floor level, and shall measure 15 feet in length from that attachment point. The extension cord used shall be suitable for use with a NEMA 5-15R duplex receptacle.

3.2.8 An on/off switch for the lighting and the HEPA blower/filter shall be located on the exterior of the gowning room.

4.0 REQUIRED DOCUMENTATION

The documentation called for in Attachment A shall be supplied by the vendor.

5.0 SHOP TESTING

The Vendor shall perform his standard testing.

6.0 INSPECTION

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

7.0 WARRANTY

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

8.0 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:	JOB NO.: V59049
EQUIPMENT: CLASS 100 GOWNING ROOMS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-157

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	8 Wks.		X	2	X		
VENDOR Q.A. PLAN							
CLEANING PROCEDURE							
PREP FOR SHIPMENT PROCEDURE	8 Wks.		X	2	X		
ASSEMBLY DRAWINGS	8 Wks.			2	X		
DESIGN REVIEW							
IN-PROCESS INSPECTIONS							
OPERATION & MAINTENANCE MANUALS	12 Wks.			5	X		
SHOP TEST PLAN							
SHOP TEST (WITH REPORT)							
SHOP DIMENSIONAL INSPECTION							
WELDING PROCEDURES							

SPECIFICATION FOR 80K PUMP VENT LINE CHECK VALVE FOR LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE [signature]

TECHNICAL DIRECTOR: D. A. Williams

PROJECT MANAGER: _____

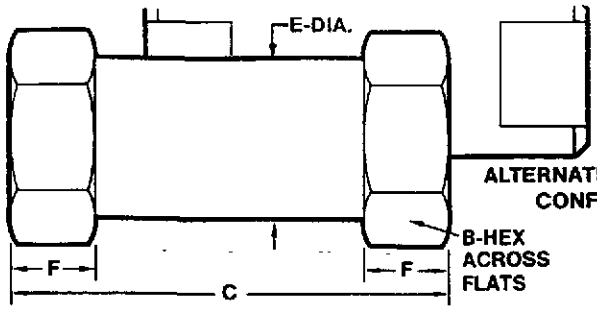
REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	RM 11/15/96		Revised per DEC # 0348
0	DM 10/21/96		Initial release, quote, & purchase DEC # 0315

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED DM	DATE 10/21/96	APPROVED	DATE	Number A V049-2-162	Rev. 1

Title: **SPECIFICATION FOR 80K PUMP VENT LINE CHECK VALVE**

Supplier:	Circle Seal Controls
Description:	Brass check valve with female pipe thread ends, and teflon seal. Dimensions shown on Attachment 1 of this specification.
Size:	1/2 inch
Rating:	0.5 psid cracking pressure
Model Number:	2320B4PP0.5
Quantity:	One of each tag no: CV-107, CV-157, CV-207, CV-257, CV-307, CV-357 CV-407, CV-507, CV-607, CV-657, CV-707, CV-807
Documentation:	Five copies (total) of operating and maintenance instructions.

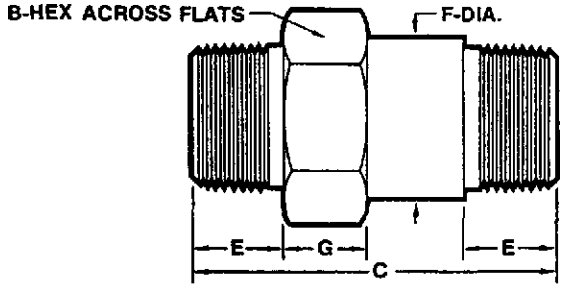
SPECIFICATION		
Number A	**V049-2-162**	Rev. 1



ALTERNATE ROUND STOCK CONFIGURATION

2300-†PP

DIMENSIONS				
SIZE	B-HEX	C	E	F
⅛	.625	1.50	.59	.31
¼	.813	2.00	.77	.41
⅜	1.00	2.35	.95	.50
½	1.25	2.89	1.19	.56
¾	1.50	3.30	1.43	.69



2300-†MM

DIMENSIONS					
SIZE	B-HEX	C	E	F-DIA.	G
¼	.625	1.82	.60	.59	.31
⅜	.813	2.21	.61	.77	.41
½	1.00	2.75	.79	.95	.50
¾	1.25	3.03	.80	1.19	.56
1	1.50	3.67	.99	1.43	.69

PART NUMBERS—(FEMALE CONNECTIONS)

MATERIAL	SIZE†	2349	2359	2333	2320
ALUMINUM	⅛	2349A-1PP	2359A-1PP	2333A-1PP	2320A-1PP
	¼	2349A-2PP	2359A-2PP	2333A-2PP	2320A-2PP
	⅜*	2349A-3PP	2359A-3PP	2333A-3PP	2320A-3PP
	½*	2349A-4PP	2359A-4PP	2333A-4PP	2320A-4PP
	¾*	2349A-6PP	2359A-6PP	2333A-6PP	2320A-6PP
BRASS	⅛	2349B-1PP	2359B-1PP	2333B-1PP	2320B-1PP
	¼	2349B-2PP	2359B-2PP	2333B-2PP	2320B-2PP
	⅜	2349B-3PP	2359B-3PP	2333B-3PP	2320B-3PP
	½	2349B-4PP	2359B-4PP	2333B-4PP	2320B-4PP
	¾	2349B-6PP	2359B-6PP	2333B-6PP	2320B-6PP
17-4PH STAINLESS STEEL	⅛	2349R-1PP	2359R-1PP	2333R-1PP	2320R-1PP
	¼	2349R-2PP	2359R-2PP	2333R-2PP	2320R-2PP
	⅜	2349R-3PP	2359R-3PP	2333R-3PP	2320R-3PP
	½	2349R-4PP	2359R-4PP	2333R-4PP	2320R-4PP
	¾	2349R-6PP	2359R-6PP	2333R-6PP	2320R-6PP

PART NUMBERS—(MALE CONNECTIONS)

MATERIAL	SIZE†	2349	2359	2333	2320
ALUMINUM	¼*	2349A-2MM	2359A-2MM	2333A-2MM	2320A-2MM
	⅜*	2349A-3MM	2359A-3MM	2333A-3MM	2320A-3MM
	½*	2349A-4MM	2359A-4MM	2333A-4MM	2320A-4MM
	¾*	2349A-6MM	2359A-6MM	2333A-6MM	2320A-6MM
	1"*	2349A-8MM	2359A-8MM	2333A-8MM	2320A-8MM
BRASS	¼*	2349B-2MM	2359B-2MM	2333B-2MM	2320B-2MM
	⅜*	2349B-3MM	2359B-3MM	2333B-3MM	2320B-3MM
	½*	2349B-4MM	2359B-4MM	2333B-4MM	2320B-4MM
	¾*	2349B-6MM	2359B-6MM	2333B-6MM	2320B-6MM
	1"*	2349B-8MM	2359B-8MM	2333B-8MM	2320B-8MM
17-4PH STAINLESS STEEL	¼*	2349R-2MM	2359R-2MM	2333R-2MM	2320R-2MM
	⅜*	2349R-3MM	2359R-3MM	2333R-3MM	2320R-3MM
	½*	2349R-4MM	2359R-4MM	2333R-4MM	2320R-4MM
	¾*	2349R-6MM	2359R-6MM	2333R-6MM	2320R-6MM
	1"*	2349R-8MM	2359R-8MM	2333R-8MM	2320R-8MM

*NOTE: Normally manufactured to order—minimum order quantity—40 pcs.

Attachment 1
V049-2-162 Rev.1
Pg 1 of 1

CIRCLE SEAL CONTROLS, INC.
POST OFFICE BOX 3666
ANAHEIM, CALIFORNIA 92803
PHONE (714) 774-6110 • FAX (714) 772-7332

SPECIFICATION FOR 80K PUMP RESERVOIR RELIEF VALVE FOR LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE Gene Senecal

TECHNICAL DIRECTOR: D. M. W. Mears

PROJECT MANAGER: Rich Bayer

REV LTR	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
0	DMM 10/27/96	RBS 10/23/96	Released for quote & purchase ECO # 0527

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number A V049-2-164	Rev. 0
	DMoore	10/22/96	RBS	10/23/96		

Title: SPECIFICATION FOR 80K PUMP RESERVOIR RELIEF VALVE

Supplier:	Kunkle
Description:	Bronze Safety Valve, Top Outlet
Size:	1/2". See Attachment 1 of this specification for dimensions.
Set Pressure:	15 psig
Model Number:	0001-C-KC0015
Quantity:	One of each tag. no. RV-133, RV-183, RV-233, RV-283, RV-333, RV-383 RV-483, RV-583, RV-633, RV-683, RV-783, RV-883

SPECIFICATION		
Number	A V049-2-164	Rev. Ø

Attachment 1

KUNKLE®
Valve Division

BRONZE SAFETY VALVES FOR AIR, NON-HAZARDOUS GAS, STEAM SERVICE

PRESSURE LIMITS

STEAM — 250 PSIG - 406°F.
AIR/GAS — 250 PSIG - 300°F.

ASME Standard
UV
N.B. Certified

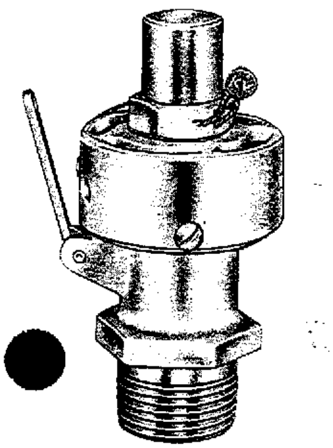
APPLICATIONS

- Air/Gas Compressors — portable or stationary.
- Pressure Vessels — including tanks, receivers, intercoolers, aftercoolers.
- Steam turbines, kettles, other steam-processing equipment.

FEATURES

The "Original Kunkle" design. Very compact assembly. Cup-Type disc. Extra-long disc guides with precision lapped beveled seats. Fully enclosed spring. Warn ring offers easy adjustability for precise opening with minimum pre-open or simmer and exact blowdown control. Pivot between disc and spring corrects for mis-alignment and compensates for spring side thrust. Every valve is 100% tested/inspected for pressure setting, blowdown and leakage. All adjustments are factory sealed to prevent tampering or dis-assembly. Unique lift lever incorporated into valve body.

Overall Height — ½ & ¾" Model 1 – 3⅜" ; Model 2 – 4"
1" Model 1 – 4½"; Model 2 – 5¼"
Weight — ½ & ¾" Model 1 – 12 Oz.; Model 2 – 15 Oz.
1" Model 1 – 1¾ Lbs.; Model 2 – 2¼ Lbs.

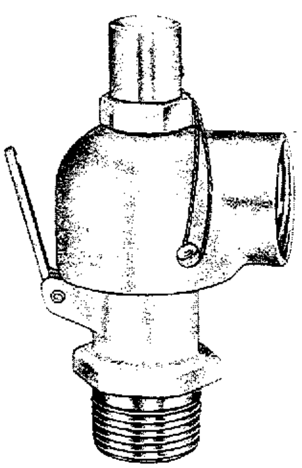


MODEL 1
(TOP OUTLET)

Nickel/Chrome plating for use on institutional equipment.
Vibration dampener on lift lever.

AIR/STEAM CAPACITIES

Set Pressure PSIG	½" x ¾"		1"		Set Pressure PSIG	½" x ¾"		1"		Set Pressure PSIG	½" x ¾"		1"	
	Lbs./Hr. Steam 10% Acc.	SCFM Air 10% Acc.	Lbs./Hr. Steam 10% Acc.	SCFM Air 10% Acc.		Lbs./Hr. Steam 10% Acc.	SCFM Air 10% Acc.	Lbs./Hr. Steam 10% Acc.	SCFM Air 10% Acc.		Lbs./Hr. Steam 10% Acc.	SCFM Air 10% Acc.	Lbs./Hr. Steam 10% Acc.	SCFM Air 10% Acc.
5	82	29	142	50	50	258	92	445	158	150	517	183	895	318
10	104	37	179	63	60	293	104	504	179	175	553	196	959	340
15	125	44	215	76	70	325	115	560	199	200	577	205	1003	356
20	145	52	250	89	80	355	126	613	217	225	590	210	1028	365
25	165	59	284	101	90	384	136	662	235	250	592	210	1034	367
30	185	66	318	113	100	411	146	709	252					
40	223	79	383	136	125	469	167	811	288					



MODEL 2
(SIDE OUTLET)

MODEL NUMBER/ORDER GUIDE

MODEL NO. POSITION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
EXAMPLE	0	0	0	1	—	C	0	1	—	K	C	0	1	2	5
	0	0	0	2											

INLET SIZE
C – 1/2"
D – 3/4"
E – 1"

VARIATION
Number Provided Only by Manufacturer to Cover Specific Feature or Option

DESIGN REVISION
Indicates Non-Interchangeable Revision
Dash (-) if Original Design

VALVE SERVICE
K-Air Gas ASME Sec VIII
L-Steam ASME Sec VIII

SET PRESSURE
5 PSIG (0005) Thru 250 PSIG (0250)

IMPORTANT: Kunkle Valve Division is not liable for any damage resulting from misuse or misapplication of its products (see warranty).

KUNKLE®
Valve Division
8222 Bluffton Road Box 1740 Fort Wayne, Indiana 46801-1740
219-747-1533 FAX 219-747-7958

SPECIFICATION FOR 80K PUMP VENT MANUAL BYPASS VALVE FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE:

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER:

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
Ø	DM 10/23/96	RSS 10/27/96	Release for quote and purchase DEO #0327

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number A V049-2-165	Rev.
	DMoore	10/23/96	RSS	10/28/96		Ø

Title: SPECIFICATION FOR 80K PUMP VENT MANUAL BYPASS VALVE

Supplier: TBV

Description: Cryogenic, extended stem manual ball valve

Size: 1-1/2". See Attachment 1 of this specification for dimensions.

Operating Pressure: 1 atmosphere, absolute

Model Number: 1-1/2" 21 SW 2 34 34 CT

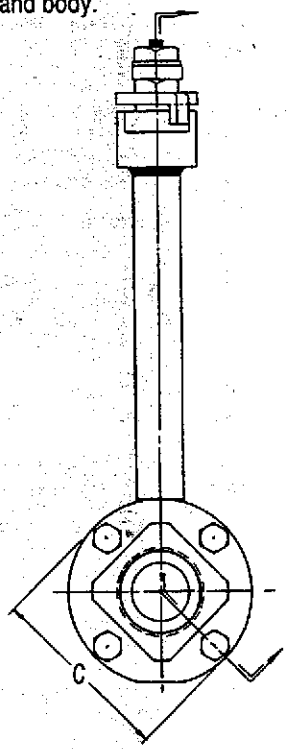
Quantity: One of each tag. no:

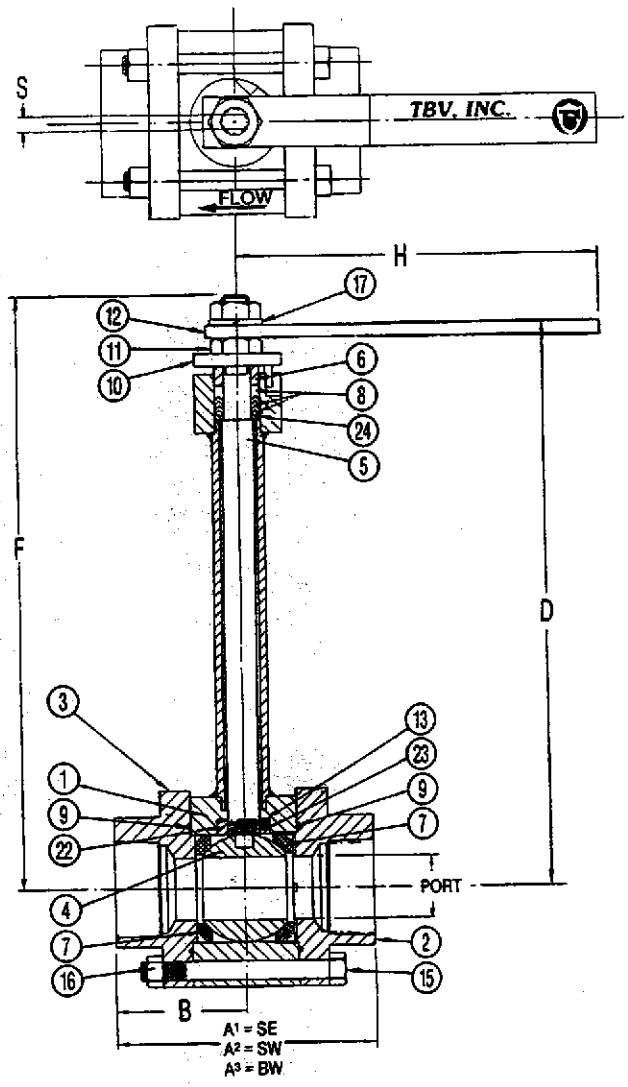
HV-107, HV-157, HV-207, HV-257, HV-307, HV-357
HV-407, HV-507, HV-607, HV-657, HV-707, HV-807

SPECIFICATION	
Number A V049-2-165	Rev. Ø

FEATURES AND BENEFITS

1. One piece, high strength blowout proof stem.
2. Specially designed Cryofil seats provide leakproof operation to -452°F.
3. Leakproof Chevron V-Ring packing.
4. Totally encapsulated body seal prevents "cold flow" of TFE.
5. Slotted upstream endplate provides positive cavity venting.
6. All welded bonnet construction.
7. Stainless Steel externals.
8. Automation available with optional mounting pad.
9. Optional grounding springs between ball and stem, and stem and body.



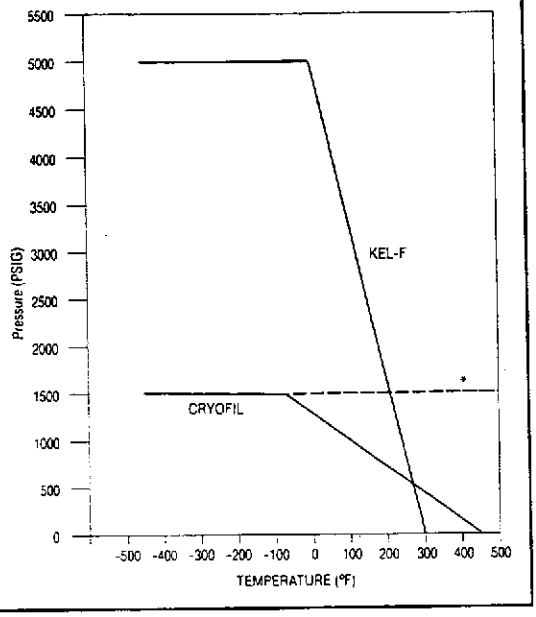


MAJOR DIMENSIONS

Valve Size	Port	A¹	A²	A³	B	C	D	F	H
1/2"	0.50	3.14	3.14	3.14	1.57	2.50	8.80	8.96	5.94
3/4"	0.50	3.14	3.14	3.14	1.57	2.50	8.80	8.96	5.94
1"	0.81	3.75	3.69	3.67	1.87	3.25	9.15	9.31	5.94
1½"	1.25	4.82	4.76	4.70	2.35	4.12	11.31	11.66	8.40
2"	1.50	5.06	5.00	5.00	2.53	4.36	11.50	11.85	8.40
3"	2.50	8.25	8.25	8.25	4.13	7.25	18.98	17.47	14.50
4"	3.25	9.25	9.25	9.25	4.63	8.37	19.58	18.07	14.50
6"	4.38	10.25	10.25	10.25	5.13	11.00	*	21.46	*

*See Note 2

SEAT RATING CHART



SEAT MATERIAL IDENTIFICATION CODE

C— Cryofil[3]	orange
K— Kel-F[2]	translucent

[2]Registered Trade Mark of 3-M Company.

[3]Registered Trade Mark of TBV, Inc.

*Consult factory for pressure exceeding 1500 PSI for special designs.

Attachment 1
V049-2-165, Rev. 0
Sht. 1 of 1

SPECIFICATION FOR LIQUID NITROGEN THERMAL RELIEF VALVE FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE:

TECHNICAL DIRECTOR: D. a. McWilliams

PROJECT MANAGER:

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
Ø	DM 10/29/96	RCB 10/23/96	Initial release for quote & purchase DEO #[illegible]

PROCESS SYSTEMS INTERNATIONAL, INC.					SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number A V049-2-166	Rev. Ø
	DMoore	10/29/96	[illegible]	10/23/96		

Title: **SPECIFICATION FOR LIQUID NITROGEN THERMAL RELIEF VALVE**

Supplier: Circle Seal Controls

Description: Stainless steel popoff relief valve with vent cap

Size: 1/4". See Attachment 1 of this specification for dimensions.

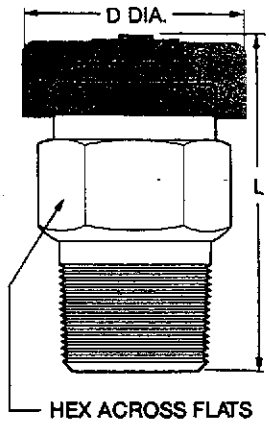
Set Pressure: 55 psig

Model Number: D580T1-2M-G

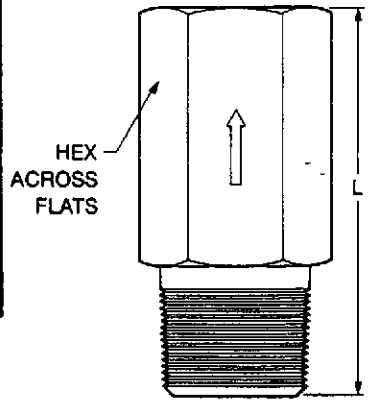
Quantity: One of each tag. no:

RV-108, RV-158, RV-208, RV-258, RV-308, RV-358
RV-408, RV-508, RV-608, RV-658, RV-708, RV-808

SPECIFICATION	
Number A V049-2-166	Rev. ϕ



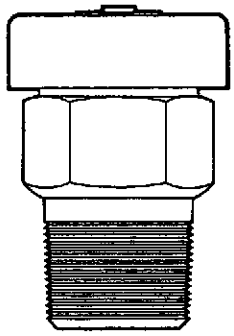
VENT TO ATMOSPHERE DIMENSIONS			
PIPE SIZE MALE	L	HEX	D DIA. MAX
⅛	1.14	½	.63
¼	1.38	⅝	.90
⅜	1.43	¾	1.21
½	1.98	1	1.45
¾	2.31	1⅛	1.45
1	3.16	1½	1.89



INLINE DIMENSIONS		
PIPE SIZE MALE & FEMALE	L	HEX
¼	1.62	¾
⅜	2.08	⅞
½	2.34	1⅛
¾	2.72	1¼
1	3.62	1½
1¼	4.67	1⅞

***Complete part number must include alpha code specifying cracking pressure. See chart on previous page.**

MATERIAL AND STYLE		SIZE	MODEL NUMBER			
			559	533	532	524
ALUMINUM	POPOFF	⅛	559A-1M-*	533A-1M-*	532A-1M-*	524A-1M-*
		¼	559A-2M-*	533A-2M-*	532A-2M-*	524A-2M-*
		⅜	559A-3M-*	533A-3M-*	532A-3M-*	524A-3M-*
		½	559A-4M-*	533A-4M-*	532A-4M-*	524A-4M-*
		¾	559A-6M-*	533A-6M-*	532A-6M-*	524A-6M-*
		1	559A-8M-*	533A-8M-*	532A-8M-*	524A-8M-*
	INLINE	¼	559A-2MP-*	533A-2MP-*	532A-2MP-*	524A-2MP-*
BRASS	POPOFF	⅛	559B-1M-*	533B-1M-*	532B-1M-*	524B-1M-*
		¼	559B-2M-*	533B-2M-*	532B-2M-*	524B-2M-*
		⅜	559B-3M-*	533B-3M-*	532B-3M-*	524B-3M-*
		½	559B-4M-*	533B-4M-*	532B-4M-*	524B-4M-*
		¾	559B-6M-*	533B-6M-*	532B-6M-*	524B-6M-*
		1	559B-8M-*	533B-8M-*	532B-8M-*	524B-8M-*
	INLINE	¼	559B-2MP-*	533B-2MP-*	532B-2MP-*	524B-2MP-*
		⅜	559B-3MP-*	533B-3MP-*	532B-3MP-*	524B-3MP-*
		½	559B-4MP-*	533B-4MP-*	532B-4MP-*	524B-4MP-*
		¾	559B-6MP-*	533B-6MP-*	532B-6MP-*	524B-6MP-*
		1	559B-8MP-*	533B-8MP-*	532B-8MP-*	524B-8MP-*
		1¼	559B-10MP-*	533B-10MP-*	532B-10MP-*	524B-10MP-*
316 S.S.	POPOFF	⅛	559T1-1M-*	533T1-1M-*	532T1-1M-*	524T1-1M-*
		¼	559T1-2M-*	533T1-2M-*	532T1-2M-*	524T1-2M-*
		⅜	559T1-3M-*	533T1-3M-*	532T1-3M-*	524T1-3M-*
		½	559T1-4M-*	533T1-4M-*	532T1-4M-*	524T1-4M-*
		¾	559T1-6M-*	533T1-6M-*	532T1-6M-*	524T1-6M-*
		1	559T1-8M-*	533T1-8M-*	532T1-8M-*	524T1-8M-*
	INLINE	¼	559T1-2MP-*	533T1-2MP-*	532T1-2MP-*	524T1-2MP-*
		½	559T1-4MP-*	533T1-4MP-*	532T1-4MP-*	524T1-4MP-*
		¾	559T1-6MP-*	533T1-6MP-*	532T1-6MP-*	524T1-6MP-*



For ASME code valve, available in ¼ inch size only. Add ASME after valve number. For operation details see ASME Valve catalog sheet, Form Number CSP-366L

REPLACEMENT SPRINGS**

C.P. RANGE	1M/2MP	2M/3MP	C.P. RANGE	3M/4MP	4M/6MP	6M/8MP	8M/10MP
0.2-0.9	22335-0.5	22336-0.5	.5-2.4	10362-1	10462-1	10662-1	10845-1
1.0-2.3	22335-1	22336-1	2.5-5.9	10362-4	10462-4	10662-4	10845-4
2.4-5.5	22335-4	22336-4	6.0-13.9	10362-10	10462-10	10662-10	10845-10
5.6-13.9	22335-10	22336-10	14.0-31.0	10362-20	10462-20	10662-20	10845-20
14.0-27.9	22335-20	22336-20	31.1-72.9	10362-50	10462-50	10662-50	10845-50
28.0-33.9	22335-30	22336-30	73.0-150.0	10362-100PH	10462-100PH	10662-100PH	10845-100PH
34.0-74.9	22335-55	22336-55					
75.0-104.9	22335-90PH	22336-90PH					
105.0-147.9	22335-125PH	22336-125PH					

****Springs for each valve size are interchangeable. The Cracking Pressure range can be changed by replacing the spring with one covering the desired range.**

Attachment 1
V049-2-166, Rev 5
Page 1 of 1

CIRCLE SEAL CONTROLS, INC.
POST OFFICE BOX 3666
ANAHEIM, CALIFORNIA 92803
PHONE (714) 774-6110 • FAX (714) 772-7332

SPECIFICATION FOR LIQUID NITROGEN MANUAL COOLDOWN VALVE FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE:

TECHNICAL DIRECTOR:

PROJECT MANAGER:

D	DM 10/24/96		Initial release for quote & purchase ECO # 330
REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE

PROCESS SYSTEMS INTERNATIONAL, INC.					SPECIFICATION	
INITIAL APPROVALS	PREPARED DM	DATE 10/24/96	APPROVED	DATE	Number A V049-2-167	Rev. D

Title: **SPECIFICATION FOR LIQUID NITROGEN MANUAL COOLDOWN VALVE**

Supplier:	The Wm. Powell Co.
Description:	Stainless steel, extended stem, socket welded, manual globe valve
Size:	1/2". See Attachment 1 of this specification for dimensions.
Operating Pressure:	15 psig
Model Number:	7K1861W48
Quantity:	One of each tag. no: HV-194, HV-196, HV-294, HV-296, HV-394, HV-396 HV-494, HV-594, HV-694, HV-696, HV-794, HV-894

SPECIFICATION		
Number	A V049-2-167	Rev. 0

SPECIFICATION FOR FILTER IN LIQUID NITROGEN SUPPLY LINE FOR LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE: NA

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: [signature]

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
Ø	DM 12/3/96	RGS 12/5/96	Initial release for quote & purchase DEC # 380

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE DMoore 12/3/96	APPROVED DATE RGS 12/5/96	Number A V049-2-176	Rev. Ø

Title:

SPECIFICATION FOR FILTER IN LIQUID NITROGEN SUPPLY LINE

Supplier:	Cambridge Valve and Fitting Co.
Manufacturer:	Nupro
Description:	Stainless steel filter with Kel-F gasket, male NPT
Part Number:	SS-8TF2-KG-230
Size:	1/2 inch
Tag Nos:	SM130, SM131, SM230, SM231, SM330, SM331 SM430, SM530, SM630, SM631, SM730, SM830

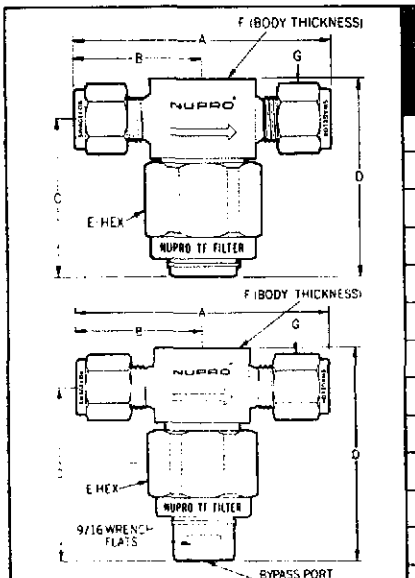
SPECIFICATION		
Number	A V049-2-176	Rev. Ø

"TF" SERIES TEE TYPE REMOVABLE FILTERS (continued)

FLOW CAPACITIES

	PRESSURE DROP ACROSS ELEMENT TO ATM (ΔP) PSI	"2TF" FILTERS AIR SCFM @ 70°F (21°C)	"2TF" FILTERS WATER GPM @ 70°F (21°C)	"2TF2" FILTERS AIR SCFM @ 70°F (21°C)	"2TF2" FILTERS WATER GPM @ 70°F (21°C)	"2TF4•4TF•4TF2•4TF4•4TF-TW" FILTERS AIR SCFM @ 70°F (21°C)	"2TF4•4TF•4TF2•4TF4•4TF-TW" FILTERS WATER GPM @ 70°F (21°C)	ALL "6TF-8TF" FILTERS AIR SCFM @ 70°F (21°C)	ALL "6TF-8TF" FILTERS WATER GPM @ 70°F (21°C)
SINTERED ELEMENTS		0.5 MICRON-MAX. FLOW C_V = 0.029		0.5 MICRON-MAX. FLOW C_V = 0.029		0.5 MICRON-MAX. FLOW C_V = 0.029		0.5 MICRON-MAX. FLOW C_V = 0.045	
	10	0.42	0.09	0.42	0.09	0.42	0.09	0.63	0.14
	50	1.11	0.21	1.11	0.21	1.11	0.21	1.73	0.32
	100	1.97	0.29	1.97	0.29	1.97	0.29	3.06	0.45
		2 MICRON-MAX. FLOW C_V = 0.035		2 MICRON-MAX. FLOW C_V = 0.040		2 MICRON-MAX. FLOW C_V = 0.040		2 MICRON-MAX. FLOW C_V = 0.055	
	10	0.51	0.11	0.55	0.13	0.55	0.13	0.78	0.18
	50	1.33	0.25	1.53	0.28	1.53	0.28	2.10	0.39
	100	2.31	0.35	2.71	0.40	2.71	0.40	3.72	0.53
		7 MICRON-MAX. FLOW C_V = 0.046		7 MICRON-MAX. FLOW C_V = 0.054		7 MICRON-MAX. FLOW C_V = 0.056		7 MICRON-MAX. FLOW C_V = 0.11	
	10	0.64	0.15	0.75	0.17	0.77	0.18	1.52	0.35
	50	1.76	0.33	2.07	0.38	2.14	0.40	4.21	0.78
	100	3.12	0.46	3.66	0.54	3.80	0.56	7.46	1.10
		15 MICRON-MAX. FLOW C_V = 0.053		15 MICRON-MAX. FLOW C_V = 0.068		15 MICRON-MAX. FLOW C_V = 0.074		15 MICRON-MAX. FLOW C_V = 0.13	
	10	0.73	0.17	0.94	0.22	1.02	0.23	1.80	0.41
	50	2.03	0.37	2.60	0.48	2.83	0.52	4.97	0.92
	100	3.59	0.53	4.61	0.68	5.02	0.74	8.82	1.30
		60 MICRON-MAX. FLOW C_V = 0.089		60 MICRON-MAX. FLOW C_V = 0.16		60 MICRON-MAX. FLOW C_V = 0.22		60 MICRON-MAX. FLOW C_V = 0.37	
	10	1.23	0.28	2.21	0.51	3.04	0.70	5.12	1.17
	50	3.40	0.63	6.12	1.13	8.42	1.56	14.15	2.62
	100	6.04	0.89	10.85	1.60	14.92	2.20	25.09	3.70
		90 MICRON-MAX. FLOW C_V = 0.094		90 MICRON-MAX. FLOW C_V = 0.18		90 MICRON-MAX. FLOW C_V = 0.28		90 MICRON-MAX. FLOW C_V = 0.50	
	10	1.30	0.30	2.49	0.57	3.87	0.89	6.92	1.58
	50	3.60	0.66	6.89	1.27	10.71	1.98	19.13	3.54
	100	6.37	0.94	12.21	1.80	18.99	2.80	33.91	5.00
STRAINER ELEMENTS		40, 140, 230 OR 440 MICRON MAX. FLOW C_V = 0.10		40, 140, 230 OR 440 MICRON MAX. FLOW C_V = 0.21		40, 140, 230 OR 440 MICRON MAX. FLOW C_V = 0.37		40, 140, 230 OR 440 MICRON MAX. FLOW C_V = 0.73	
	10	1.38	0.32	2.91	0.66	5.12	1.17	10.10	2.31
	50	3.83	0.71	8.03	1.48	14.15	2.62	27.92	5.16
	100	6.78	1.00	14.24	2.10	25.09	3.70	49.50	7.30

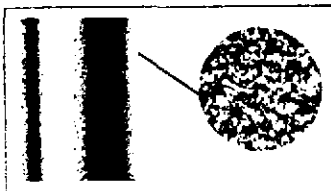
TABLE OF DIMENSIONS



BASIC ORDERING NUMBER[1]	ORIFICE IN	ORIFICE OUT	CONNECTION SIZE INLET & OUTLET	DIMENSIONS[2] A	B	C	D	E HEX	F	G HEX
-2TF-	0.094	2.4	1/8 SWAGELOK	2 9/32	1 9/64	1 1/2	1 7/8	1	1	7/16
-2TF4-	0.172	4.4	1/8 Female NPT	2	1	1 1/2	1 7/8	1	1	—
-4TF-	0.172	4.4	1/4 SWAGELOK	2 15/32	1 15/64	1 1/2	1 7/8	1	1	9/16
-4TF-F2-[3]	0.172	4.4	1/4 SWAGELOK	2 15/32	1 15/64	1 23/32	2 3/32	1	1	9/16
-4TF2-	0.172	4.4	1/4 Male NPT	2 1/8	1 1/16	1 1/2	1 7/8	1	1	—
-4TF4-	0.172	4.4	1/4 Female NPT	2 1/8	1 1/16	1 1/2	1 7/8	1	1	—
-4TF-TW-	0.172	4.4	1/4 TSW / 3/8 MTW	1 7/16	27/32	1 1/2	1 7/8	1	1	—
-6TF-	0.213	5.4	3/8 SWAGELOK	2 27/32	1 27/64	1 23/32	2 3/16	1 1/8	1 1/8	11/16
-6TF2-	0.250	6.4	3/8 Male NPT	2 3/8	1 3/16	1 23/32	2 3/16	1 1/8	1 1/8	—
-6TF-TW-	0.213	5.4	3/8 TSW / 1/2 MTW	2	1	1 23/32	2 3/16	1 1/8	1 1/8	—
-8TF-	0.250	6.4	1/2 SWAGELOK	3 1/16	1 17/32	1 23/32	2 3/16	1 1/8	1 1/8	7/8
-8TF2-	0.250	6.4	1/2 Male NPT	2 3/4	1 3/8	1 23/32	2 3/16	1 1/8	1 1/8	—
-8TF-TW-	0.250	6.4	1/2 TSW / 3/4 MTW	2	1	1 23/32	2 3/16	1 1/8	1 1/8	—

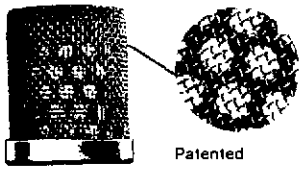
[1]For a complete ordering number, add B for brass or SS for 316 stainless steel as a prefix to the basic ordering number. For filters with sintered elements, add 05, 2, 7, 15, 60 or 90 as a suffix to the basic ordering number. Example: B-4TF-7. For filters with strainer elements, add 40, 140, 230 or 440 as a suffix to the basic ordering number. Example: SS-8TF-TW-230 [2]Dimensions shown with SWAGELOK nuts finger-tight, where applicable. All dimensions are in inches — for reference only, subject to change. [3]Other models with the bypass option are available on special order.

REPLACEMENT — SINTERED & STRAINER ELEMENTS FOR "TF" & "F" SERIES FILTERS



SINTERED CONSTRUCTION

Sintered 316 stainless steel filter elements in nominal micron sizes of 0.5 to 90, trap particulate contamination in the tortuous matrix. (Magnified 13X.)



Patented

WIRE MESH CONSTRUCTION

316 stainless steel mesh strainer elements available in 40, 140, 230 and 440 micron sizes effectively remove large particle contamination. (Magnified 2X.)

ELEMENT MATERIALS

Sintered Elements — 316 stainless steel (0.5, 2, 7, 15, 60 and 90 micron available) — Alloy 400 and Alloy C-276 available on special order.

Strainer Elements — 316 stainless steel wire mesh, silver brazed (40, 140, 230 and 440 micron available).

FILTRATION DEFINITIONS

Micron — One micron equals 1/25000 inch (.00004 inches/.001 mm). Microns are used to indicate mean pore diameter of a sintered element or mean particle diameter of fluid contamination. Filter Element — That portion of a filter which actually traps fluid contamination. Efficiency — Initial removal of 95% to 98% of particles larger than a given size. Flow Area — The actual area available to flow in a filter element. Filter Cake — The accumulation of solids deposited on a filter element from usage.

FILTER SERIES	ELEMENT PART* NUMBER	STRAINER ELEMENT NOMINAL MICRON SIZE	SINTERED ELEMENT NOMINAL MICRON SIZE	SINTERED ELEMENT MICRON RANGE
2F	SS-2F-K4-	NOT AVAILABLE	0.5	0.5-2
			2	1-4
2TF-4TF, 4F	SS-4F-K4-	40, 140, 230, 440	7	5-10
			15	11-25
6TF-8TF, 6F-8F	SS-8F-K4-	40, 140, 230, 440	60	50-75
			90	75-150

*To order spare sintered elements, add -05, -2, -7, -15, -60 or -90 as a suffix to the element part number. Add -40, -140, -230 or -440 to specify a strainer element. Example: SS-4F-K4-7, SS-8F-K4-140.

V049-2-176, Rev Ø Pg 3 of 3

SPECIFICATION FOR DERIME VALVES FOR 80K PUMP SUPPLY LINE FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: David Moore

QUALITY ASSURANCE NA

TECHNICAL DIRECTOR: D. G. McWilliam

PROJECT MANAGER: [signature]

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.

Ø	DM 12/4/96	RBB 12/4/96	Initial release for quotation & purchase DEC #Ø351
REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE

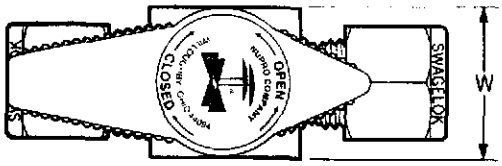
PROCESS SYSTEMS INTERNATIONAL, INC.					SPECIFICATION	
INITIAL APPROVALS	PREPARED D Moore	DATE 12/4/96	APPROVED RBB	DATE 12/5/96	Number A V049-2-177	Rev. Ø

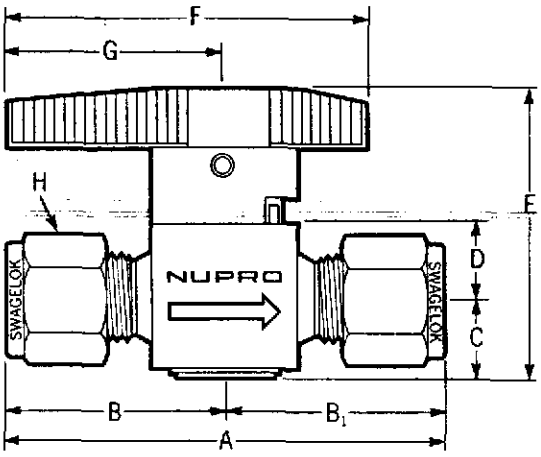
Title: **SPECIFICATION FOR DERIME VALVES FOR 80K PUMP SUPPLY LINE**

Supplier:	Cambridge Valve and Fitting Co.
Manufacturer:	Nupro
Description:	Stainless steel plug valve with swagelok ends
Part Number:	SS-6P6T
Size:	3/8 inch
Tag Nos:	HV100, HV108, HV150, HV158, HV200, HV208, HV250, HV258, HV300, HV308, HV350, HV358, HV400, HV408, HV500, HV508, HV600, HV608, HV650,HV658, HV700, HV708, HV800, HV808

SPECIFICATION		
Number A	V049-2-177	Rev. ϕ

TABLE OF DIMENSIONS





TECHNICAL DATA

Valve Series	Standard Material	Pressure Rating[2] at 70°F (21°C)	Temperature Rating
P4T	Brass & 316SS	3000 psig (206 bar)	-10° to 400°F (-23° to 204°C) with TFE coated Viton seals
P6T	Brass	2000 psig (137 bar)	
	316SS	3000 psig (206 bar)	

[2] If reverse flow occurs, differential pressure is limited to 150 psi (10 bar) max. In such cases, the valve should be actuated quickly to prevent O-Ring damage.

FLOW CAPACITY DATA

Basic Ordering Number	C_V	Pressure Drop To Atmosphere (△p) psi					
		Air std ft³/min. at 70°F (21°C)			Water U.S. gal/min. at 70°F (21°C)		
		10	50	100	10	50	100
-2P4T	0.2	2.26	6.00	10.64	0.63	1.41	2.00
-2P4T2	1.0	11.30	30.01	53.20	3.16	7.07	10.00
-2P4T4	1.0	11.30	30.01	53.20	3.16	7.07	10.00
-4P4T	1.4	15.82	42.01	74.48	4.43	9.90	14.00
-4P4T1	1.4	15.82	42.01	74.48	4.43	9.90	14.00
-4P4T2	0.9	10.17	27.01	47.88	2.85	6.36	9.00
-4P4T4	0.9	10.17	27.01	47.88	2.85	6.36	9.00
-4P4T4-RT	0.9	10.17	27.01	47.88	2.85	6.36	9.00
-4P4T5	0.9	10.17	27.01	47.88	2.85	6.36	9.00
-6P4T	1.1	12.43	33.01	58.52	3.48	7.78	11.00
-6P4T-MM	1.4	25.99	69.02	122.36	7.27	16.26	23.00
-4P6T4	3.6	40.68	108.03	191.51	11.38	25.46	36.00
-6P6T	7.0	79.09	210.06	372.39	22.14	49.50	70.00
-8P6T	4.0	45.20	120.03	212.79	12.65	28.28	40.00
-8P6T2	2.3	25.99	69.02	122.36	7.27	16.26	23.00
-8P6T4	2.3	25.99	69.02	122.36	7.27	16.26	23.00
-8P6T4-RT	2.3	25.99	69.02	122.36	7.27	16.26	23.00
-10P6T-MM	5.7	64.40	171.05	303.23	18.02	40.31	57.00
-12P6T-MM	4.3	48.59	129.03	228.75	13.60	30.41	43.00

Plug Valves			End Connections		Dimensions[4]									
Basic[3] Ordering Number	Plug Orifice		Inlet	Outlet	A	B	B_1	C	D	E	F	G	H Hex	W
	in.	mm												
-2P4T[5]	0.172	4.4	1/8 SWAGELOK		1.99	0.99	0.99	0.45	0.37	1.52	1.88	1.14	7/16	0.75
-2P4T2			1/8 Male NPT		1.53	0.76	0.76						–	
-2P4T4			1/8 Female NPT		1.78	0.89	0.89						–	
-4P4T			1/4 SWAGELOK		2.17	1.08	1.08						9/16	
-4P4T1			1/4 Male NPT	1/4 SWAGELOK	2.03	0.95	1.08						9/16	
-4P4T2			1/4 Male NPT		1.90	0.95	0.95						–	
-4P4T4			1/4 Female NPT		2.09	1.05	1.05						–	
-4P4T4-RT			1/4 Female ISO/BSP Tapered[6]		2.21	1.11	1.11						–	
-4P4T5			1/4 Male NPT	1/4 Female NPT	2.00	0.95	1.05						–	
-6P4T			3/8 SWAGELOK		2.29	1.14	1.14						11/16	
-6P4T-MM			6mm SWAGELOK		2.17	1.08	1.08						14mm	
-4P6T4	0.281	7.2	1/4 Female NPT		2.38	1.19	1.19	0.66	0.56	2.13	2.49	1.50	–	1.12
-6P6T			3/8 SWAGELOK		2.66	1.33	1.33						11/16	
-8P6T			1/2 SWAGELOK		2.88	1.44	1.44						7/8	
-8P6T2			1/2 Male NPT		2.64	1.32	1.32						–	
-8P6T4			1/2 Female NPT		2.88	1.44	1.44						–	
-8P6T4-RT			1/2 Female ISO/BSP Tapered[6]		3.14	1.57	1.57						–	
-10P6T-MM			10mm SWAGELOK		2.68	1.34	1.34						19mm	
-12P6T-MM			12mm SWAGELOK		2.96	1.48	1.48						22mm	

[3] For a complete Ordering Number, use **B** for brass, **SS** for 316 stainless steel, or **S** for carbon steel as a prefix to the Basic Ordering Number. Examples: **B**-4P4T2; **SS**-4P4T; **S**-8P6T4

[4] Dimensions shown with SWAGELOK nuts finger-tight, where applicable. *All dimensions are in inches (except where mm is indicated)* – for reference only, subject to change.

[5] Body orifice 0.093" (2.4mm).

[6] Reference Specifications: BS21 & ISO 7/1

REVISIONS						
FILM	REV.	CHANGE NOTICE	DESCRIPTION	DATE	BY	APPV.

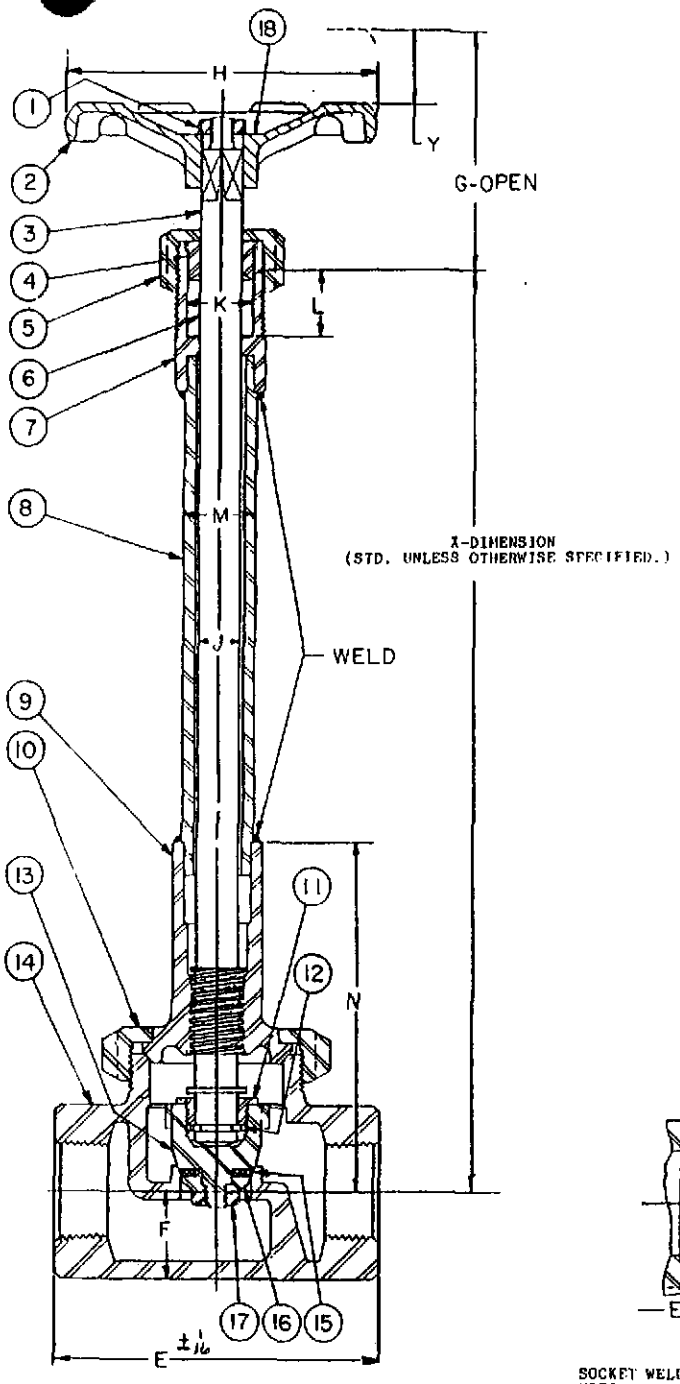
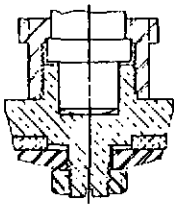


FIGURE NUMBER:
7K1861 (TE)
7K1861 (SWE)

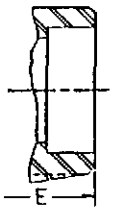
CLASS 200

PRESSURE
TEMPERATURE RATING
SEE DRAWING 061077

PRESSURE TESTS
SEE DRAWING 061081



SIZES 1 1/2" & 2"



SOCKET WELDING END (SWE)
NOTE: FOR DIMENSIONS
SEE DWG. NO. C-058358

	SIZE OF VALVE	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2
A									
B									
C									
D									
E	END TO END	2 7/16	2 7/16	2 7/16	3 3/8	3 3/8	5 1/2	5 1/2	6
F	CENTER TO BOTTOM	5/8	5/8	5/8	15/16	1 1/2	1 1/2	1 7/8	
G	PACKING SLEEVE TO TOP-OPEN	1 3/4	1 3/4	1 3/4	2 5/16	2 5/16	2 13/16	2 7/8	3 1/8
H	DIA OF HANDWHEEL	2 3/4	2 3/4	2 3/4	3 1/4	3 1/4	4 1/16	4 1/16	4 3/4
J	DIA OF STEM	11/32	11/32	11/32	27/64	27/64	9/16	9/16	27/32
K	DIA OF STUFFING BOX	9/16	9/16	9/16	11/16	11/16	1	1	1 1/8
L	DEPTH OF STUFFING BOX	1/2	1/2	1/2	11/16	11/16	7/8	7/8	1
M	DIA OF COLUMN	11/16	11/16	11/16	11/16	11/16	1 1/16	1 1/16	1 1/16
N	CENTER TO TOP OF BONNET	2 11/16	2 11/16	2 11/16	3 5/8	3 5/8	5 5/16	5 5/16	6 1/16
X	CENTER TO TOP OF STUFFING BOX	12	12	12	12	13	13	13	14
Y	LIFT	3/8	3/8	3/8	7/16	7/16	5/8	5/8	11/16

NO	DESCRIPTION	MATERIAL	SPECIFICATION
1	WHEEL NUT	STEEL	ASTM A-563 GRADE A OR B
2	HANDWHEEL	MALLEABLE IRON	ASTM A47 GRADE 32510
3	STEM	SI BR	ASTM B-371 C69400
4	PACKING GLAND	STAINLESS STEEL	ASTM A-276 TYPE 316
5	PACKING NUT	STAINLESS STEEL	ASTM A-276 TYPE 316
6	PACKING	TEFLON	COMM.
7	PACKING SLEEVE	STAINLESS STEEL	ASTM A-276 TYPE 316
8	EXTENSION COLUMN	STAINLESS STEEL	ASTM A-312 TYPE 304
9	BONNET **	STAINLESS STEEL	ASTM A-351 GRADE CF8M
10	BONNET RING	STAINLESS STEEL	ASTM A-351 GRADE CF8M
11	LOCKNUT	STAINLESS STEEL	ASTM A-276 TYPE 316
12	HORSE SHOE RING	STAINLESS STEEL	300 SERIES
13	DISC HOLDER	SI BR	ASTM B-371 C69400
14	BODY	STAINLESS STEEL	ASTM A-351 GRADE CF3M
15	DISC	KEL-F	COMM.
16	DISC PLATE	BRASS	ASTM B-16
17	DISC NUT	STAINLESS STEEL	ASTM A-276 TYPE 316
18	IDENT. PLATE	ALUMINUM	COMM.

** 1/4", 3/8", & 1/2" VA. SIZES --- ASTM A-276 TYPE 316

NOTE: ALL VALVES THOROUGHLY CLEANED, DEGREASED & PIPE ENDS SEALED TO PREVENT CONTAMINATION.

USED ON	
SUPERSEDES	67041
DRAWN BY / DATE	P.E.KEMEN 10-7-82
CHECKED BY / DATE	
APPROVED BY / DATE	3-31-83

THE WM. POWELL COMPANY
3503 Spring Grove Avenue, P.O. Box 14000, Cincinnati, Ohio 45214 U.S.A.

TITLE: NPS 1/4" to 2" GLOBE VA. INS DISC EXT. BONNET, TE, SWE

CODE IDENT. NO.	SIZE	DWG. NO.	REV.
48422	C	058332	A

SCALE	WEIGHT	SHEET	FILM

Attachment 1 V011-2-1611 Rev A Sht 1 of 1 51

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

TITLE: **INSTRUMENT LIST**

ENGINEERING CALCULATIONS

NO: V049-1-036

BY: D. PAREDES DEPT.: I/E

PROJECT: LIGO

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

DATE: 5-7-96
PREPARED BY: D. PARENTI
CHECKED BY: F. Bartha

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
006	LIC - 0100	WACS	WCP1 80K Cryopump Level Control Loop Output	AO				1							
006	LT - 0100	WACS	WCP1 80K Cryopump Level Transmitter	AI			1					069	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					069	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	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
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			
006	RV - 0132	WACS	WCP1 LN2 Dewar Pressure Control Relief Valve	-												
006	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	-								082			
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							082			
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	-											

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	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			

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
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			

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
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					069	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								

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
006	TIC - 0203	WAMS	WCP3 80K Cryopump Regen Loop Temperature Control	-												
006	TSH - 0203	WAMS	WCP3 80K Cryopump Regen Loop HI 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	-									088	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 HI Vacuum Pressure Indication	-										3 x 10-11	1 x 10-2	TORR
002	PT - 0210B	WAMS	WBSC6 Ion Gauge Transmitter	AI			1						004			
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				
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													

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
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	006			
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			

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
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						069	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						069	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						069	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										

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
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					091	-320	375*F	Deg F
006	TE - 0303A	WAMS	WCP5 80K Cryopump Regen Loop Thermocouple	T/C-T					1				056	32	2300	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						GNB Corp	112CM, Gate Valve, Electric, Tag WVG14	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
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			
016	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			
016	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			
016	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			

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
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				058	32	2300	Deg F
006	FE - 0354	WAMS	WCP6 80K Cryopump Regen Loop Pitot Tube Flow Element	-									078	0	12,000	SCFH
006	FI - 0354	WAMS	WCP6 80K Cryopump Regen Loop Flow Indicator	-									068	0	12,000	SCFH
006	LT - 0355	WAMS	WCP6 LN2 Dewar Level Transmitter	AI			1						069	0	100	% Level
006	PI - 0355	WAMS	WCP6 LN2 Dewar Pressure Indicator	-												
006	LI - 0356A	WAMS	WCP6 LN2 Dewar Level Indicator	-												
006	LI - 0356B	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	-												

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
006	RV - 0390	WACS	WCP8LN2 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	-									068	0	12,000	SCFH
006	LT - 0405	WAES	WCP7 LN2 Dewar Level Transmitter	AI			1						069	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													

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
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					069	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	-											

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
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				058	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			

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. D. #	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	WCP6 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	WCP6 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						089	0	100	% Level
006	LV - 0600	LACS	LCP1 80K Cryopump Level Control Valve	-									082			
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

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
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				058	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	-									068	0	12,000	SCFH
006	LT - 0605	LACS	LCP1 LN2 Dewar Level Transmitter	AI			1						069	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			

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
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			

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
006	LIC - 0650	LACS	LCP2 80K Cryopump Level Control Loop Output	AO				1								
006	LT - 0650	LACS	LCP2 80K Cryopump Level Transmitter	AI			1						069	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						060	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				058	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	-									066	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 - 0656	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	[illegible]	LACS	LIP2-2 2500 L/S Ion Pump Voltage Indication										004			

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
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							Varian Vacu Products	10" SST Gate Valve	555029	006			

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
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						069	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						060	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	-												

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
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	006			
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			

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
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 60K Cryopump Discharge Relief Valve	-												
006	LIC - 0800	LAES	LCP4 60K Cryopump Level Control Loop Output	AO				1								
006	LT - 0800	LAES	LCP4 60K Cryopump Level Transmitter	AI			1						069	0	100	% Level
006	LV - 0800	LAES	LCP4 60K Cryopump Level Control Valve	-									062			
006	LY - 0800	LACS	LCP4 60K Cryopump Level Control Loop Output	AO				1								
006	XV - 0800	LAES	LCP4 60K Cryopump Level Control Valve Solenoid	DO		1										
006	ZSC - 0800	LAES	LCP4 60K Cryopump Level Control Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag LVG11	554617	005			
006	PI - 0801	LAES	LCP4 60K Cryopump Discharge Pressure Indication	-												
006	PT - 0801	LAES	LCP4 60K Cryopump Discharge Pressure Transmitter	AI									090	0	25	PSIG
006	TE - 0802	LAES	LCP4 60K Cryopump Discharge Temperature	T/C												

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
006	TI - 0602	LAES	LCP4 80K Cryopump Discharge Temperature Indication	-												
006	JC - 0603	LACS	LCP4 80K Cryopump Regen SCR Controller	AI			1									
006	TIC - 0603	LAES	LCP4 80K Cryopump Regen Loop Temperature Control	-												
006	TSH - 0603	LAES	LCP4 80K Cryopump Regen Loop HI Temperature	-												
006	TY - 0603	LAES	LCP4 80K Cryopump Regen Loop Temperature Control Loop Output	AO				1								
006	TE - 0603A	LAES	LCP4 80K Cryopump Regen Loop Thermocouple	T/C-T					1				091	-320	700	Deg F
006	TE - 0603B	LAES	LCP4 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	TE - 0603C	LAES	LCP4 80K Cryopump Regen Loop Thermocouple	T/C-K					1				056	32	2300	Deg F
006	FE - 0604	LAES	LCP4 80K Cryopump Regen Loop Pitot Tube Flow Element	-									079	0	12,000	SCFH
006	FI - 0604	LAES	LCP4 80K Cryopump Regen Loop Flow Indicator	-									088	0	12,000	SCFH
006	LT - 0605	LAES	LCP4 LN2 Dewar Level Transmitter	AI			1						089	0	100	% Level
006	PI - 0605	LAES	LCP4 LN2 Dewar Pressure Indicator	-												
006	LI - 0605A	LAES	LCP4 LN2 Dewar Level Indicator	-												
006	LI - 0605B	LAES	LCP4 LN2 Dewar Level Indication	-												
006	RD - 0606	LAES	LCP4 LN2 Dewar Rupture Disc	-												
006	RV - 0606	LAES	LCP4 LN2 Dewar Relief Valve	-												
006	RD - 0607	LAES	LCP4 LN2 Dewar Rupture Disc	-												
006	RV - 0607	LAES	LCP4 LN2 Dewar Relief Valve	-												
006	RV - 0608	LAES	LCP4 LN2 Dewar Relief Valve	-												
025	EV - 0609	LAES	LCP4 80K Cryopump Outlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag LVG11	554617	005			
025	HS - 0609	LAES	LCP4 80K Cryopump Outlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0609	LAES	LGV11 25 L/S Ion Pump Current Indication	AI			1						004			
025	SC - 0609	LAES	LCP4 80K Cryopump Outlet Isolation Valve Controller	-												
025	XA - 0609	LAES	LCP4 80K Cryopump Outlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0609	LAES	LGV11 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
025	ZSC - 0609	LAES	LCP4 80K Cryopump Outlet Isolation Valve Closed	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag LVG12	554617	005			
025	ZSO - 0609	LAES	LCP4 80K Cryopump Outlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag LVG11	554617	005			
002	PC - 0610	LAES	LBSC4 Pressure Control Valve Controller	-									061			
002	PCV - 0610	LAES	LBSC4 Pressure Control Valve	-									061			
002	PY - 0610	LAES	LBSC4 Pressure Control Loop Output	AO				1								
002	PE - 0610A	LAES	LBSC4 Pirani Gauge Tube	-									007			
002	PI - 0610A	LAES	LBSC4 Lo Vacuum Pressure Indication	-												
002	PT - 0610A	LAES	LBSC4 Pirani Gauge Transmitter	AI			1							1 x 10-3	1000	TORR
002	PE - 0610B	LAES	LBSC4 Ion Gauge Tube	-									007			
002	PI - 0610B	LAES	LBSC4 HI Vacuum Pressure Indication	-												
002	PT - 0610B	LAES	LBSC4 Ion Gauge Transmitter	AI			1							3 x 10-11	1 x 10-2	TORR
002	II - 0611	LAES	LBSC4 75 L/S Ion Pump Current Indication	AI			1						004			
002	XIC - 0611	LAES	LBSC4 75 L/S Ion Pump Controller	-						Varian Vacu Products	75 L/S Noble Diode Ion Pump Controller	554936	004			
025	EV - 0619	LAES	LCP4 80K Cryopump Inlet Isolation Valve	-						GNB Corp	112CM, Gate Valve, Electric, Tag LVG12	554617	005			
025	HS - 0619	LAES	LCP4 80K Cryopump Inlet Isolation Valve Open/Close Switch	DO		1							005			
005	II - 0619	LAES	LGV12 25 L/S Ion Pump Current Indication	AI			1						004			
025	SC - 0619	LAES	LCP4 80K Cryopump Inlet Isolation Valve Controller	-												
025	XA - 0619	LAES	LCP4 80K Cryopump Inlet Isolation Valve Common Alarm	DI	1											
005	XIC - 0619	LAES	LGV12 25 L/S Ion Pump Controller	-						Varian Vacu Products	25 L/S Noble Diode Ion Pump Controller	554936	004			
025	ZSC - 0619	LAES	LCP4 80K Cryopump Inlet Isolation Valve Closed	DI	1								005			
025	ZSO - 0619	LAES	LCP4 80K Cryopump Inlet Isolation Valve Open	DI	1					GNB Corp	112CM, Gate Valve, Electric, Tag LVG12	554617	005			
025	HV - 0620	LAES	LCP4 80K Cryopump 10" Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
025	ZSC - 0620	LAES	LCP4 80K Cryopump Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
025	ZSO - 0620	LAES	LCP4 80K Cryopump Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
025	HV - 0621	LAES	Right End Beam Tube 10" Pumpout Port Valve	-						Varian Vacu Products	10" SST Gate Valve	555029	006			
025	ZSC - 0621	LAES	Right End Beam Tube Pumpout Port Valve Closed	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			
025	ZSO - 0621	LAES	Right End Beam Tube Pumpout Port Valve Open	DI	1					Varian Vacu Products	10" SST Gate Valve	555029	006			

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
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									
025	XA - 0822A	LAES	LIP6-1 2500 L/S Ion Pump Fault Alarm	DI	1								004			
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									
025	XA - 0822B	LAES	LIP6-2 2500 L/S Ion Pump Fault Alarm	DI	1								004			
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							007			
025	PE - 0823A	LAES	Right End Beam Tube Pirani Gauge Tube	-												
025	PI - 0823A	LAES	Right End Beam Tube Lo Vacuum Pressure Indication	-										1 x 10-3	1000	TORR
025	PT - 0823A	LAES	Right End Beam Tube Pirani Gauge Transmitter	AI			1						007			
025	PE - 0823B	LAES	Right End Beam Tube Ion Gauge Tube	-												
025	PI - 0823B	LAES	Right End Beam Tube Hi Vacuum Pressure Indication	-										3 x 10-11	1 x 10-2	TORR
025	PT - 0823B	LAES	Right End Beam Tube Ion Gauge Transmitter	AI			1						007			
025	PE - 0824A	LAES	CLP4 Pirani Gauge Tube	-												
025	PI - 0824A	LAES	CLP4 Lo Vacuum Pressure Indication	-										1 x 10-3	1000	TORR
025	PT - 0824A	LAES	CLP4 Pirani Gauge Transmitter	AI			1						007			
025	PE - 0824B	LAES	CLP4 Ion Gauge Tube	-												
025	PI - 0824B	LAES	CLP4 Hi Vacuum Pressure Indication	-										3 x 10-11	1 x 10-2	TORR
025	PT - 0824B	LAES	CLP4 Ion Gauge Transmitter	AI			1									
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	554817	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	554817	005			
021	ZSO - 0850	LAMJ	Right Mid Joint Isolation Valve Open	DI	1					GNB Corp	122CM, Gate Valve, Electric, Tag LVG8	554817	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	-												

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
006	PCV - 0673	LAES	LCP4 LN2 Dewar Pressure Control Valve	-												
006	RV - 0682	LAES	LCP4 LN2 Dewar Pressure Control Relief Valve	-												
006	RV - 0683	LAES	LCP4 80K Cryopump Discharge Relief Valve	-												

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	D.M.W	Issued for Purchase DEO #051

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number A V049-2-049	Rev. Ø
	APS 1/26/96	D.M.W 1-26		

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)

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
2	[illegible] 10/2/96	D. McW	Issue for Purchase DEO # 0287
1	PPS 3/12/96	D. McW	Issued for Purchase DEO # 0090
0	PPS 1/26/96	D. McW	Issued for Purchase DEO # 051

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

INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number A V049-2-050	Rev. 2
	PPS	1/26/96	D. McW	1-26-96		

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) (7) 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	

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
1	PPS 10/24/96	KEB 10/23/96	Issued for Purchase DEO # 0823
0	PPS 1/26/96	D. McIlwain	ISSUED FOR PURCHASE DEO #0051

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number A V049-2-051	Rev. 1
	PPS 1/26/96	D. McIlwain 1-26-96		

Allen-Bradley PLC Interface Modules As Follows :

1. 1771-DMC
   Control Co-Processor Main Module with 256 KBYTE

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: _____

PROJECT MANAGER: _____

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
0	PPS 2/21/96	DMW 2-21-96	Issued for Purchase DEO # 66

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number V049-2-057	Rev. 0
	PPS 2/21/96	DMW 2-21-96		

PC - Allen Bradley PLC Interface Module as Follows:

1. 1784 - KTX

   DH+, DH-485, REM I/O Interface Module

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
1	PPS 10/25/96	REB 10/23/96	Issued for Purchase UPO# 0063
0			Issued for Purchase DEO# 0069

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number V049-2-058	Rev. 1
	PPS	2/22/96	REB	2/22/96		

PC - Interface Software running on Windows NT/95 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 for Windows 95/NT (only 1 required for entire project)

C. Cyberlogic Windows 95 driver

Title: **SPECIFICATION FOR FLOW METER**

SPECIFICATION

FOR

FLOW METER

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY Thomas Murphy

ELECTRICAL F. Bach

QUALITY ASSURANCE [signature]

TECHNICAL DIRECTOR [signature]

PROJECT MANAGER [signature]

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	DP 9-6-96	F. Bach 9-6-96	RELEASED FOR PURCHASE PER DEO # 258
0	TM 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 V049-2-079	Rev 1

V0492079.DOC

TABLE OF CONTENTS

1.0 SCOPE

2.0 CODES AND STANDARDS

3.0 GENERAL REQUIREMENTS

4.0 MARKING

5.0 RESPONSIBILITY

6.0 REQUIRED DOCUMENTATION

7.0 INSPECTION

8.0 PREPARATION FOR SHIPMENT

ATTACHMENTS

A) LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

B) DATA SHEET

C) SPECIFICATION FOR EQUIPMENT PURCHASE COMMERCIAL REQUIREMENTS: SPEC.# V049-2-034

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: FLOW METER	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:
OPERATION & MAINTENANCE MANUALS				5			

PROCESS SYSTEMS INTERNATIONAL.

ATTACHMENT "B".

ROTAMETERS (VARIABLE AREA FLOWMETERS)

NO	BY	DATE	REVISION
	FB	9-6-96	1

SHEET 1 OF 3

SPEC. NO. V049-2-079 REV. 1

CONTRACT DATE 9-6-96

REQ. · P.O.

BY FB CHK'D PAB APPR.

GENERAL	1	Tag Number			FI-104			FI-154			FI-204			FI-254	
	2	Service			NITROGEN GAS			NITROGEN GAS			NITROGEN GAS			NITROGEN GAS	
	3	Line No./Vessel No.			1127			1130			242			245	
	4	Function													
	5	Mounting			1.5" NPT HORIZONTAL			1.5" NPT HORIZONTAL			1.5" NPT HORIZONTAL			1.5" NPT HORIZONTAL	
	6	Power Supply													
	7	Conn. Size	Type												
	8	Inlet Dir.	Outlet Dir.		LEFT	RIGHT		LEFT	RIGHT		LEFT	RIGHT		LEFT	RIGHT
	9	Fitting Material													
	10	Packing or O-Ring Mtl.			ETHYLENE PROPYL			ETHYLENE PROPYL			ETHYLENE PROPYL			ETHYLENE PROPYL	
	11	Enclosure Type													
METER	12	Size	Float Guide												
	13	Tube Mtl.	Float Mtl.												
	14	Meter Scale: Length & Type													
	15	Meter Scale Range			0-12000 SCFH			0-12000 SCFH			0-12000 SCFH			0-12000 SCFH	
	16	Meter Factor													
	17	Rated Accuracy			± 3% FS			±3% FS			± 3% FS			± 3% FS	
	18	Hydraulic Calib. Required													
FLUID DATA	19	Fluid													
	20	Color or Transparency													
	21	Maximum Flow Rate			12000 SCFH			12000 SCFH			12000 SCFH			12000 SCFH	
	22	Norm Flow	Min Flow			2650 SCFH			2650 SCFH			2650 SCFH			2650 SCFH
	23	Oper. Specific Gravity (Liq)													
	24	Max Oper. Viscosity													
	25	Oper. Press.	Oper. Temp.		10 PSIG	-15 to 96°F		10 PSIG	-15 to 96°F		10 PSIG	-15 to 96°F		10 PSIG	-15 to 96°F
	26	Oper. Density (Gases)													
	27	Std. Density	Mol. Wgt.												
	28	Max. Allowable Press. Drop			2.0 PSIG			2.0 PSIG			2.0 PSIG			2.0 PSIG	
	29	DESIGN PRESSURE			10 PSIG			10 PSIG			10 PSIG			10 PSIG	
EXT	30	Extension Well Mtl.													
	31	Gasket Mtl.													
XMTR	32	Transmitter Output													
	33	Trans. Enclosure Class													
	34	Scale Range													
ALARM	35	No. of Contacts	Form												
	36	Rating	Housing												
	37	Action													
	38														
OPTIONS	39	Valve Size & Material													
	40	Valve Location													
	41	Const. Diff. Relay Mtl.													
	42	Purge Meter Tubing													
	43	Airset													
	43a														
	44	Manufacturer			ERDCO			ERDCO			ERDCO			ERDCO	
	45	Model Number			3211-06-T1			3211-06-T1			3211-06-T1			3211-06-T1	
	46	Tube Number													
	47	Float Number													

Notes:

ROTAMETERS
(VARIABLE AREA FLOWMETERS)

NO	BY	DATE	REVISION

SHEET 2 OF 3

SPEC. NO.	REV.
CONTRACT	DATE
REQ. · P.O.	
BY / CHK'D / APPR.	

GENERAL	1	Tag Number			FI-304		FI-354		FI-404		FI-504	
	2	Service			N_2 GAS		N_2 GAS		N_2 GAS		N_2 GAS.	
	3	Line No./Vessel No.			342		345		452		552	
	4	Function										
	5	Mounting			1.5" NPT HORIZONTAL		1.5" NPT HORIZONTAL		1.5" NPT HORIZONTAL		1.5" NPT HORIZONTAL	
	6	Power Supply										
	7	Conn. Size	Type									
	8	Inlet Dir.	Outlet Dir.	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
	9	Fitting Material										
	10	Packing or O-Ring Mtl.		ETHYLENE PROPYL		ETHYLENE PROPYL		ETHYLENE PROPYL		ETHYLENE PROPYL	
	11	Enclosure Type										
METER	12	Size	Float Guide									
	13	Tube Mtl.	Float Mtl.									
	14	Meter Scale: Length & Type										
	15	Meter Scale Range		0-12000 SCFH		0-12000 SCFH		0-12000 SCFH		0-12000 SCFH	
	16	Meter Factor										
	17	Rated Accuracy		±3% FS		±3% FS		±3% FS		±3% FS.	
	18	Hydraulic Calib. Required										
FLUID DATA	19	Fluid										
	20	Color or Transparency										
	21	Maximum Flow Rate		12000 SCFH		12000 SCFH		12000 SCFH		12000 SCFH	
	22	Norm Flow	Min Flow		2650 SCFH		2650 SCFH		2650 SCFH		2650 SCF
	23	Oper. Specific Gravity (Liq)										
	24	Max Oper. Viscosity										
	25	Oper. Press.	Oper. Temp.	10 PSIG	-156 96°F	10 PSIG	-156 96°F	10 PSIG	-156 96°F	10 PSIG	-156 96
	26	Oper. Density (Gases)										
	27	Std. Density	Mol. Wgt.									
	28	Max. Allowable Press. Drop		2.0 PSIG		2.0 PSIG		2.0 PSIG		2.0 PSIG	
	29	DESIGN PRESSURE		10 PSIG		10 PSIG		10 PSIG		10 PSIG	
EXT	30	Extension Well Mtl.										
	31	Gasket Mtl.										
XMTR	32	Transmitter Output										
	33	Trans. Enclosure Class										
	34	Scale Range										
ALARM	35	No. of Contacts	Form									
	36	Rating	Housing									
	37	Action										
	38											
OPTIONS	39	Valve Size & Material										
	40	Valve Location										
	41	Const. Diff. Relay Mtl.										
	42	Purge Meter Tubing										
	43	Airset										
	43a											
	44	Manufacturer		ERDCO		ERDCO		ERDCO		ERDCO.	
	45	Model Number		3211-06-T1		3211-06-T1		3211-06-T1		3211-06-T1	
	46	Tube Number										
	47	Float Number										

Notes:

ROTAMETERS (VARIABLE AREA FLOWMETERS)

NO	BY	DATE	REVISION

SHEET 3 OF 3

SPEC. NO. | REV.

CONTRACT | DATE

REQ. - P.O.

BY | CHK'D | APPR.

GENERAL	1	Tag Number	FI-604				FI-654				FI-704				FI-804	
	2	Service	N2 GAS				N2 GAS				N2 GAS				N2 GAS	
	3	Line No./Vessel No.	692				695				733				833.	
	4	Function														
	5	Mounting	1.5" NPT HORIZONTAL				1.5" NPT HORIZONTAL				1.5" NPT HORIZONTAL				1.5" NPT HORIZONTAL	
	6	Power Supply														
	7	Conn. Size		Type												
	8	Inlet Dir.	LEFT	Outlet Dir.	RIGHT		LEFT		RIGHT		LEFT		RIGHT		LEFT	RIGHT
	9	Fitting Material														
	10	Packing or O-Ring Mtl.	ETHYLENE PROPYL				ETHYLENE PROPYL				ETHYLENE PROPYL				ETHYLENE PROPYL	
	11	Enclosure Type														
METER	12	Size		Float Guide												
	13	Tube Mtl.		Float Mtl.												
	14	Meter Scale: Length & Type														
	15	Meter Scale Range	0-12000 SCFH				0-12000 SCFH				0-12000 SCFH				0-12000 SCFH	
	16	Meter Factor														
	17	Rated Accuracy	±3% FS				±3% FS				±3% FS				±3% FS.	
	18	Hydraulic Calib. Required														
FLUID DATA	19	Fluid														
	20	Color or Transparency														
	21	Maximum Flow Rate	12000 SCFH				12000 SCFH				12000 SCFH				12000 SCFH	
	22	Norm Flow		Min Flow	5300 SCFH				5300 SCFH				5300 SCFH			5300 SCFH
	23	Oper. Specific Gravity (Liq)														
	24	Max Oper. Viscosity														
	25	Oper. Press.	10 PSIG	Oper. Temp.	-156%°F		10 PSIG		-156%°F		10 PSIG		-156%°F		10 PSIG	-156%°F
	26	Oper. Density (Gases)														
	27	Std. Density		Mol. Wgt.												
	28	Max. Allowable Press. Drop	2.0 PSIG				2.0 PSIG				2.0 PSIG				2.0 PSIG	
	29	DESIGN PRESSURE	10 PSIG				10 PSIG				10 PSIG				10 PSIG	
EXT	30	Extension Well Mtl.														
	31	Gasket Mtl.														
XMTR	32	Transmitter Output														
	33	Trans. Enclosure Class														
	34	Scale Range														
ALARM	35	No. of Contacts		Form												
	36	Rating		Housing												
	37	Action														
	38															
OPTIONS	39	Valve Size & Material														
	40	Valve Location														
	41	Const. Diff. Relay Mtl.														
	42	Purge Meter Tubing														
	43	Airset														
	43a															
	44	Manufacturer	ERDCO				ERDCO				ERDCO				ERDCO.	
	45	Model Number	3211-06-T1				3211-06-T1				3211-06-T1				3211-06-T1	
	46	Tube Number														
	47	Float Number														

Notes:

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 Alan R Brodbook

TECHNICAL DIRECTOR D. C. McWilliams

PROJECT MANAGER Richard Bagley

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	T.M. 5-2-96	F. Bark 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. Bark DATE 5-2-96	Number A V049-2-088	Rev 0

V0492088.DOC

TABLE OF CONTENTS

1.0 SCOPE

2.0 CODES AND STANDARDS

3.0 GENERAL REQUIREMENTS

4.0 MARKING

5.0 RESPONSIBILITY

6.0 REQUIRED DOCUMENTATION

7.0 INSPECTION

8.0 PREPARATION FOR SHIPMENT

ATTACHMENTS

A) LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

B) DATA SHEET

C) SPECIFICATION FOR EQUIPMENT PURCHASE COMMERCIAL REQUIREMENTS: SPEC.# V049-2-034

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 purch 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 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:
OPERATION & MAINTENANCE MANUALS				5			

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

DIFFERENTIAL PRESSURE GAUGES **V049-2-088, Rev**

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	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	Buna-N	Buna-N	Buna-N	Buna-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
ACCURACY, FULL SCALE	5%	5%	5%	5%
QUANTITY	1	1	1	1
MANUFACTURER				
MODEL				

	BY	DATE	NOTES
INSTRUMENT ENGINEER	TM	8/12/96	
ENGINEERING APPROVAL	[illegible]	8/13/96	
PROJECT APPROVAL	F. Barish	8-13-96	

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET — **LIGO**

DIFFERENTIAL PRESSURE GAUGES — **V049-2-088, Rev**

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	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		Buna-N	Buna-N	Buna-N	Buna-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
ACCURACY, FULL SCALE		5%	5%	5%	5%
QUANTITY		1	1	1	1
MANUFACTURER					
MODEL					

	BY	DATE	NOTES
INSTRUMENT ENGINEER	TA	8/13/96	
ENGINEERING APPROVAL	[illegible]	[illegible]	
PROJECT APPROVAL	F. Barb	9-13-96	

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

DIFFERENTIAL PRESSURE GAUGES **V049-2-088, Rev 1**

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	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	Buna-N	Buna-N	Buna-N	Buna-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
ACCURACY, FULL SCALE	5%	5%	5%	5%
QUANTITY	1	1	1	1
MANUFACTURER				
MODEL				

	BY	DATE	NOTES
INSTRUMENT ENGINEER	TM	8-13-96	
ENGINEERING APPROVAL	TM	8/13/96	
PROJECT APPROVAL	F. Raab	8-13-96	

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. McClellan

PROJECT MANAGER Richard Bagley

REV LTR	BY—DATE	APP.—DATE	DESCRIPTION OF ACTION
3	TM 10-2-96	F Bark 10-2-96	Released For Purchase Per DEO# 284
2	DP 9-6-96	F Bark 9-6-96	RELEASED FOR PURCHASE PER DEO# 0259
1	DP 7-26-96	F Bark 8-7-96	RELEASED FOR QUOTE PER DEO# 0233
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	DATE	APPROVED BY	DATE	Number / Rev
	T. Murphy	5-2-96	F. Bark	5-2-96	A V049-2-089 / 3

TABLE OF CONTENTS

1.0 SCOPE

2.0 CODES AND STANDARDS

3.0 GENERAL REQUIREMENTS

4.0 MARKING

5.0 RESPONSIBILITY

6.0 REQUIRED DOCUMENTATION

7.0 INSPECTION

8.0 PREPARATION FOR SHIPMENT

ATTACHMENTS

A) LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

B) DATA SHEET

C) SPECIFICATION FOR EQUIPMENT PURCHASE COMMERCIAL REQUIREMENTS: SPEC.# V049-2-034

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 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:	SPECNO.: 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:
OPERATION & MAINTENANCE MANUALS				5			

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

LEVEL TRANSMITTER (DIFFERENTIAL PRESSURE TYPE) **V049-2-089, Rev 3**

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 150	0 to 150	0 to 150	0 to 150
CALIBRATED RANGE IN H_2O	41	41	41	41
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	% level	% level	% level	% level
ENCLOSURE NEMA RATING REQD.	4	4	4	4
3 MATERIAL: FLANGES / CAPSULE	CS / SST	CS / SST	CS / SST	CS / SST
MATERIAL: NUTS & BOLTS	SST	SST	SST	SST
PRESSURE RATING PSIG	50	50	50	50
MAXIMUM D.P. RATING IN H_2O	50	50	50	50
CAPSULE FILL	Silicone	Silicone	Silicone	Silicone
PROCESS CONNECTIONS	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
MINIMUM ACCURACY REQD.	0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
3 MOUNTING BRACKET REQD.	YES	YES	YES	YES
CONDUIT CONNECTION SIZE	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
QUANTITY	1	1	1	1
MANUFACTURER	Rosemount	Rosemount	Rosemount	Rosemount
2 MODEL	1151DP 4 E 52 B4 Q4	1151DP 4 E 52 B4 Q4	1151DP 4 E 52 B4 Q4	1151DP 4 E 52 B4 Q4

	BY	DATE	NOTES
INSTRUMENT ENGINEER			
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET — **LIGO**

LEVEL TRANSMITTER (DIFFERENTIAL PRESSURE TYPE) — **V049-2-089, Rev 3**

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 150	0 to 150	0 to 150	0 to 150
CALIBRATED RANGE	IN H_2O	41	41	41	41
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		% level	% level	% level	% level
ENCLOSURE NEMA RATING REQD.		4	4	4	4
MATERIAL: FLANGES / CAPSULE		CS / SST	CS / SST	CS / SST	CS / SST
MATERIAL: NUTS & BOLTS		SST	SST	SST	SST
PRESSURE RATING	PSIG	50	50	50	50
MAXIMUM D.P. RATING	IN H_2O	50	50	50	50
CAPSULE FILL		Silicone	Silicone	Silicone	Silicone
PROCESS CONNECTIONS		1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
MINIMUM ACCURACY REQD.		0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.		NO	NO	NO	NO
MOUNTING BRACKET REQD.		YES	YES	YES	YES
CONDUIT CONNECTION SIZE		1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
QUANTITY		1	1	1	1
MANUFACTURER		Rosemount	Rosemount	Rosemount	Rosemount
MODEL		1151DP 4 E 52 B4 Q4	1151DP 4 E 52 B4 Q4	1151DP 4 E 52 B4 Q4	1151DP 4 E 52 B4 Q4

	BY	DATE	NOTES
INSTRUMENT ENGINEER			
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET — ***LIGO***

LEVEL TRANSMITTER (DIFFERENTIAL PRESSURE TYPE) — **V049-2-089, Rev 3**

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 150	0 to 150	0 to 150	0 to 150
CALIBRATED RANGE IN H_2O	41	41	41	41
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	% level	% level	% level	% level
ENCLOSURE NEMA RATING REQD.	4	4	4	4
3 MATERIAL: FLANGES / CAPSULE	CS / SST	CS / SST	CS / SST	CS / SST
MATERIAL: NUTS & BOLTS	SST	SST	SST	SST
PRESSURE RATING PSIG	50	50	50	50
MAXIMUM D.P. RATING IN H_2O	50	50	50	50
CAPSULE FILL	Silicone	Silicone	Silicone	Silicone
PROCESS CONNECTIONS	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
MINIMUM ACCURACY REQD.	0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
3 MOUNTING BRACKET REQD.	YES	YES	YES	YES
CONDUIT CONNECTION SIZE	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
QUANTITY	1	1	1	1
MANUFACTURER	Rosemount	Rosemount	Rosemount	Rosemount
3 MODEL	1151DP 4 E 52 B4 Q4	1151DP 4 E 52 B4 Q4	1151DP 4 E 52 B4 Q4	1151DP 4 E 52 B4 Q4

	BY	DATE	NOTES
INSTRUMENT ENGINEER			
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

LEVEL TRANSMITTER (DIFFERENTIAL PRESSURE TYPE) **V049-2-089, Rev 3**

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 1000	0 to 1000	0 to 1000	0 to 1000
CALIBRATED RANGE	IN H_2O	0 to 453	0 to 453	0 to 379	0 to 379
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		% level	% level	% level	% level
ENCLOSURE NEMA RATING REQD.		4	4	4	4
MATERIAL: FLANGES / CAPSULE		CS / SST	CS / SST	CS / SST	CS / SST
MATERIAL: NUTS & BOLTS		SST	SST	SST	SST
PRESSURE RATING	PSIG	50	50	50	50
MAXIMUM D.P. RATING	IN H_2O	500	500	400	400
CAPSULE FILL		Silicone	Silicone	Silicone	Silicone
PROCESS CONNECTIONS		1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
MINIMUM ACCURACY REQD.		0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.		NO	NO	NO	NO
MOUNTING BRACKET REQD.		YES	YES	YES	YES
CONDUIT CONNECTION SIZE		1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
QUANTITY		1	1	1	1
MANUFACTURER		Rosemount	Rosemount	Rosemount	Rosemount
MODEL		2024D 3 A 12A 2 S 1 B4 Q4	2024D 3 A 12A 2 S 1 B4 Q4	2024D 3 A 12A 2 S 1 B4 Q4	2024D 3 A 12A 2 S 1 B4 Q4

	BY	DATE	NOTES
INSTRUMENT ENGINEER			
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET **LIGO**

LEVEL TRANSMITTER (DIFFERENTIAL PRESSURE TYPE) **V049-2-089, Rev 3**

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 1000	0 to 1000	0 to 1000	0 to 1000
CALIBRATED RANGE IN H_2O	0 to 379	0 to 379	0 to 379	0 to 379
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	% level	% level	% level	% level
ENCLOSURE NEMA RATING REQD.	4	4	4	4
MATERIAL: FLANGES / CAPSULE	CS / SST	CS / SST	CS / SST	CS / SST
MATERIAL: NUTS & BOLTS	SST	SST	SST	SST
PRESSURE RATING PSIG	50	50	50	50
MAXIMUM D.P. RATING IN H_2O	400	400	400	400
CAPSULE FILL	Silicone	Silicone	Silicone	Silicone
PROCESS CONNECTIONS	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
MINIMUM ACCURACY REQD.	0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
MOUNTING BRACKET REQD.	YES	YES	YES	YES
CONDUIT CONNECTION SIZE	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
QUANTITY	1	1	1	1
MANUFACTURER	Rosemount	Rosemount	Rosemount	Rosemount
MODEL	2024D 3 A 12A 2 S 1 B4 Q4	2024D 3 A 12A 2 S 1 B4 Q4	2024D 3 A 12A 2 S 1 B4 Q4	2024D 3 A 12A 2 S 1 B4 Q4

	BY	DATE	NOTES
INSTRUMENT ENGINEER			
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET — **LIGO**

LEVEL TRANSMITTER (DIFFERENTIAL PRESSURE TYPE) — **V049-2-089, Rev 3**

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 1000	0 to 1000	0 to 1000	0 to 1000
CALIBRATED RANGE	IN H_2O	0 to 453	0 to 453	0 to 379	0 to 379
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		% level	% level	% level	% level
ENCLOSURE NEMA RATING REQD.		4	4	4	4
MATERIAL: FLANGES / CAPSULE		CS | SST	CS | SST	CS | SST	CS | SST
MATERIAL: NUTS & BOLTS		SST	SST	SST	SST
PRESSURE RATING	PSIG	50	50	50	50
MAXIMUM D.P. RATING	IN H_2O	500	500	400	400
CAPSULE FILL		Silicone	Silicone	Silicone	Silicone
PROCESS CONNECTIONS		1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
MINIMUM ACCURACY REQD.		0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.		NO	NO	NO	NO
MOUNTING BRACKET REQD.		YES	YES	YES	YES
CONDUIT CONNECTION SIZE		1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
QUANTITY		1	1	1	1
MANUFACTURER		Rosemount	Rosemount	Rosemount	Rosemount
MODEL		2024D 3 A 12A 2 S 1 B4 Q4	2024D 3 A 12A 2 S 1 B4 Q4	2024D 3 A 12A 2 S 1 B4 Q4	2024D 3 A 12A 2 S 1 B4

	BY	DATE	NOTES
INSTRUMENT ENGINEER			
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

SPECIFICATION

FOR

PRESSURE TRANSMITTERS

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY Thomas Murphy

ELECTRICAL F. Bark

QUALITY ASSURANCE [signature]

TECHNICAL DIRECTOR D. A. McWilliams

PROJECT MANAGER [signature]

4	TM 11-2-96	F. Bark [illegible]	Release For Purchase Per DEO# 284
3	DP 9/6/96	F. Bark 9-6-96	RELEASE FOR PURCHASE PER DEO# 0259
2	DP 7/29/96	F. Bark 8-7-96	RELEASE FOR QUOTE PER DEO# 0233
1	TM 5/7/96	F. Bark 5-7-96	Revised Per DEO #0179
0	TM. 5-2-96	F. Bark 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	DATE	APPROVED BY	DATE	Number	Rev
	T. Murphy	5-2-96	F. Bark	5-2-96	A V049-2-090	4

TABLE OF CONTENTS

1.0 SCOPE

2.0 CODES AND STANDARDS

3.0 GENERAL REQUIREMENTS

4.0 MARKING

5.0 RESPONSIBILITY

6.0 REQUIRED DOCUMENTATION

7.0 INSPECTION

8.0 PREPARATION FOR SHIPMENT

ATTACHMENTS

A) LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

B) DATA SHEET

C) SPECIFICATION FOR EQUIPMENT PURCHASE COMMERCIAL REQUIREMENTS: SPEC.# V049-2-034

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 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:	SPECNO.: V049-2-090

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:
OPERATION & MAINTENANCE MANUALS				5			

ATTACHMENT B

INSTRUMENT DATA SHEET
PRESSURE TRANSMITTERS

LIGO
V049-2-090 Rev 4

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 10	0 to 10	0 to 10	0 to 10
TEMPERATURE DEGREES F	15 to 96	15 to 96	15 to 96	15 to 96
ADJUSTABLE RANGE PSIG	0 to 30	0 to 30	0 to 30	0 to 30
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
2 MATERIAL: NUTS & BOLTS	SST	SST	SST	SST
PRESSURE RATING PSIG	25	25	25	25
CAPSULE FILL	Silicone	Silicone	Silicone	Silicone
PROCESS CONNECTIONS	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
MINIMUM ACCURACY REQD.	0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
3 MOUNTING BRACKET REQD.	YES	YES	YES	YES
CONDUIT CONNECTION SIZE	1/2"	1/2"	1/2"	1/2"
MANUFACTURER	Rosemount	Rosemount	Rosemount	Rosemount
3 MODEL	2088G 1 A 22 A 1 B4 Q4	2088G 1 A 22 A 1 B4 Q4	2088G 1 A 22 A 1 B4 Q4	2088G 1 A 22 A 1 B4 Q4

	APPROVED	DATE	NOTES
INSTRUMENT ENGINEER	TM 10-2-96		
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT B

INSTRUMENT DATA SHEET
PRESSURE TRANSMITTERS

LIGO
V049-2-090 Rev 4

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 10	0 to 10	0 to 10	0 to 10
TEMPERATURE DEGREES F	15 to 96	15 to 96	15 to 96	15 to 96
ADJUSTABLE RANGE PSIG	0 to 30	0 to 30	0 to 30	0 to 30
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	SST	SST	SST	SST
PRESSURE RATING PSIG	25	25	25	25
CAPSULE FILL	Silicone	Silicone	Silicone	Silicone
PROCESS CONNECTIONS	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
MINIMUM ACCURACY REQD.	0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
MOUNTING BRACKET REQD.	YES	YES	YES	YES
CONDUIT CONNECTION SIZE	1/2"	1/2"	1/2"	1/2"
MANUFACTURER	Rosemount	Rosemount	Rosemount	Rosemount
MODEL	2088G 1 A 22 A 1 B4 Q4	2088G 1 A 22 A 1 B4 Q4	2088G 1 A 22 A 1 B4 Q4	2088G 1 A 22 A 1 B4 Q4

	APPROVED	DATE	NOTES
INSTRUMENT ENGINEER	TM 10-2-96		
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT B

INSTRUMENT DATA SHEET
PRESSURE TRANSMITTERS

LIGO
V049-2-090 Rev 4

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 10	0 to 10	0 to 10	0 to 10
TEMPERATURE DEGREES F	15 to 96	15 to 96	15 to 96	15 to 96
ADJUSTABLE RANGE PSIG	0 to 30	0 to 30	0 to 30	0 to 30
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	SST	SST	SST	SST
PRESSURE RATING PSIG	25	25	25	25
CAPSULE FILL	Silicone	Silicone	Silicone	Silicone
PROCESS CONNECTIONS	1/2" NPT	1/2" NPT	1/2" NPT	1/2" NPT
MINIMUM ACCURACY REQD.	0.25%	0.25%	0.25%	0.25%
SMART ELECTRONICS REQD.	NO	NO	NO	NO
MOUNTING BRACKET REQD.	YES	YES	YES	YES
CONDUIT CONNECTION SIZE	1/2"	1/2"	1/2"	1/2"
MANUFACTURER	Rosemount	Rosemount	Rosemount	Rosemount
MODEL	2088G 1 A 22 A 1 B4 Q4	2088G 1 A 22 A 1 B4 Q4	2088G 1 A 22 A 1 B4 Q4	2088G 1 A 22 A 1 B4 Q4

	APPROVED	DATE	NOTES
INSTRUMENT ENGINEER	TM 10-1-96		
ENGINEERING APPROVAL			
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

SPECIFICATION

FOR

TEMPERATURE ELEMENTS

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY Thomas Murphy

ELECTRICAL F. Bark

QUALITY ASSURANCE Alan L Bradbook

TECHNICAL DIRECTOR D. C. McClain

PROJECT MANAGER Rabbi Bagby

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 V049-2-091 / 0

TABLE OF CONTENTS

1.0 SCOPE

2.0 CODES AND STANDARDS

3.0 GENERAL REQUIREMENTS

4.0 MARKING

5.0 RESPONSIBILITY

6.0 REQUIRED DOCUMENTATION

7.0 INSPECTION

8.0 PREPARATION FOR SHIPMENT

ATTACHMENTS

A) LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

B) DATA SHEET

C) SPECIFICATION FOR EQUIPMENT PURCHASE COMMERCIAL REQUIREMENTS: SPEC.# V049-2-034

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: 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 #				

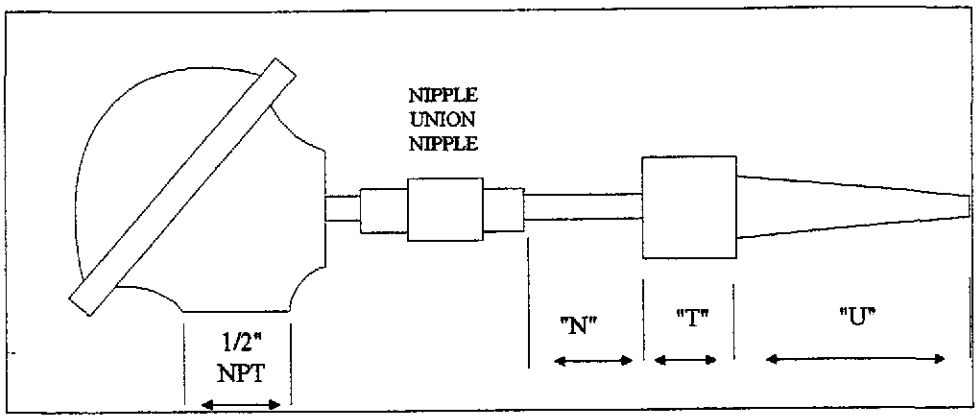
	BY	DATE	NOTES
ENGINEERING APPROVAL			* VENDOR TO ADVISE
PROJECT APPROVAL			

REVISION	NO.	DATE	APP.	APP.	APP.

ATTACHMENT "B"

INSTRUMENT DATA SHEET
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 / REG

TECHNICAL DIRECTOR D. A. McWilliam

PROJECT MANAGER _____

REV LTR	BY—DATE	APPD—DATE	DESCRIPTION OF ACTION
Ø	PPS 5/1/96	REG 5/6/96	Issued for Review DEO # 0155

PROCESS SYSTEMS INTERNATIONAL, INC				SPECIFICATION	
INITIAL APPROVALS	PREPARED BY PPS	DATE 5/1/96	APPROVED BY REG	DATE 5/6/96	Number A V049-2-092	Rev 0

TABLE OF CONTENTS

			Page
1.	Vacuum System Overview		
	1.0	Interlock / Permissive Overview	3
	1.1	Software Alarming Overview	3
	1.2	Emergency Shutdown Overview	3

(Attachment Index)

Washington Site Interlocks/Permissives	**Attachment-A**
Louisiana Site Interlocks / Permissives	**Attachment-B**
Washington Site Software Alarm Listing	**Attachment-C**
Louisiana Site Software Alarm Listing	**Attachment-D**

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: SPECIFICATION FOR PIPING DESIGN AND MATERIAL

SPECIFICATION FOR

PIPING DESIGN AND MATERIAL

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
And
Livingston, Louisiana

PROCESS ENGINEER: Robert Than

PROJECT ENGINEER: S. Moten

CIVIL/STRUC. ENGINEER: R. D. [illegible]

MANUFACTURING ENGINEER: Phillip [illegible]

QUALITY ASSURANCE ENGINEER: Alan L. Bradbrook

PROJECT MANAGER: [illegible]

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
3	[illegible] 10/16/96	D.M.W. 10-[illegible]-96	Added "CC", spec. sht for cryogenic copper lines. REVISED (B)-FLANGES DEO #0319
2	REC 8/24/96	PAH/REB 8/28/96	REVISED "T4" SPEC SH7.17, ITEM 5. RELEASED FOR PURCHASE. DEO.249
1	REC 7/25/96	REB 8/13/96	REVISED "T4" SPEC. SH7.17 RELEASED FOR PURCHASE DEO#0236
0	REC 1-19-96	D.M.W.	RELEASED FOR DESIGN & QUOTES DEO#0044

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED: R. Curtis	DATE: 1-11-96	APPROVED: D.M.W.	DATE: 1-18-96	Number: A V049-2-037	Rev. 3

TABLE OF CONTENTS

1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	MATERIAL/MANUFACTURING REQUIREMENTS
4.0	EXAMINATION AND TESTING
5.0	LINE NUMBER SYSTEM
6.0	VALVE AND INSTRUMENT NUMBERING SYSTEM
7.0	PIPING DESIGN AND MATERIAL SPECIFICATIONS
1B1	150# CLASS STAINLESS STEEL 304 - CRYOGENIC
1B2	150# CLASS STAINLESS STEEL 304 - NON-CRYOGENIC
C2	TYPE "L" COPPER TUBING - GENERAL NON-CRYOGENIC
T1	316 STAINLESS STEEL TUBING - CRYOGENIC
T2	304 STAINLESS STEEL TUBING - GENERAL NON-CRYOGENIC
T3	304L STAINLESS STEEL TUBING - VACUUM
T4	304L STAINLESS STEEL TUBING - ULTRA HIGH VACUUM
T5	304L STAINLESS STEEL TUBING - CLASS 100 CLEAN AIR
VJ	304 STAINLESS STEEL - CRYOGENIC VACUUM JACKETED SEE SPEC. V049-2-016
C1	TYPE "L" COPPER TUBING - CRYOGENIC
ATTACHMENT A	LIGO QUALITY ASSURANCE SUMMARY

1.0 SCOPE

The following piping and material specifications define the piping and fittings to be used for the LIGO Vacuum Equipment.

2.0 CODES AND STANDARDS

2.1 Priority of Codes and Standards

Priority of documents shall be as follows:

1. Codes (highest priority)
2. This specification

2.2 Applicable Codes and Standards

ANSI - American National Standards Institute

- B31.3 Chemical Plant and Petroleum Refinery Piping (for process piping only)
- B31.5 Refrigeration Piping
- B36.19 Stainless Steel Pipe
- B16.5 Pipe Flanges and Flange Fittings

ASTM - American Society of Testing and Materials

- A380-88 Standard Practice for Cleaning and Descaling Stainless Steel
- E427-71(81) Standard Practice for Testing for Leaks Using the Halogen Leak Detector
- E493-73(80) Standard Practice for Testing for Leaks Using the Mass Spectrometer Leak Detector in the inside-Out Testing Mode
- E498-73(80) Standard Test Method for Leaks Using the Mass Spectrometer Leak Detector or Residual Gas Analyzer in the Tracer Probe Mode
- E499-73(80) Standard Methods of Testing for Leaks Using the Mass Spectrometer Leak Detector Probe Mode

2.3 Specification Compliance

The equipment shall comply with any drawings, data sheets, specifications, codes and standards (latest editions) referred to or attached as part of this specification. State or local codes or regulations, if applicable, will be provided as an attachment to this specification. The Vendor is responsible for compliance with such standards, specifications, codes and regulations, if attached.

3.0 MATERIAL/MANUFACTURING REQUIREMENTS

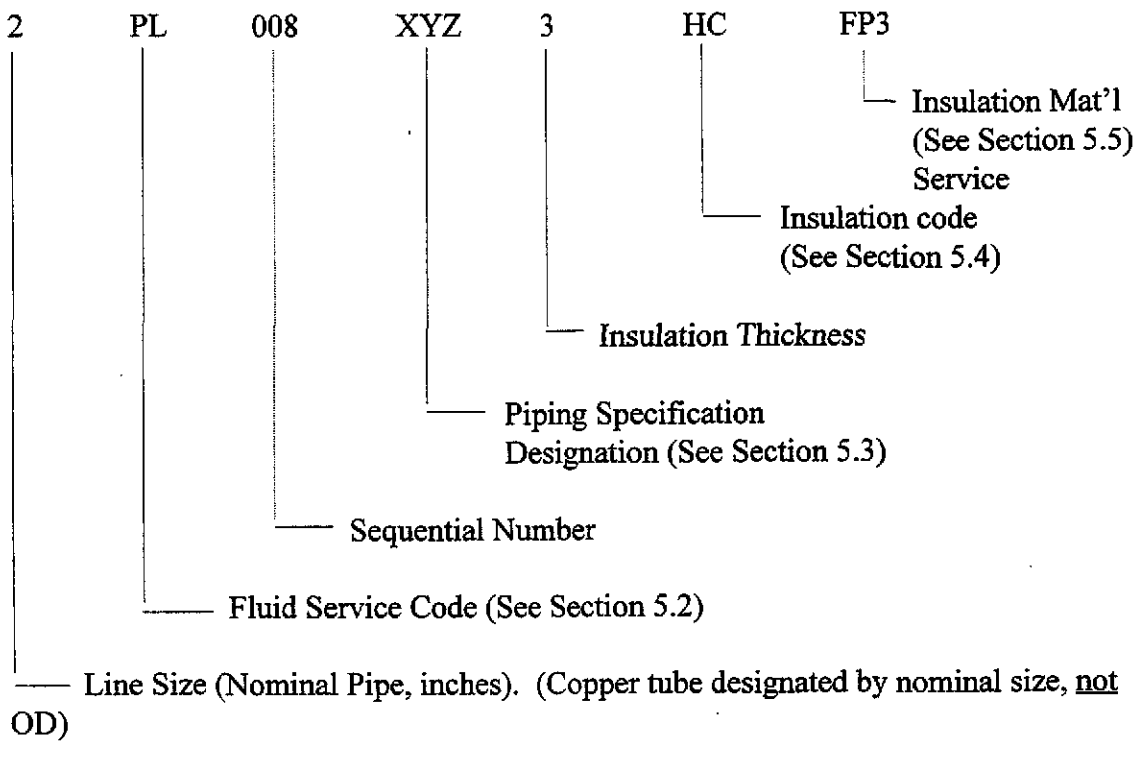
3.1 All materials used to manufacture the piping, tubing, flanges or fittings, as designated per this specification, are to be of U.S.A. origin and manufacture.

4.0 EXAMINATION AND TESTING

Examination and Pressure Testing as required by ANSI B31.3-1990 Chapter VI.

5.0 LINE NUMBER SYSTEM

4.1 Lines shall be numbered according to the following chart:



Number

Rev.

SPECIFICATION

Number	Rev.
A V049-2-037	3

5.2 Fluid Codes

Code	Fluid
IA	Instrument Air
CA	Class 100 Clean Air
CWS	Cooling Water Supply
CWR	Cooling Water Return
NGS	Natural Gas Supply
LN2	Liquid Nitrogen
GN2	Gaseous Nitrogen
PV	Process Vacuum
PUV	Process Ultra High Vacuum
VA	Vent and Relief To ATM
N2	Nitrogen Gas
N	Nitrogen (Either Gas or Liquid)

5.3 Piping Specification Designation

4.4.1 "X" First Digit Identifiers

1 = 150 # ANSI

4.4.2 "Y" Second Digit Identifiers

A = 6061 T6 Aluminum
B = 304 Stainless Steel
C = Type L Copper Tubing
T = Stainless Steel Tubing

4.4.3 "Z" Third Digit Identifiers

1 = Cryogenic
2 = Non-Cryogenic
3 = Vacuum
4 = Ultra High Vacuum
5 = Class 100 Clean Air

5.4 Insulation Service

Insulation Symbol	Insulation Service
HC	Hot and Cold
C	Cold Conservation
PC	Personnel Protection COLD
PH	Personnel Protection HOT
VJ	Vacuum Jacketed

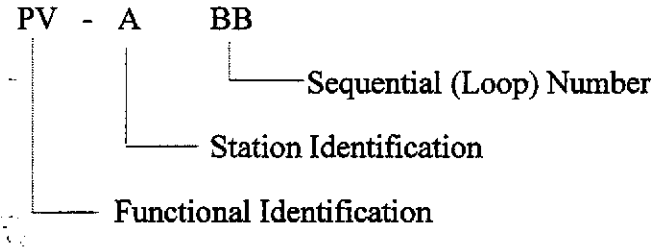
5.5 Insulation Material Codes

FP3	1" Fiberglass Inner	2" Polyisocyanurate Outer
FP3.5	1" Fiberglass Inner	2 1/2" Polyisocyanurate Outer
FP4	1" Fiberglass Inner	3" Polyisocyanurate Outer

If no insulation material code appears in the line number then it shall be understood that no insulation is required.

6.0 VALVE AND INSTRUMENT NUMBER SYSTEM

Control valves, manual valves and associated instruments shall be designated according to P&ID Drawing Symbols. If the required designation is not specified on the drawing, then ISA-S5.1, Table 1 will take precedence.



Manual valves that do not carry an instrument loop numbers (described above) shall be assigned one of the following valve type descriptions, preceeded by the valve size in inches.

Type	Description
GVHV	Gate Valve, High Vacuum, SS, Viton Seals, Handwheel or Lever, CF Conn.
GVUH	Gate Valve, Ultra High Vacuum, SS, Viton Seals, Handwheel, CF Conn.
AVHV	Angle Valve, High Vacuum, SS, Viton Seals, Handwheel, ISOKF or K Conn.
AVUV	Angle Valve, Ultra High Vacuum, SS, Metal Seals, Handwheel, CF Conn.
IRV	Instrument Root Valve, SS
VJV	Vacuum Jacketed Valve, SS
BVCR	Ball Valve, Cryogenic, SS, 3 Piece
BVCA	Ball Valve, Class 100 Clean Air, SS, 3 Piece
GLV	Globe Valve
BVU	Ball Valve, Utility, Brass or Bronze
VSOV	Vacuum Seal-Off Valve, SS
VSOO	Vacuum Seal-Off Valve Operator, SS

VSOV Vacuum Seal-Off Valve, SS
VSOO Vacuum Seal-Off Valve Operator, SS

1B1

PIPING DESIGN AND MATERIAL SPECIFICATION

Service:	Cryogenic
Primary Rating:	150# ANSI 304 SSTL
Design Conditions:	
Pressure	0 to 192 psig
Temperature	-320°F to 350°F
Corrosion Allowance	Zero
Pipe:	
12" and smaller	ASTM A312 TP304
Pipe Schedule:	
1 1/2" and smaller	Schedule 10S SMLS
8" and smaller	Schedule 10S SMLS or EFW
10" thru 12"	Schedule 10S EFW

Note: Vacuum jacketed piping will be designed and fabricated in accordance with the manufacturer's standard, and PSI spec. V049-2-016.

Fittings:	
1 1/2" and smaller	Socket Welded 3000#
2" and larger	Butt Weld ASTM A403 WP304 WPS, WPW O'Let's ASTM A182-F304

Flanges: Not allowed, except on atmospheric vent lines as indicated on P&ID's.

Valves: Valves shall be furnished under their own unique specification.

Continued on Next Page

1B1

Branch Connections:

Run Size "	Branch Size ½	¾	1	1½	2	3	4	6	8	10	12
½	04										
¾	06	04									
1	12	06	04								
1½	05	05	06	04							
2	05	05	06	06	04						
3	05	05	05	05	06	04					
4	05	05	05	05	12	06	04				
6	05	05	05	05	12	12	06	04			
8	05	05	05	05	12	12	12	06	04		
10	05	05	05	05	12	12	12	12	06	04	
12	05	05	05	05	12	12	12	12	12	06	04

04 - Tee
05 - Sockolet
06 - Tee Then Reducer or Reducing Tee
12 - BW O'let

1B2

PIPING DESIGN AND MATERIAL SPECIFICATION

Service:	Non-Cryogenic - Clean
Primary Rating:	150# ANSI 304 SSTL
Design Conditions:	
Pressure	0 to 192 psig
Temperature	-20>°F to 350°F
Corrosion Allowance	Zero
Pipe:	
12" and smaller	ASTM A312 TP304
Pipe Schedule:	
1 1/2" and smaller	Schedule 10S SMLS
8" and smaller	Schedule 10S SMLS or EFW
10" thru 12"	Schedule 10S EFW
Fittings:	
1 1/2" and smaller	Socket Welded 3000#
2" and larger	Butt Weld ASTM A403 WP304 WPS, WPW Elbow O'Let ASTM A182-F304

Flanges: 2" and larger ANSI 150# RF, ASTM A182 F304, Weldneck with o-ring gaskets.

Gaskets: O-ring, Viton non-lubricated, cleaned and sealed for shipment.

Valves: Valves shall be furnished under their own unique specification.

Continued on next page.

1B2

Branch Connections:

Run Size "											
½	04							04 - Tee			
¾	06	04						05 - Sockolet			
1	12	06	04					06 - Tee Then			
1½	05	05	06	04				Reducer or			
2	05	05	06	06	04			Reducing Tee			
3	05	05	05	05	06	04		12 - BW O'let			
4	05	05	05	05	12	06	04				
6	05	05	05	05	12	12	06	04			
8	05	05	05	05	12	12	12	06	04		
10	05	05	05	05	12	12	12	12	06	04	
12	05	05	05	05	12	12	12	12	12	06	04
Branch Size	½	¾	1	1½	2	3	4	6	8	10	12

Note:

1. Piping and fittings to be internally cleaned, dryed and ends sealed during shipping, storing and installation.
2. ID of pipe and fittings to be free of hydrocarbon contamination, or dirt. of any kind.
3. Surface finish to be standard white pickled ID and O.D.
4. Tube Bending - The following is not allowed: Sand packing, Mechanical scratches on tube I.D., Any type of lubricant.
5. Material manufactures certificate of compliance to applicable ASTM specifications are required and must accompany shipment.
6. Tubing, flanges and fittings to be etched or stamped with manufacturers name, part number and material type.

C2

PIPING DESIGN AND MATERIAL SPECIFICATION

Service: Gaseous Nitrogen, Cooling Water, Instrument Air

Design Conditions:

Pressure	200 PSIG
Temperature	-20°F to 150°F
Corrosion Allowance	Zero

Tube: All sizes — Type "L" Copper - Hard Drawn ASTM B88, B280, Copper Tube designated by its Nominal sizes, not OD on P&ID's and piping drawings..

Note: Copper tube and fittings are to be specified on PSI BOM's by the actual O.D. of the tube.

Fittings: All sizes — Wrought Copper ASTM B75
All Fittings to be female solder cup ends.
Brass Parker CPI tube fittings (or equal).

Unions: 1/4" to 1" — Brass Parker CPI tube fittings (or equal) may also be used.

Valves: Valves shall be furnished under their own unique specification.

Soldering: All joints in wrought copper fittings shall be soldered using 95-5 Tin-Antimony.

Notes:

1. Tubing is to be internally cleaned and the ends sealed during shipping, storing and installation. Spools are to have all flux residue, grit, splatters or dirt removed before installation.

2. Fittings are to be cleaned after manufacturing and sealed in plastic during shipping, storing and installation.

Number

Rev.

T1

PIPING DESIGN AND MATERIAL SPECIFICATION

Service: Cryogenic

Design Conditions:

Pressure	0 to 300 psig
Temperature	-320°F to 350°F
Corrosion Allowance	Zero

Tube:

All sizes	ASTM A269 GR 304L SMLS Tube sizes designated by OD dimensions.

Tube Size (OD):	Minimum Wall Thickness (Inches)
1/4"	0.035"
3/8"	0.035"
1/2"	0.049"
3/4"	0.049"
1"	0.065"

Fittings: All Fittings to be Parker Weld tube fittings SA479 or ASTM A276 GR TP316 and ASTM A182 GR TP316, or equal.

Valves: Valves shall be furnished under their own unique specification.

Note:

1. Tubing to be internally cleaned, dryed and ends sealed during shipping, storing and installation. Tube ID to be free of hydrocarbon contamination.
2. Fittings to be cleaned after manufacturing and sealed in plastic bags during shipping, storing and installation.
3. Tubing surface finish to be standard white pickled I.D. & O.D.

T2

PIPING DESIGN AND MATERIAL SPECIFICATION

Service: Non-Cryogenic

Design Conditions:

Pressure	0 to 300 psig
Temperature	-20°F to 350°F
Corrosion Allowance	Zero

Tube:

All sizes	ASTM A269 GR TP304 SMLS Tube sizes designated by OD dimensions.

Tube Size (OD):	Minimum Wall Thickness (Inches)
1/4"	0.035"
3/8"	0.035"
1/2"	0.049"
3/4"	0.049"
1"	0.065"

Fittings: All Fittings to be Parker A-LOK tube fittings SA479 or ASTM A276 GR TP316 and ASTM A182 GR TP316 or equal.

Valves: Valves shall be furnished under their own unique specification.

Note:

1. Tubing to be internally cleaned, dryed and ends sealed during shiping, storing and installation. Tube ID to be free of hydrocarbon contamination.
2. Fittings to be cleaned after manufacturing and sealed in plastic bags during shipping, storing and installation.
3. Tubing surface finish to be standard white pickled I.D. & O.D.

T3

PIPING DESIGN AND MATERIAL SPECIFICATION

Service: Process Vacuum

Design Conditions:

Pressure	Vacuum 10^{-5} Torr to 2 psig
Temperature	-20°F to 150°F
Corrosion Allowance	Zero

Tube: (Tube sizes designated by OD dimensions)

All sizes up to 1"	ASTM A269 GR TP304L SMLS
1 1/2" and larger	ASTM A26 GRTP304L SMLS or Welded.

Tube Size (OD):	Minimum Wall Thickness (Inches)	Conflat Flange Size	No. Bolts	B.C. Dia.	Thru Hole Dia.
1/4"	0.035"	1 1/3" Nom. O.D.	6	1.062"	.172"
3/8"	0.035"	1 1/3" Nom. O.D.	6	1.062"	.172"
1/2"	0.035"	1 1/3" Nom. O.D.	6	1.062"	.172"
3/4"	0.035"	2 1/8" Nom. O.D.	4	1.625"	.265"
1"	0.065"	2 3/4" Nom. O.D.	6	2.312"	.265"
1 1/2"	0.065"	2 3/4" Nom. O.D.	6	2.312"	.265"
2"	0.065"	3 3/8" Nom. O.D.	8	2.85"	.332"
2 1/2"	0.065"	4 1/2" Nom. O.D.	8	3.628"	.332"
4"	0.083"	6" Nom. O.D.	16	5.128"	.332"
6"	0.083	8" Nom. O.D.	20	7.128"	.332"
8"	0.120	10" Nom. O.D.	24	9.128"	.332"
10"	0.120	12" Nom. O.D.	32	11.181"	.332"
12"	0.120	14" Nom. O.D.	30	12.810"	.390"
14"	0.120	16 1/2" Nom. O.D.	36	15.310"	.390"

Flanges: All Flanges to be Conflat, ISO Large Flange or KF tube fittings 304L Stainless Steel.

Continued on next page.

T3

Fittings: All fittings to be 304L butt weld or flanged O.D. tube, wall thickness to match tube wall thickness listed above.

Valves: Valves shall be furnished under their own unique specification.

Notes:

1. Tubing to be internally cleaned, dryed and ends sealed during shipping, storing and installation. Tube ID to be free of hydrocarbon contamination.
2. Fittings to be cleaned after manufacturing and sealed in plastic bags during shipping, storing and installation.
3. Tubing surface finish to be standard white pickled I.D. & O.D.
4. Tube Bending - The following is not allowed: Sand packing, Mechanical scratches on tube I.D., or any type of lubricant.
5. Material manufactures certificate of compliance to applicable ASTM specifications are required and must accompany shipment.
6. Tubing, flanges and fittings to be etched or stamped with manufacturers name, part number and material type.
7. Conflat flanges to be made from either electro slag remelt, vacuum remelt or cross forged material.

T4

PIPING DESIGN AND MATERIAL SPECIFICATION

Service: Process Ultra High Vacuum

Design Conditions:

Pressure	Vacuum 10^{-10} Torr to 2 psig
Temperature	-20°F to 150°F
Corrosion Allowance	Zero

Tube: (Tube sizes designated by OD dimensions)

All sizes up to 1"	ASTM A269 GR TP304L SMLS
1 1/2" and larger	ASTM A269 GRTP304L SMLS or welded.

Tube Size (OD):	Minimum Wall Thickness (Inches)	Conflat Flange Size	No. Bolts	B.C. Dia.	Thru Hole Dia.
1/4"	0.035"	1 1/3" Nom. O.D.	6	1.062"	.172"
3/8"	0.035"	1 1/3" Nom. O.D.	6	1.062"	.172"
1/2"	0.035"	1 1/3" Nom. O.D.	6	1.062"	.172
3/4"	0.035"	2 1/8" Nom. O.D.	4	1.625"	.265"
1"	0.065"	2 3/4" Nom. O.D.	6	2.312"	.265"
1 1/2"	0.065"	2 3/4" Nom. O.D.	6	2.312"	.265"
2"	0.065"	3 3/8" Nom. O.D.	8	2.85"	.332"
2 1/2"	0.065"	4 1/2" Nom. O.D.	8	3.628"	.332"
4"	0.083"	6" Nom. O.D.	16	5.128"	.332"
6"	0.083	8" Nom. O.D.	20	7.128"	.332"
8"	0.120	10" Nom. O.D.	24	9.128"	.332"
10"	0.120	12" Nom. O.D.	32	11.181"	.332"
12"	0.120	14" Nom. O.D.	30	12.810"	.390"
14"	0.120	16 1/2" Nom. O.D.	36	15.310"	.390"

Continued on next page.

T4

Flanges: All Flanges to be Conflat, 304L Stainless Steel. Flanges with 1/2 nipples to have a minimum wall thickness per table (page 16), also see note 7.

Fittings: All fittings to be 304L butt weld or flanged O.D. tube. Wall thickness to match tube wall thickness listed in Table (Page 16).

Valves: Valves shall be furnished under their own unique specification. Valves whose seats form part of the UHV boundary shall be all metal.

Cleaning: Surfaces exposed to vacuum shall be cleaned and protected by PSI approved procedures suitable for UHV service.

Note:

1. Tubing to be internally cleaned, dryed and ends sealed during shipping, storing and installation. Tube ID to be free of hydrocarbon contamination.
2. Fittings and conflat - 1/2 nipples to be cleaned after manufacturing and sealed in plastic bags during shipping, storing and installation.
3. Tubing surface finish to be standard white pickled I.D. & O.D.
4. Material manufacturers Certificate of Compliance to applicable ASTM specifications are required and must accompany shipment.
5. Tubing, flanges and fittings to be etched or stamped with manufacturers name, part number, material type and customers PO number on the outside surface.
6. Conflats shall be made from 304L material suitable for ultra high vacuum service.
7. All welding exposed to vacuum shall be done by the tungsten-arc inert-gas (TIG) process. Exceptions may be allowed subject to PSI approval. Welding techniques shall be made in accordance with the best ultra high vacuum practice to eliminate any virtual leaks in the welds; i.e., all vacuum welds shall be, wherever possible, internal and continuous; all external welds added to these for structural purposes shall be intermittent to eliminate trapped volumes. Defective welds shall be repaired by removal to sound metal and rewelding. All vacuum weld procedures shall include steps to avoid contamination of the heat affected zone with air, hydrogen, or water. This requires that inert purge gas, such as argon, be used to flood the vacuum side of heated portions. Vendors to provide weld procedures, with weld cleaning procedures to PSI for approval.

T5

PIPING DESIGN AND MATERIAL SPECIFICATION

Service: Class 100 Clean Air

Design Conditions:

Pressure	Vacuum to 2 psig
Temperature	-20°F to 150°F
Corrosion Allowance	Zero

Tube: (Tube sizes designated by OD dimensions)

All sizes up to 1"	ASTM A269 GR TP304 SMLS
1 1/2" and larger	ASTM A269 GRTP304 SMLS or Welded.

Tube Size (OD):	Minimum Wall Thickness (Inches)	Conflat Flange Size	No. Bolts	B.C. Dia.	Thru Hole Dia.
1/4"	0.035"	1 1/3" Nom. O.D.	6	1.062"	.172"
3/8"	0.035"	1 1/3" Nom. O.D.	6	1.062"	.172"
1/2"	0.035"	1 1/3" Nom. O.D.	6	1.062	.172"
3/4"	0.035"	2 1/8" Nom. O.D.	4	1.625"	.265"
1"	0.065"	2 3/4" Nom. O.D.	6	2.312"	.265"
1 1/2"	0.065"	2 3/4" Nom. O.D.	6	2.312"	.265"
2"	0.065"	3 3/8" Nom. O.D.	8	2.85"	.332"
2 1/2"	0.065"	4 1/2" Nom. O.D.	8	3.628"	.332"
4"	0.083"	6" Nom. O.D.	16	5.128"	.332"
6"	0.083	8" Nom. O.D.	20	7.128"	.332"
8"	0.120	10" Nom. O.D.	24	9.128"	.332"
10"	0.120	12" Nom. O.D.	32	11.181"	.332"
12"	0.120	14" Nom. O.D.	30	12.810"	.390"
14"	0.120	16 1/2" Nom. O.D.	36	15.310"	.390"

Continued on next page.

T5

Flanges: All Flanges to be Conflat tube fittings 304 Stainless Steel.

Fittings: All Fittings to be 304 butt weld or flanged O.D. tube. Wall thickness to match the tube wall thickness.

Valves: Valves shall be furnished under their own unique specification

Cleaning: Internal surfaces shall be cleaned and protected by PSI approved procedures suitable for Class 100 air service.

Note:

1. Tubing to be internally cleaned, dryed and ends sealed during shiping, storing and installation. Tube ID to be free of hydrocarbon contamination.
2. Fittings to be cleaned after manufacturing and sealed in plastic bags during shipping, storing and installation.
3. Tubing surface finish to be standard white pickled I.D. & O.D.
4. Material manufactures Certificate of Compliance to applicable ASTM specifications are required and must accompany shipment.
5. Tubing, flanges and fittings to be etched or stamped with manufacturers name, part number and material type.
6. Conflat flanges to be made from either electro slag remelt, vacuum remelt or crossforged material.

C1

PIPING DESIGN AND MATERIAL SPECIFICATION

Service:	Cryogenic
Design Conditions:	
Pressure	150 PSIG
Temperature	-320°F to 350°F
Corrosion Allowance	None
Tube:	
All sizes	Type "L" Copper - Hard Drawn ASTM B88, B280, copper tube designated by its nominal sizes, not OD (UON).
Fittings:	
All sizes	Wrought copper ASTM B75 All fittings to be female solder cup ends.
Valves:	Valves shall be furnished under their own unique specification.

Brazing;

All joints shall be brazed using brazing alloy BCuP-5 (American Welding Society Designation). No flux is required.

SPECIFICATION		
Number A	V036-2-037	Rev. 3

ATTACHMENT "A"

LIGO QUALITY ASSURANCE REQUIREMENTS SUMMARY

LIGO VACUUM EQUIPMENT	VENDOR:	JOB NO.: V59049
EQUIPMENT: PIPE, TUBING & FITTINGS	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPECNO: V049-2-037

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:
VENDOR Q.A. PLAN			X	2	X		
CLEANING PROCEDURE			X	2	X		
PREP FOR SHIPMENT PROCEDURE			X	2	X		
CERTIFICATE OF COMPLIANCE				2	X		

SPEC V049-2-037

Pg. 20 Rev. B

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. Curtis

QUALITY ASSURANCE: Alan L Budlong

TECHNICAL DIRECTOR: D.A. McWilliams

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
4	REC 6/20/96	D M(W)	ADDED P/N V049M260-1 ADDED ATTACHMENT "B" DEO# 0209
3	REC 5/20/96	D M(W)	REVISED SECTIONS 4.3, 4.5, 4.7, 4.8, 10.1 & 10.2 DEO# 0183
2	REC, 4/8/96	D M(W)	ADDED DELIVERY SCHEDULE DEO# 0115
1	REC 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. 4
	REC 11/21/95	REC 11/27/95		

SPECIFICATION TABLE OF CONTENTS

1.0 Scope

2.0 Schedule

3.0 Material Requirements

4.0 Manufacture Requirements

5.0 Material Testing

6.0 Inspection/Witness

7.0 Rejections and Repair of Defects

8.0 Identification

9.0 Documentation

10.0 Packaging, Storing and Shipping

11.0 Non-escort Privileges and Inspection Right

Attachment A LIGO Quality Assurance Requirements Summary

Attachment B Head End Prep. Details

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	19 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	19 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	19 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	14	PSI, Westborough	19 July 1996
11	V049M002-1	60.5	8	PSI, Westborough	1 Nov. 1996
12	V049M002-1	60.5	6	PSI, Westborough	1 Feb. 1997
13	V049M138-1	79.5	3	PSI, Westborough	19 July 1996
14	V049M260-1	79.5	3	PSI, Westborough	19 July 1996
15	V049M138-1	79.5	3	PSI, Westborough	1 Nov. 1996
16	V049M260-1	79.5	3	PSI, Westborough	1 Nov. 1996
17	V049M138-1	79.5	3	PSI, Westborough	1 Feb. 1997
18	V049M260-1	79.5	3	PSI, Westborough	1 Feb. 1997
19	V049M138-1	79.5	3	PSI, Westborough	15 Apr. 1997
20	V049M260-1	79.5	3	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 = within 1/2% of head I.D.

4.4 Heads to be square trimmed by manufacturer to a flatness tolerance of ± 1/8".

4.5 Heads to be manufactured with or without center holes as specified in P.O.

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 or chlorides) 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 - After Pickling

The heads are intended for use in a high vacuum application. Potential hydrocarbon or chloride contamination shall be eliminated. Also, the material shall be wrapped and covered at all times with polyethylene sheet, for protection.

5.0 MATERIAL TESTING

5.1 2" x 2" material coupons must be supplied to PSI with 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 head material shall be wrapped in waterproof polyethylene and covered with a tarp immediately after pickle processing operations have been completed to minimize contamination.

10.2 The heads shall be shipped wrapped in waterproof polyethylene and covered with tarps to prevent any roadway contamination.

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:Vacuum Vessel Heads	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPECNO.:V049-2-039

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				2	X		
IN-PROCESS INSPECTIONS		X		2	X		
OPERATION & MAINTENANCE MANUALS							
SHOP TEST PLAN							
SHOP TEST (WITH REPORT)							
SHOP DIMENSIONAL INSPECTION		X		2	X		

Pg 7 of 8

Spec. V049-2-039 Rev. 4.

ATTACHMENT "B"

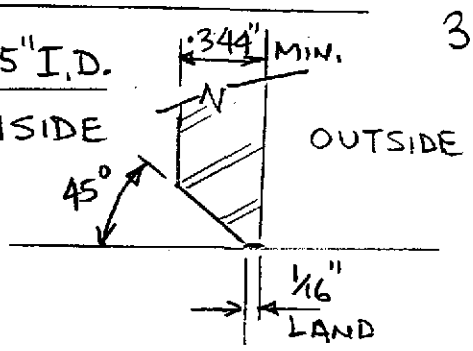
By: D. Curtis 21 June 96

HEAD WELD PREP. BEVELS BY HEAD MANUFACTURER

P/N V049M132_1

QTY. 36

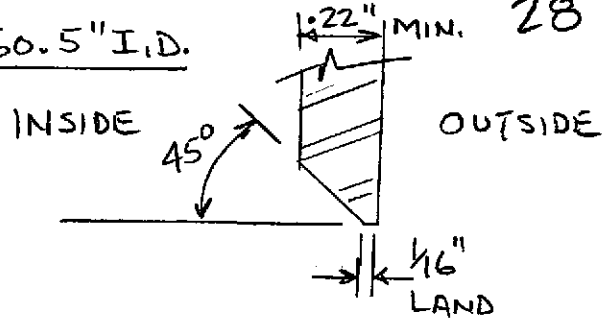
84.25" I.D.



P/N V049M002_1

QTY. 28

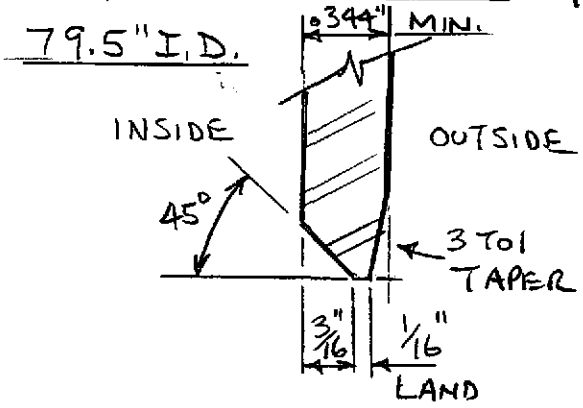
60.5" I.D.



P/N V049M138_1

QTY. 12.

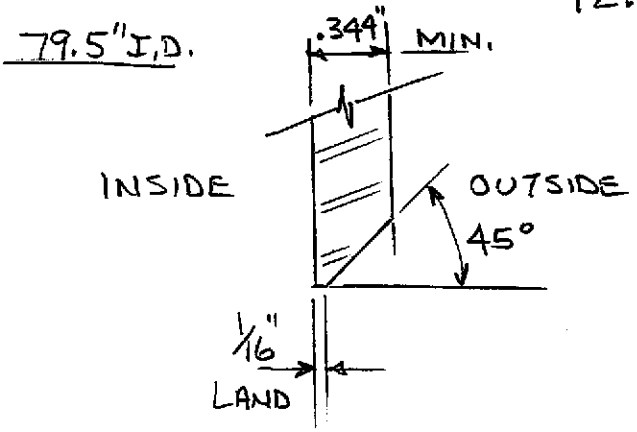
79.5" I.D.



P/N V049M260_1

QTY. 12.

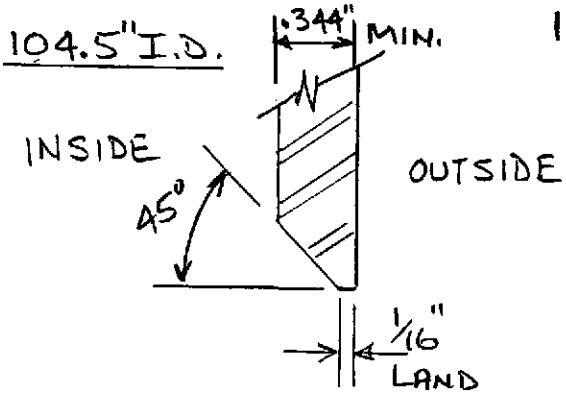
79.5" I.D.



P/N V049M001_1

QTY. 15

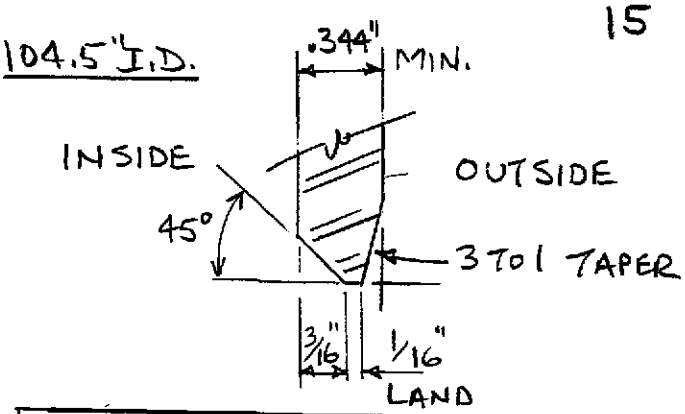
104.5" I.D.



P/N V049M010_1

QTY. 15

104.5" I.D.



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. Craft

QUALITY ASSURANCE: A R Bradbrook

TECHNICAL DIRECTOR: D.A. McWilliams

PROJECT MANAGER: Rich Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
6	REG 6/17/96	D.M.W.	DELETED P/N V049M248-1 & V049M249-1 FROM SHTS. 7 OF 10 & 9 OF 10. DEO #0201
5	REG 6/14/96	PHH/REB 6/14/96	ADDED 1.97" OFFSET TO P/N V049M248-1 & V049M249-1 DEO # 0197
4	REG 5/29/96	REB 5/30/96	ADDED ATTACHMENT "B" SIZE & QUANTITIES REVISED FOR PURCHASE DEO #0189
3	REG 9/11/96	REB 9/11/96	REVISED TOLERANCES IN SECTION 4.0. ADDED SCHEDULE SECTION 2.0 DEO #0117
2	D.M.W 3-15-96	REB for RGB	REV SECT 3.5 (MAX SULFUR CONTEN) PER DEO #0094
1	REG 12/22/95	D.M.W.	REVISED SECT. 3.4, 3.5 & 1, 9.1 DEO #0037
0	D.M.W.		ISSUED PER DEO 0021 (MAT'L PROCUREMENT)

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
INITIAL APPROVALS	PREPARED DATE	APPROVED DATE	Number A V049-2-040	Rev. 6
	REG 11/21/95	REB 11/27/95		

SPECIFICATION TABLE OF CONTENTS

1.0 Scope

2.0 Schedule of Deliveries

3.0 Material Requirements

4.0 Manufacture Requirements

5.0 Material Testing

6.0 Inspection/Witness

7.0 Rejections and Repair of Defects

8.0 Identification

9.0 Documentation

10.0 Packaging, Storing and Shipping

11.0 Non-escort Privileges and Inspection Right

Attachment A — LIGO Quality Assurance Requirements Summary

Attachment B — Schedule of Deliveries in Lots With Sizes and Quantities

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 Attachment "B".

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, sulfur, and chlorides.

4.7 Cleanliness

The forgings are intended for use in a high vacuum application. Potential hydrocarbon contamination shall be eliminated.

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:	SPECNO: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		

ATTACHMENT "B"

Schedule of Deliveries in Lots with Sizes and Quantities

Flange rings shall be delivered in lots as follows:

PSI Part No.	Lot No.	I.D. x O.D. x Thk (Dimensions in Inches)	Qty.	Destination	Date
V049M003-1	1	104.25 x 112.5 x 1.5	4	PSI Westboro	1 July 1996
V049M004-1	1	104.25 x 112.5 x 1.25	4	PSI Westboro	1 July 1996
V049M133-1	1	84.0 x 92.25 x 1.63	12	PSI Westboro	1 July 1996
V049M136-1	1	83.75 x 92.25 x 1.38	12	PSI Westboro	1 July 1996
V049M135-1	1	60.0 x 68.5 x 1.63	30	PSI Westboro	1 July 1996
V049M243-1	1	60.0 x 68.5 x 1.25	26	PSI Westboro	1 July 1996
V049M244-1	1	44.0 x 52.25 x 1.5	14	PSI Westboro	1 July 1996
V049M245-1	1	44.0 x 52.25 x 1.25	6	PSI Westboro	1 July 1996
V049M242-1	1	48.0 x 56.25 x 1.5	12	PSI Westboro	1 July 1996
V049M241-1	1	48.0 x 56.25 x 1.25	4	PSI Westboro	1 July 1996
V049M250-1	1	56.3 x 72.5 x 1.25	2	PSI Westboro	1 July 1996
V049M246-1	1	72.00 x 80.25 x 1.63	10	PSI Westboro	1 July 1996
V049M247-1	1	72.00 x 80.25 x 1.25	6	PSI Westboro	1 July 1996
		Total	142		

PSI Part No.	Lot No.	I.D. x O.D. x Thk (Dimensions in Inches)	Qty.	Destination	Date
V049M003-1	2	104.25 x 112.5 x 1.5	4	PSI Westboro	1 Nov. 1996
V049M004-1	2	104.25 x 112.5 x 1.25	4	PSI Westboro	1 Nov. 1996
V049M133-1	2	84.0 x 92.25 x 1.63	10	PSI Westboro	1 Nov. 1996
V049M136-1	2	83.75 x 92.25 x 1.38	10	PSI Westboro	1 Nov. 1996
V049M135-1	2	60.0 x 68.5 x 1.63	24	PSI Westboro	1 Nov. 1996
V049M243-1	2	60.0 x 68.5 x 1.25	26	PSI Westboro	1 Nov. 1996
V049M244-1	2	44.0 x 52.25 x 1.5	14	PSI Westboro	1 Nov. 1996
V049M245-1	2	44.0 x 52.25 x 1.25	4	PSI Westboro	1 Nov. 1996
V049M246-1	2	72.0 x 80.25 x 1.63	4	PSI Westboro	1 Nov. 1996
		Total	100		

PSI Part No.	Lot No.	I.D. x O.D. x Thk (Dimensions in Inches)	Qty.	Destination	Date
V049M003-1	3	104.25 x 112.5 x 1.5	4	PSI Westboro	1 Feb. 1997
V049M004-1	3	104.25 x 112.5 x 1.25	4	PSI Westboro	1 Feb. 1997
V049M133-1	3	84.0 x 92.25 x 1.63	8	PSI Westboro	1 Feb. 1997
V049M136-1	3	83.75 x 92.25 x 1.38	8	PSI Westboro	1 Feb. 1997
V049M135-1	3	60.0 x 68.5 x 1.63	21	PSI Westboro	1 Feb. 1997
V049M243-1	3	60.0 x 68.5 x 1.25	11	PSI Westboro	1 Feb. 1997
V049M244-1	3	44.0 x 52.25 x 1.5	10	PSI Westboro	1 Feb. 1997
V049M245-1	3	44.0 x 52.25 x 1.25	2	PSI Westboro	1 Feb. 1997
V049M242-1	3	48.0 x 56.25 x 1.5	4	PSI Westboro	1 Feb. 1997
V049M250-1	3	56.3 x 72.5 x 1.25	1	PSI Westboro	1 Feb. 1997
V049M246-1	3	72.00 x 80.25 x 1.63	12	PSI Westboro	1 Feb. 1997
V049M247-1	3	72.00 x 80.25 x 1.25	8	PSI Westboro	1 Feb. 1997
		Total	93		

PSI Part No.	Lot No.	I.D. x O.D. x Thk (Dimensions in Inches)	Qty.	Destination	Date
V049M003-1	4	104.25 x 112.5 x 1.5	3	PSI Westboro	15 Apr. 1997
V049M004-1	4	104.25 x 112.5 x 1.25	3	PSI Westboro	15 Apr. 1997
V049M133-1	4	84.0 x 92.25 x 1.63	6	PSI Westboro	15 Apr. 1997
V049M136-1	4	83.75 x 92.25 x 1.38	6	PSI Westboro	15 Apr. 1997
V049M135-1	4	60.0 x 68.5 x 1.63	10	PSI Westboro	15 Apr. 1997
V049M244-1	4	44.0 x 52.25 x 1.5	10	PSI Westboro	15 Apr. 1997
V049M245-1	4	44.0 x 52.25 x 1.25	2	PSI Westboro	15 Apr. 1997
V049M246-1	4	72.00 x 80.25 x 1.63	2	PSI Westboro	15 Apr. 1997
		Total	42		

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. Catto

QUALITY ASSURANCE: A L Budbrook

TECHNICAL DIRECTOR: D. A. McWilliams

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
3	REL 7/30/96	RBB	pg. 4 & 5 DEO#0227 REVISED SIZE OF P/N V049M174, WAS 1/4"x54x192
2	REL 5/7/96		REVISED SIZE OF P/N V049M155, WAS 1/4"x72x229. DEO #0193 REVISED QTY. OF P/N V049M166, WAS QTY. 4
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. 3
	R.E.L. 11/21/95	R.B.B. 11/27/95		

SPECIFICATION TABLE OF CONTENTS

1.0 Scope

2.0 Schedule and Delivery

3.0 Material Requirements

4.0 Manufacture Requirements

5.0 Material Testing

6.0 Inspection/Witness

7.0 Rejections and Repair of Defects

8.0 Identification

9.0 Documentation

10.0 Packaging, Storing and Shipping

11.0 Non-escort Privileges and Inspection Right

Attachment A LIGO Quality Assurance Requirements Summary

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.	3/8 x 96 x 230	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

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 57 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	2	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 57 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.	3/8 x 96 x 230	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:	SPECNO.: 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:

LIGO VACUUM EQUIPMENT; V59049

O RING SPECIFICATION

PROJECT ENGINEER S. Moten

TECHNICAL DIRECTOR D.O. McWilliams

QUALITY ASSURANCE A.L. Bradbrook

PROJECT MANAGER [signature]

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
5	SM 11/24/96	D.McW	Released per DEO 0367
4	SM 10/9/96	DMcW 10-11-96	Released per DEO 0297
3	SM 9/17/96	DMcW 9-11-96	Released per DEO 0268
2	SM 8/21/96	DMcW 8-21-96	Released per DEO 0247
1	SM 7/16/96	DMcW 7-16-96	RELEASED PER DEO 0223
Φ	SM 12/27/95	DMcW 1-2-96	RELEASED PER DEO 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	5

Title

O RING SPEC. V049-2-045

SM LIGOV7.WB1

SERVICE : ULTRA HIGH VACUUM SEALS

MATERIAL: EXTRUDED CORD STOCK; CERTIFIED DUPONT VITON A-500

DUROMETER : 70-75

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 170 C (338 F) IN A PURE N2 ATMOSPHERE,AT A PRESSURE = 1 TORR,FOR A 12 HOUR DURATION.AFTER BAKING,THE O-RING PART NO. WILL HAVE THE SUFFIX "V" REMOVED.(SEE TABLE 1)

4. PRIOR TO OBTAINING A RELEASE FOR SHIPMENT,VENDOR MUST CERTIFY THAT ALL SPLICED JOINTS HAVE BEEN VISUALLY INSPECTED AND TESTED IN ACCORDANCE WITH ASTM STANDARD D2527-83(REAPPROVED 1992).JOINT CLASSIFICATION IS CLASS 3.

5. THE O-RING VENDOR WILL SUPPLY UNBAKED O-RINGS WITH THE SUFFIX "V" ADDED TO THE PART NUMBER.(SEE TABLE 1)

Number

Rev.

SPECIFICATION

Number	Rev.
A V049-2-045	5

Title

O RING SPEC. V049-2-045

SM UGOV7.WB1

TABLE 1

PART NO. UNBAKED	PART NO. BAKED	FLANGE SIZE	CROSS SECT. INCHES	CORD LENGTH INCHES	REF. DWG.
V049M016V	V049M016	104	0.275 + - 0.006	337.5	V049-4-022
V049M017V	V049M017	104	0.275 + - 0.006	328.125	V049-4-022
V049M018V	V049M018	84	0.275 + - 0.006	274.375	V049-4-021
V049M019V	V049M019	84	0.275 + - 0.006	265.125	V049-4-021
V049M020V	V049M020	72	0.275 + - 0.006	237.125	V049-4-020
V049M021V	V049M021	72	0.275 + - 0.006	227.75	V049-4-020
V049M022V	V049M022	60	0.275 + - 0.006	200.625	V049-4-019
V049M023V	V049M023	60	0.275 + - 0.006	191.25	V049-4-019
V049M024V	V049M024	48	0.275 + - 0.006	162.5	V049-4-018
V049M025V	V049M025	48	0.275 + - 0.006	153.125	V049-4-018
V049M026V	V049M026	44.25	0.275 + - 0.006	150	V049-4-017
V049M027V	V049M027	44.25	0.275 + - 0.006	140.75	V049-4-017
V049M030V *	V049M030 *	60	0.275 + - 0.006	213	V049-4-067
V049M031V *	V049M031 *	60	0.275 + - 0.006	203.75	V049-4-067
V049M032V	V049M032	44.625	0.275 + - 0.006	151.25	V049-4-132
V049M033V	V049M033	44.625	0.275 + - 0.006	203.75	V049-4-132

* BE-3A'S ONLY

Number

Rev.

SPECIFICATION

Number A V049-2-045 Rev. 5

11/88

PS-997

Title: SPECIFICATION FOR STAINLESS STEEL RINGS CUT OUT OF PLATE

SPECIFICATION FOR

STAINLESS STEEL RINGS CUT OUT OF PLATE

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: R.E. Center 6/4/96

STRUCTURAL ENGINEER: R.D. Gatto 6/7/96

QUALITY ASSURANCE: Alan L Budlong

TECHNICAL DIRECTOR: D.A. McWilliams

PROJECT MANAGER: P.F. Hendry for R.E.B.

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	RZC 6/17/96	D. McW	ATTACHMENT "B", REVISED TOL. SECT. 4.2 ADDED P/N V049M248-1 & P/N V049M249-1 DEO 0201
0	RZC, 6/12/96	D. McW	RELEASED FOR PURCHASE DEO# 0193

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number A V049-2-134	Rev.
	RZC	6/12/96	REB/PFH	6/12/96		1

SPECIFICATION TABLE OF CONTENTS

1.0 Scope

2.0 Schedule and Delivery

3.0 Material Requirements

4.0 Manufacture Requirements

5.0 Material Testing

6.0 Inspection/Witness

7.0 Rejections and Repair of Defects

8.0 Identification

9.0 Documentation

10.0 Packaging, Storing and Shipping

11.0 Non-escort Privileges and Inspection Right

Attachment A — LIGO Quality Assurance Requirements Summary

Attachment B — Schedule of Deliveries in Lots with Sizes and Quantities

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

Rings shall be delivered in lots with sizes and quantities as specified in Attachment "B".

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 Diameter Tolerance

The rings to be flame cut to the following tolerances:
ID -1/4" + 0, OD + 1/4" - 0

4.2.1 Surface flatness per ASTM A480.

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, no grinding with abrasive wheels, cloth or stones is permitted. No iron, carbon steel or other contaminants (such as grease, cloride compounds, oils, 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. The plate shall be cleaned prior to shipment.

5.0 MATERIAL TESTING

5.1 A 2" x 2" wide coupon, 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 2" in from the O.D. 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 shipment of the material.

9.2 A record of the material thickness for each group of materials 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 tarps 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 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: Stainless Steel Rings Cut Out Of Plate	VENDOR ENG. OFFICE:	DWG. NO.:
PSI P.O. NO:	VENDOR FACTORY:	SPEC NO.: V049-2-134

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		

ATTACHMENT "B"

Schedule of Deliveries in Lots with Sizes and Quantities

Rings are to be delivered in lots as follows:

PSI Part No.	Lot No.	I.D. x O.D. x Thk (Dimensions in Inches)	Qty.	Destination	Date
V049M251-1	1	44.9 x 80.3 x 1.25	6	PSI Westboro	15 July 1996
V049M252-1	1	48.5 x 68.5 x 1.25	6	PSI Westboro	15 July 1996
V049M253-1	1	48.5 x 68.5 x 1.25 with 48.5 hole offset from O.D. center line by 5.88 in.	2	PSI Westboro	15 July 1996
V049M254-1	1	30.8 x 68.5 x 1.25	4	PSI Westboro	15 July 1996
V049M255-1	1	60.8 x 72.5 x 1.25	4	PSI Westboro	15 July 1996
V049M256-1	1	60.8 x 80.3 x 1.25	2	PSI Westboro	15 July 1996
V049M257-1	1	44.9 x 68.5 x 1.25	2	PSI Westboro	15 July 1996
V049M258-1	1	30.8 x 68.5 x 1.63	4	PSI Westboro	15 July 1996
V049M248-1	1	60.25 x 72.5 x 1.63 with 60.25 hole offset from O.D. center line by 1.97 in.	2	PSI Westboro	15 July 1996
V049M249-1	1	60.25 x 72.5 x 1.25 with 60.25 hole offset from O.D. center line by 1.97 in.	2	PSI Westboro	15 July 1996

ATTACHMENT "B"

Schedule of Deliveries in Lots with Sizes and Quantities

Rings are to be delivered in lots as follows:

PSI Part No.	Lot No.	I.D. x O.D. x Thk (Dimensions in Inches)	Qty.	Destination	Date
V049M251-1	2	44.9 x 80.3 x 1.25	4	PSI Westboro	1 Feb. 1997
V049M252-1	2	48.5 x 68.5 x 1.25	2	PSI Westboro	1 Feb. 1997
V049M254-1	2	30.8 x 68.5 x 1.25	2	PSI Westboro	1 Feb. 1997
V049M255-1	2	60.8 x 72.5 x 1.25	2	PSI Westboro	1 Feb. 1997
V049M259-1	2	48.5 x 80.3 x 1.25	2	PSI Westboro	1 Feb. 1997
V049M258-1	2	30.8 x 68.5 x 1.63	2	PSI Westboro	1 Feb. 1997
V049M248-1	2	60.25 x 72.5 x 1.63 with 60.25 hole offset from O.D. centerline by 1.97 in.	1	PSI Westboro	1 Feb. 1997
V049M249-1	2	60.25 x 72.5 x 1.25 with 60.25 hole offset from O.D. centerline by 1.97 in.	1	PSI Westboro	1 Feb. 1997