

Title: SPECIFICATION FOR LIGO VACUUM EQUIPMENT INSTALLATION AND COMMISSIONING



SPECIFICATION FOR  
LIGO VACUUM EQUIPMENT  
INSTALLATION AND COMMISSIONING

*Raymond D. Ciatto* 7/22/97  
EXPIRES 8/5/99

PROJECT MANAGER: *Bradley Bagley*  
 STRUCTURAL ENGINEER: *Raymond D. Ciatto*  
 ELECTRICAL/CONTROL: *[Signature]*  
 TECHNICAL DIRECTOR: *Dr. M. W. Hellman*  
 INSTALLATION 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.

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PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
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CONTENTS

ATTACHMENT LISTING .....3

1 INTRODUCTION .....4

2 DEFINITIONS.....4

3 SITE VISIT .....5

4 CONTRACTOR CONTACTS.....5

5 PERMITS AND CODES.....5

6 SAFETY REGULATIONS.....7

7 GENERAL REQUIREMENTS .....7

8 SCOPE OF WORK.....13

9 TESTING.....21

10 MATERIAL / SERVICES PROVIDED BY CONTRACTOR .....22

11 MATERIALS FURNISHED BY OTHERS/BUYER .....24

12 PROJECT DOCUMENTS LIST .....24

13 SCHEDULE OF THE WORK.....25

14 BASIS OF BID.....25

15 SELECTION OF THE CONTRACTOR.....26

**SPECIFICATION**

Number

**A** V049-2-021

Rev

**3**

**ATTACHMENTS**

- Attachment A.....Project Installation/Commissioning Document List**
- Attachment B.....Building Crane Coverage**
- Attachment C.....Equipment Supplied by the Buyer**
- Attachment D.....Electrical & Instrument Construction Work V049-2-022**
- Attachment E.....Final Design Report Volume IV Installation/Commissioning V049-1-100**
- Attachment F.....Washington Site Installation Drawing Package**
- Attachment G.....LIGO Building Drawing Package**
- Attachment H.....Vendor Equipment Drawing Package**
- Attachment I.....Carbon Steel Supports Supplied by The Buyer**
- Attachment J.....Equipment Groupings for Shipment**
- Attachment K .....Fabricated Class 100 Vacuum and Air Piping V049-2-178**
- Attachment L .....Concrete Floor Reinforcement Details and Layouts**
- Attachment M.....Concrete Anchor Installation Procedure V049-1-101**
- Attachment N.....Equipment Rigging and Handling Procedures V049-2-123**
- Attachment O.....Washington Installation Document Revision List**

**SPECIFICATION**

Number	Rev
<b>A V049-2-021</b>	<b>3</b>

## 1.0 INTRODUCTION

- 1.1 This specification covers the installation and commissioning of the Vacuum Equipment for the LIGO Project at Hanford, WA. The Livingston, LA site is covered by a separate specification

The LIGO (Laser Interferometer Gravitational-Wave Observatory) project is a scientific facility designed to detect gravitational waves. The vacuum equipment is installed in five buildings throughout the site.

The buildings, foundations and vacuum enclosures between each of the buildings is provided by others.

The location for the scope of work of this specification is the LIGO facility in Hanford, WA. (Actual location: Rt. 10, (Mile Marker 2), Richland, WA)

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) installed inside a vacuum enclosure, vacuum pumping systems and other support facilities.

## 2.0 DEFINITIONS

- 2.1 Where the word "Buyer" is used in this specification, it shall be understood as referring to Process Systems International, Inc. (PSI).
- 2.2 Where the word "Owner" is used in this specification, it shall be understood as referring to California Institute of Technology and the US Government.
- 2.3 Where the word "Contractor" is used in this specification, it shall be understood as referring to the Successful Bidder designated by the Buyer to supply all items required to successfully complete the Scope of Work.
- 2.4 Where the word "Scope of Work"/"Work" is used in this specification, it shall be understood as referring to all items of work required to complete the work defined in this specification, indicated on the project drawings, or enumerated in the project specifications.
- 2.5 Where the word "Subcontractor" is used in this specification, it shall be understood as referring to any party designated by the Contractor to supply items required to complete the scope of work, subject to Buyer's acceptance.

### SPECIFICATION

Number

**A** V049-2-021

Rev

**3**

2.6 The term "Joint Occupancy" as used in this specification means the time the individual buildings can be occupied by the LIGO Project staff, its equipment contractors, including it's Construction Contractor to finish and close out the final inspection items. The Vacuum Equipment Contractor shall perform the installation effort under this Purchase Order on a "non-interference by others" basis.

### 3.0 SITE VISIT

3.1 The Contractor shall visit the job site and familiarize himself with the site conditions, local unions and proposed facilities, carefully examining local conditions, together with investigating all other possible conditions that may affect costs, complicate, delay, or otherwise obstruct the progress of the Work and include description and costs associated with such conditions in their proposal.

Selected LIGO site building drawings are included in this package (Attachment G&L). Other building drawings will be provided on an as needed basis.

### 4.0 CONTRACTOR CONTACTS

4.1 After award, all Contractor questions should be directed to:  
Mr. David Evers  
Process Systems International, Inc.  
20 Walkup Drive  
Westborough, MA 01581  
Phone: (508) 898-0206  
FAX: (508) 898-0322

### 5.0 PERMITS AND CODES

5.1 Before starting work on this project, it shall be the responsibility of the Contractor to make certain that all necessary permit, license and approvals are obtain for performance of the work at the site. Contractor shall obtain such permits, license and approvals at their own expense and furnish copies to the Buyer. The Buyer will provide drawings stamped by a Washington state professional engineer for obtaining permits.

5.2 The Contractor shall include in their Lump Sum Bid all costs associated with performing the work in compliance with Federal, State, and Local codes and standards governing the Work.

## SPECIFICATION

Number

**A** V049-2-021

Rev

**3**

5.3 Codes And Standards

5.3.1 Unless otherwise required, material and workmanship shall conform to and comply with current editions and the latest revisions of applicable codes and standards.

5.3.2 The following codes and standards, as applicable, shall be followed for the procurement, installation and testing of the equipment and piping:

- AISC - American Institute of Steel Construction
- ANSI - American National Standards Institute
  - B16.1 Cast Iron Pipe Flanges
  - B16.5 Steel Pipe Flanges
  - B31.1 Also For Utilities
  - B31.3 Chemical Plant and Petroleum Refinery Piping
  - B31.9 Building Services Piping
- ASME - American Society of Mechanical Engineers
  - Section VIII, Pressure Vessels
  - Division I Boiler and Pressure Vessel Code
  - Section IX, Welding Qualifications
- ASTM - American Society for Testing Materials
- AWS - American Welding Society Welding Symbols
- NEMA - Motors and Generators, MG-1
- OSHA - Occupational Safety and Health Act Noise Standard
- SSPC - Structural Steel Painting Council
- Applicable - Local Codes and Standards

5.4 Specification Compliance

5.4.1 Work shall comply with drawings, data sheets, standards, codes and specifications referred to herein or attached as part of this specification. Applicable national, state or local codes, standards, and regulations shall be considered as part of this specification. The Contractor is responsible for compliance with such standards, specifications, codes or regulations.

5.4.2 The Buyer's Installation Manager or his designee shall be advised by the contractor of all scheduled inspections by regulatory agencies, and be allowed the option to witness such inspections.

<b>SPECIFICATION</b>	
Number	Rev
<b>A</b> V049-2-021	<b>3</b>

5.4.3 Conflicts between documents or incomplete technical information shall be brought to the attention of the Buyer and resolved at the time of quotation. After contract award, the contractor shall identify all conflicts for resolution prior to executing the work. The most stringent requirement will be considered to be incorporated into their lump sum price.

## 6.0 SAFETY REGULATIONS

- 6.1 A site specific safety plan shall be developed by the Contractor, complying with Federal OSHA regulations.
- 6.2 The Contractor shall also comply with the Owner's on-site Construction Safety, Health and Environmental Management program.
- 6.3 The Contractor shall be fully responsible for providing first aid equipment and other safety equipment required for his personnel (including subcontractors).
- 6.4 The Contractor shall designate a person to be responsible for safety management at the site. Contractor shall conduct weekly safety meetings with their crew and send a representative to all site wide safety meetings.
- 6.5 To ensure safety, the Contractor is responsible for supporting and bracing partially installed equipment.

## 7.0 GENERAL REQUIREMENTS

- 7.1 This specification covers installation and commissioning activities for the LIGO Vacuum Equipment systems. The vacuum equipment will be installed indoors (except for the LN<sub>2</sub> tanks and vaporizer systems) in five site buildings (provided by others). The buildings will be complete (except for minor punch list items) prior to vacuum equipment installation. The Contractor shall have joint occupancy of the buildings on a staggered schedule as defined in the Purchase Order and LN<sub>2</sub> foundations as defined in Section 2.6.
- 7.2 It is the intent that the Work be executed in accordance with the Project Drawings and Project Specifications by qualified craft persons. It is not intended that the Project Drawings, Project Specifications including this Specification enumerate every possible eventuality that the Contractor may encounter before completing the Work. The Contractor represents that he has practical construction knowledge and experience in performing the Work. Therefore, the Contractor shall review and inspect all facilities and equipment and materials supplied to him to ensure correctness and suitability for interfacing with the Contractor's Scope of Work.

### SPECIFICATION

Number

**A** V049-2-021

Rev

**3**

Additionally, the Contractor shall provide materials required (beyond what is identified in contract documents as furnished by others) to complete the Scope of Work. Interferences among pipe, conduit, steel, etc., where occurring in limited instances, shall be considered normal working circumstances and to have been included in the Contractor's Lump Sum Bid and, therefore, shall not be reimbursable by the Buyer. Minor errors or interferences, and problems due to lack of field verification or error shall be corrected at the Contractor's expense.

- 7.3 Bid shall state what work the Contractor intends to subcontract and their proposed subcontractors. The Contractor is responsible for the performance of subcontractor(s) and will assume the responsibility for supervising each subcontractor(s). The Buyer's written acceptance will be required of each Subcontractor. The Buyer will be furnished a copy of each subcontract.
- 7.4 The contract uses the June 1995 Hanford Labor Rates in accordance with the Project Labor Agreement LIGO-C950331-00-P. Any rate increases at a later date will be a change order to the contract.
- 7.5 The Contractor shall be responsible for examination and inspection of his Subcontractors' work to assure that it complies to the specifications and standards and that the work performed is of good workmanship quality.
- 7.6 Materials provided by the Buyer are detailed in Section 11.0.
- 7.7 "Hold" or "Later" shown on Drawings indicate that final dimensions and details have not been determined. Contractor shall include these areas in their Scope of Work or Bid Proposal to the extent presented on these Drawings. Actual work shall not be executed by the contractor until the "Hold" or "Later" is removed.
- 7.8 The Contractor's Work must be coordinated in the field through the Buyer's Installation Manager.
- 7.9 The Contractor shall be responsible for daily cleanup and removal of debris, rubbish, etc. as the result of the Work from the job site. Rubbish and debris resulting from the Work shall be removed and legally disposed. Before project completion, the contractor shall remove equipment, scaffolding, tools, temporary services and utilities. If the Contractor refuses, the Buyer shall take necessary steps to cleanup the Contractor's debris, rubbish, etc. and charge associated costs to the Contractor's account.

**SPECIFICATION**

Number

**A** V049-2-021

Rev

**3**



Title: SPECIFICATION FOR LIGO VACUUM EQUIPMENT INSTALLATION AND COMMISSIONING WASHINGTON SITE

7.10 Building cranes are not capable of lifting all vacuum equipment components (see Attachments B&C). The Contractor will provide equipment for lifting and alignment of the components. The Contractor is responsible for providing all other lifting devices, dollies and handling equipment.

All equipment shall be lifted and handled in strict conformance to this specification.

NOTE: It is noted that certain equipment, namely Beam Splitters, will be delivered in a horizontal position and must be rotated to a vertical position. After offloading this equipment, the contractor shall rotate these components to the vertical position without damaging the equipment. It may be necessary for the contractor to provide two cranes for this task. The contractor shall not apply lateral loads to the lifting lugs.

NOTE: Inside the site buildings, only electric drive equipment is allowed (no propane or diesel equipment).

7.11 Contractor shall furnish with the bid a detailed construction and staffing plan and schedule which specifies the resources and time required to complete the Work (including a list of the different union crafts to be utilized).

7.12 A representative of the Contractor will be required to attend weekly status meetings with the Buyer. Status meetings will be conducted by the Contractor with the Buyer's personnel to review the past week's progress and the next week's planned activities. A Two Week Look Ahead Schedule, (updated weekly) and staffing plan will be provided by the Contractor at weekly Progress Meetings (tentatively set for Monday mornings). Q.A. and safety reports shall also be reviewed. Meeting minutes shall be issued within two (2) working days of each meeting.

7.13 Buyer's field representatives and the Owner shall have the right to review Contractor's work, material, equipment and procedures as is applicable to ensure the Work is in compliance with the Specifications. The Contractor shall provide tools, instruments, etc. necessary to facilitate these reviews. As a minimum, the Buyer will verify the installation location of each vessel (HAM, BSC, etc.). See Alignment Procedure V049-2-174 in Attachment E.

7.14 The Contractor shall cooperate with Buyer's field representative in establishing a schedule of the various reviews or verifications to be performed during the progress of the Work. Buyer's field representative shall designate which events they wish to witness, and the Contractor shall furnish an agreed upon amount of notification prior to the start of each event.

**SPECIFICATION**

Number

**A V049-2-021**

Rev

**3**

Title: SPECIFICATION FOR LIGO VACUUM EQUIPMENT INSTALLATION AND COMMISSIONING  
WASHINGTON SITE

- 7.15 Contractor's field representative shall confirm by examination and tests, specified or usually used for such purposes, and submit a written report to the Buyer that the material, equipment and field installation Work conforms to the requirements of the Contract Documents including, but not limited to:
- a) The Purchase Order
  - b) The Specifications
  - c) Applicable Codes and Standards
- 7.16 The presence or activity of the Buyer's field representative shall not relieve the Contractor in any way of his obligation to maintain an adequate inspection program of his own or of other obligations under this specification. Furthermore, the fact that Buyer's field representative may inadvertently overlook a deviation from some requirement of this specification shall not constitute a waiver of that requirement, of the Contractor's obligation to correct the condition when it is discovered, or of other obligations under this specification.
- 7.17 Buyer's field representative has the authority and responsibility to stop any portion of the Work which, if continued, would make compliance with some other requirements of the specifications difficult or impossible.
- 7.18
- 7.19 The Contractor is responsible for manning the project with the number of people necessary for the Work to achieve the completion dates indicated on the approved schedule and, if it is necessary, shall work shift work and/or overtime to meet the completion dates in the Purchase Order at no additional cost to Buyer.
- 7.20 The Contractor's progress will be monitored on a weekly basis by the Buyer. If it becomes apparent to the Buyer during the monitoring of the progress of the work that a slippage in the schedule has occurred, the Buyer shall direct and the Contractor shall provide at no increase in cost to the Buyer, additional people, additional equipment, overtime and shift work to achieve the schedule. The Contractor shall maintain the corrective measure taken until the Buyer has agreed that the current progress agrees with the original project progress curve.
- 7.21 Contractor shall, at all times, have a competent Superintendent on the premises to represent him and to whom instructions may be given until final acceptance of the Work.
- 7.22 The Contractor's work, including testing is be subject to Buyer's review. The Contractor shall maintain records of tests made during the course of the job and transfer these records to the Buyer at the end of the job. The Contractor shall maintain quality control to ensure that quality requirements are met. Contractor shall submit proposed QC/QA plan and procedures no later than one month after he has been awarded the contract.

**SPECIFICATION**

Number

**A V049-2-021**

Rev

**3**

- 7.23 The Contractor shall take measurements to avoid damaging all structures, building walls, cables, conduits, pipelines, wells, fences, paving and other facilities within or adjacent to the work site. Damages shall be promptly repaired by the Contractor at his expense, including all premium time, to the satisfaction of the Buyer.
- 7.24 The Contractor's material storage shall be confined to those areas which the Owner designates as construction laydown areas. Laydown, fabrication, and painting activities are limited to areas specifically designated by the Buyer.
- 7.25 Contractor and Contractor's subcontractors shall abide by the rules and procedures the Owner has in effect at the job site pertaining to the performance of the work, materials, tools, and equipment. Contractor shall be responsible for personnel in his employment and shall take appropriate disciplinary action, including dismissal for the violations to these rules and procedures. These rules and procedures include, but are not limited to, the following:
- 7.25.1 Prior to installation, the Contractor and his personnel shall become familiar with the safety guidelines of the Owner.
- 7.25.2 Firearms or other weapons of any kind are strictly prohibited within or around the job site.
- 7.25.3 No alcohol or drugs of any kind will be allowed within or around the job site. Use of drugs or alcohol on the job site is grounds for dismissal.
- 7.26 Contractor shall maintain record drawings as follows:
- 7.26.1 At the site, maintain a set of prints marking them to accurately reflect the actual installation including changes in sizes, locations, and dimensions as the work progresses.
- 7.26.2 On a daily basis, trace over the prints with a highlighter (marker) to indicate work installed. Make these prints available to Owner's and the Buyer's representatives.
- 7.26.3 At completion of project, transfer information from your marked prints onto master prints and deliver drawings including marked prints to the Buyer's project manager.
- 7.27 Construction Installation Review
- 7.27.1 The Contractor shall participate in an installation readiness review (at the site) one month prior to mobilizing on the site. The Contractor shall present their plan (schedule, procedures, Q.A. plan, etc.) for Vacuum Equipment site installation for approval by the Buyer.

**SPECIFICATION**

Number

**A V049-2-021**

Rev

**3**

7.28 Documentation

7.28.1 The Buyer will issue to the Contractor, one (1) set of prints of Drawings and Specifications. "C" size and larger drawings will be issued as a reproducible vellum. A master set (with as-built information) shall be maintained throughout the installation contract.

7.28.2 Equipment/material identification tags shall not be removed.

7.29 Temporary Construction Water

A source of water for construction purposes will be available to the Contractor.

7.30 Temporary Sanitary Facilities

The Contractor is required to provide and maintain temporary sanitary toilets for the use of personnel employed by the Contractor, Subcontractor and others engaged in their work. These facilities shall conform to the requirements of all state, county and local ordinances.

7.31 Temporary Storage Facilities/Parking

The Buyer's representative will designate areas and locations for the temporary storage of personnel trailers, materials, tools, equipment and contractor parking.

7.32 Vacuum Equipment Operation

It shall be the responsibility of the Buyer to operate all vacuum equipment, in accordance with ultra high vacuum practice and vendor instructions. The Buyer will direct union crafts, when required, to operate vacuum equipment.

7.33 Disposition Of Debris Cleanup And Demobilization

7.33.1 No debris shall be allowed to accumulate in or be in contact with existing equipment or in such a manner as to interfere with normal, convenient and safe operations of the Work (daily cleanup is required).

7.33.2 The Contractor shall remove and dispose of construction debris from the work areas, including temporary facilities and utility connections, unless otherwise directed by the Buyer's representative. This demobilization phase of the Work shall be accomplished before construction will be considered complete.

7.33.3 Parking areas must be kept clean and neat at all times.

**SPECIFICATION**

Number

**A** V049-2-021

Rev

**3**

**7.34 FINAL ACCEPTANCE**

7.34.1 Final acceptance of the fixed price lump sum work required by the Specifications shall be on a building by building basis. This acceptance shall be given after all fix price lump sum cleanup operations and tests have been completed.

**7.35 BILLING**

7.35.1 Invoices for work performed under this specification shall be clearly identified with the Job Title, Job Number and Purchase Order Number. Prior to issuance of invoices, the invoice will be reviewed with the Buyer's Installation Manager for approval of progress achieved during the billing period. The Contractor shall propose payment milestones with their proposal.

7.35.2 Approved invoices shall then be submitted for payment of Work completed (percent progress) to:

Mr. Ron Bento  
Process Systems International  
20 Walkup Drive  
Westborough, MA. 01581-5003

**8.0 SCOPE OF WORK**

**8.1 General**

This specification covers the installation and commissioning of the LIGO Vacuum Equipment System. The system is installed into five site buildings provided by others.

The vacuum system consists of major vessels (BSC, HAM, 80K pumps, and spools), portable clean rooms and support equipment (vacuum pumps, skids, class 100 air skids, utility headers, instrumentation, valves, etc.). Major vacuum equipment has been fabricated with flanged connections (double o-ring seals) which requires only alignment, bolting together and anchor bolts to install.

All major vessels and skids have been fabricated and tested by the Buyer prior to the start of installation. (See Attachment C).

The Contractor shall include all costs associated with providing labor including supervision and transportation labor, materials, construction equipment, tools, construction supplies, consumables, required warehousing, temporary facilities and services to offload, receive, warehouse, and complete the installation of the equipment, piping and miscellaneous structural steel work (pipe supports etc.) and all other required Work indicated in the Specifications and Drawings to the satisfaction of the Buyer. Component shipping configurations are detailed in Attachment J.

<b>SPECIFICATION</b>	
Number	Rev
<b>A V049-2-021</b>	<b>3</b>

**Title: SPECIFICATION FOR LIGO VACUUM EQUIPMENT INSTALLATION AND COMMISSIONING  
WASHINGTON SITE**

The Contractor shall offload, receive, clean, inspect, assemble as required, erect, place and precision align, install anchor bolts, shim, bolt down, grout and test all required equipment as shown on P&ID, installation drawings and detailed in this specification.

The Contractor may also be asked to assist in additional commissioning and testing of the LIGO vacuum system on a time and material basis. The Bidder shall state in their proposal the applicable T&M rates.

All vacuum equipment must be installed and commissioned in a clean room environment. Any time a vessel is to be opened (for inspection, bolting to other equipment, etc.) it must be protected by a portable class 100 clean air system(assembled by the Contractor). These systems require 2-3 hours to clean up a class 100,000 environment (normal building environment) to class 100 after the class 100 clean room system is started. Portable clean rooms will be provided by the Buyer for assembly by the Contractor (6-BSC type/1 HAM type/5 gowning type).

8.1.1 Lifting of major equipment items will be performed in accordance with specific requirements and procedures listed in Attachment N. Equipment sizes and weights are detailed in this installation package. Building crane capacity and coverage is detailed in Attachment B.

8.1.2 All equipment is shipped internally clean (to class 100) and closed with bolted shipping covers.

8.1.3 The Contractor shall detail, fabricate, paint and deliver miscellaneous structural steel and pipe supports as required in accordance with Contract Documents. All vessels or major spool supports are provided by the Buyer. (See Attachment I).

8.1.4 The Contractor shall include in his lump sum bid:

8.1.4.1 Costs of moving his equipment around the site.

8.1.4.2 Cost of erecting a temporary wood and plastic shelter to clean equipment.

8.1.4.3 Costs for initial assembly of portable clean rooms supplied by the buyer.

8.1.4.4 Costs for building survey layouts required to properly locate and set equipment and the work (including WA registered land surveyor) from the Owner supplied benchmarks (per Specification V049-2-174).

8.1.4.5 Contractor shall fabricate, clean, install and anchor the corner station pipe bridge.

8.1.4.6 Contractor shall perform touch-up painting on all steel surfaces per V049-2-139

**SPECIFICATION**

Number

**A V049-2-021**

Rev

**3**

8.2 Equipment Receiving And Preliminary Cleaning

8.2.1 The Contractor will receive and offload LIGO vessels and equipment at the site.

The Contractor shall pre-clean all vacuum vessels and components external surfaces in the designated clean area before equipment is moved into the buildings and pre-positioned in Corner, Mid and End Stations (steam clean only).

The Contractor shall remove temporary shipping braces prior to moving the equipment into the buildings.

8.2.2 The Contractor shall receive, handle and store all material in accordance with the following:

V049-2-120 Raw Material Handling

V049-2-119 Contamination Control Plan

V049-2-124 Control of Non-Conformance

8.3 Equipment Setting And Alignment by the Contractor

8.3.1 Vacuum components along the beam line (BSC, HAM, 80K Pumps, Spools, Gate Valves with Supports)

A. Vacuum Equipment along the beam line shall be aligned using optical alignment equipment per Procedure V049-2-174.

B. The Contractor shall set and align the LIGO vacuum system per the Buyers installation drawings and installation plan. The center line of all beam tube nozzles must be aligned  $\pm 2$  mm in both transverse directions and to within 25 mm of the design position in the axial direction. Extreme care shall be used while setting and aligning components to avoid damage to the flange surfaces (32 RMS finishes) and bellows assemblies.

**Flange surfaces damaged while in the care, custody and control of the contractor, shall be repaired at their expense, to the satisfaction of the buyer.**

The contractor shall make arrangements for repairing damaged flange surfaces, if required, prior to mobilization at the site.

**SPECIFICATION**

Number

**A** V049-2-021

Rev

**3**

- C. The Contractor will submit and validate an anchor bolt installation procedure to be approved by the Buyer.
- D. Gate valves to be aligned and supports installed and adjusted to support the gate valve in its final alignment position.
- E. Ports shall be pre-cleaned and protected by a class 100 portable clean room anytime ports are opened. External surfaces of vessels shall be wiped down after the clean room is in place. The clean room environment must be at class 100 levels for 1 hour before opening any vessel or piece of vacuum beam line equipment. The vacuum system assemblies shall be prepared and assembled in accordance with Buyer's documents.
- F. After initial alignment, concrete anchor bolts shall be installed (per Specification V049-1-101). Vessels shall then be lifted back into place, final aligned, bolted into place and grouted (per Paragraph 8.3.5).
- G. Anchor bolts should be installed per Attachment "M"

<b>SPECIFICATION</b>	
Number	Rev
<b>A V049-2-021</b>	<b>3</b>



8.3.2 Vacuum Equipment Skids and Carts

- A. Pump carts in the main vacuum equipment rooms do not need to be connected to pipe connections along the vacuum headers and equipment to locate the anchor bolt locations. These anchor bolts shall be installed per Specification V049-2-175 and mechanical drawings. These anchor bolts (4 per cart) are now located off the pump out nozzle on the beam tube or 80K pumps and are to be installed per drawing V049-4-010 and V049-4-011.

The following list details pump cart locations requiring anchor bolt installation in each building:

**Corner Station**

Turbo Carts	6
Roughing Cart	4

**Mid Station**

Turbo Carts	4
Roughing Cart	0

**End Station**

Turbo Carts	2
Roughing Carts	0

NOTE: These anchor bolts are **NOT** installed per V049-1-101.

- B. Install all skidded vacuum equipment in the corner station mechanical rooms per the mechanical drawings. Anchor bolt and vibration isolation requirements are also shown on the mechanical drawings. (These anchor bolts are **NOT** installed per V0409-1-101). Do not grout this equipment.
- C. Install all skidded vacuum equipment in the mid and end station vacuum support equipment rooms per the mechanical drawings. Anchor bolt and vibration isolation requirements are also shown on the mechanical drawings. (These anchor bolts are **NOT** installed per V049-1-101). Do not grout this equipment.

**SPECIFICATION**

Number	Rev
<b>A V049-2-021</b>	<b>3</b>

8.3.5 Grout Requirements

Base plate grout shall be the flowable type and it shall meet with the requirements of ASTM C1107 for nonshrink, nonmetallic grout.

Tests per ASTM C579 specifications shall be performed, including strength tests, at the discretion of the PSI site manager on a T&M basis.

The minimum grout strength shall be 7000 psi at 28 days.

Acceptable grout products are:

1. Five Star Grout - manufactured by: Five Star Products.
2. Masterflow 928 - manufactured by: Masterbuilders
3. Masterflow 713 - manufactured by: Masterbuilders

Application:

NOTE: Grout must be mixed outside the vacuum equipment areas and applied in a manner to minimize contamination.

The undersides of all base plates shall be clean. The concrete surface shall be stripped of sealant and dampened prior to placing grout.

Grout shall be mixed, placed and cured in accordance with the manufacturers instructions. Care shall be taken during grout installation to avoid voids in the grout pad (proper vent holes, vibration, etc.)

Curing shall continue for a minimum of 7 days.

Grout test and QC inspection reports shall be provided to the Buyer.

8.3.6 Due to floor/beam tube center line angle/manufacturing tolerances, all beam line vessels (BSC, HAM, etc.) base plates will require an average of 3 inches of grout.

8.4 Vacuum Headers And Class 100 Air Piping

Vacuum headers and Class 100 piping shall be installed by the Contractor per the attached drawing list. In the vacuum building, vacuum headers and Class 100 piping run under the vacuum equipment. Piping shall be tested per this Specification. All vacuum headers and Class 100 piping will be supplied by the Contractor and are assembled using conflat flanges. Vacuum header and class 100 air piping materials are detailed in V049-2-037.

Note: Air inlets to all air compressors are to be fabricated from sheet metal gauge aluminum tube and adequately supported by the field contractor.

<b>SPECIFICATION</b>	
Number	Rev
<b>A V049-2-021</b>	<b>3</b>

8.4.1 Install main ion and annulus ion pumps and associated annulus tubing. Per the mechanical drawings, annulus tubing assemblies are to be pre-assembled by the Contractor and require flange and bracket bolting installation to install.

8.5 80K Pump System

The 80K pump system consists of an 80K pump vessel (shipped complete) and associated V.J. piping, S.S. piping (insulated), LN<sub>2</sub> tank, heater, vaporizer and miscellaneous valves and instruments (all provided by the Buyer for installation by the Contractor). The Contractor shall remove 80K pump shipping supports (in a Class 100 cleanroom). Shipping supports are bolted rods (10/pump) located inside on each pump and are accessible from each end. After the shipping supports are removed, four internal stainless steel sheet metal covers are screwed into place (5/end) to close up the pump.

LN<sub>2</sub> lines outside buildings shall be SCH 5S stainless steel. Lines that require mechanical insulation shall be insulated by the Contractor with material (supplied by the Contractor) and thickness as indicated on the P&ID's (per Specification V049-2-163).

The Contractor shall install the 80K pump system (8 total), including LN<sub>2</sub> tanks, supply, return, and regeneration piping per the attached drawings. The Buyer will provide the V.J. piping and all valves. The remaining piping and fittings are to be provided and installed by the Contractor.

The LN<sub>2</sub> tank area foundation and LN<sub>2</sub> tank anchor bolts are provided by the Buyer. The Contractor is responsible for installing the LN<sub>2</sub> tank and all associated equipment.

8.6 Testing

Per Section 9.0.

8.7 Electrical/Instrumentation Work

Electrical and installation work shall be accomplished per the attached Specification V049-2-022 (see Attachment A).

8.8 Piping Systems (Water, Air, LN<sub>2</sub>)

The Scope of Work includes, but is not limited to, the fabrication and installation of various utility piping systems as shown on the Project Drawings and P&ID's. S. S. utility piping to be installed and tested in accordance with ANSI B31.3. Copper lines shall be installed and tested per ANSI B31.9 "Building Services Piping". See specification for Piping Design and Materials Specification V049-2-037 for materials and classes.

**SPECIFICATION**

Number

**A V049-2-021**

Rev

**3**

Title: SPECIFICATION FOR LIGO VACUUM EQUIPMENT INSTALLATION AND COMMISSIONING  
WASHINGTON SITE

- 8.8.1 The Contractor shall supply all necessary welding procedures. Welding procedures shall be submitted by the Contractor to the Buyer for acceptance prior to commencement of welding. The Contractor shall qualify welding procedures and welders in accordance with ASME Boiler and Pressure Vessel Code, Section IX, latest edition. Most welding must be done outside the laser/vacuum equipment areas.
- 8.8.2 The Contractor shall protect piping systems from the entrance of moisture and foreign materials.
- 8.8.3 Vacuum Jacketed (VJ) Piping System materials will be furnished by Buyer. It is the responsibility of the Contractor to install these systems. VJ piping is assembled by connecting bayonet connections (no welding is required to install V.J. piping). One weld is required at the transition of V.J. to S.S. insulated piping.
- 8.8.4 Pipe penetrations are located in all walls. Walls will be closed after piping by others. The Contractor shall **not** cut any new holes in building walls without the owners approval.
- 8.8.5 The Contractor shall notify the Buyer, who will witness all tests, four (4) hours prior to test readiness. Test readiness means Contractor has verified system is leak-free. After testing, the Contractor shall safely vent test media from piping (pressure tests).
- 8.8.6 Utility piping systems shall be cleaned by the Contractor per the attached procedures (see V049-2-131).
- 8.8.7 The Contractor is responsible for inspecting piping materials furnished by others to ensure they are free of defects and damages prior to use.
- 8.8.8 The Contractor shall pneumatically pressure and leak check test the air and water utility piping systems including; but not limited to; vents, drains, pipe caps, flanges and blind flanges. The Contractor shall provide, all test gases. The gases shall be bottled nitrogen.
- 8.8.9 Material and equipment provided by the Contractor shall be new.
- 8.8.10 The Contractor is responsible for installing Buyer furnished valves (with mounted actuators) as indicated on the Buyer lists (Attachment C).

Valves with socket weld or butt weld connections are to have their seats and seals removed prior to welding installation (in accordance with manufacturers requirements) and then reinstalled after the valve has cooled.

<b>SPECIFICATION</b>	
Number	Rev
<b>A</b> V049-2-021	<b>3</b>

8.9 Equipment And Piping Insulation

8.9.1 Insulation shall be installed on equipment and piping as indicated on the Piping and Instrumentation Diagrams(P&ID's). The Contractor shall provide all insulation materials. Insulation to be installed by the Contractor per V049-2-163.

8.9.2 Insulation for piping inside buildings shall be installed on piping spools prior to installation.

8.10 Utilities

The Contractor is responsible for installing utility services (cooling water and instrument air) from the Buyer supplied points. The supply points are located in each building mechanical room.

The Contractor is responsible for installing all necessary temporary utility services to perform their work.

8.11 Pipe Cleaning - Vacuum Headers and Class 100 Piping

All vacuum headers and class 100 air piping shall be supplied cleaned by the Contractor per specification V049-2-178 listed in Attachment K.

9.0 TESTING

Required tests shall be conducted in the presence of the Buyer's representative. The Buyer's representative shall be notified at least 4 hours prior to the performance of a test. The Buyer shall determine if test results are acceptable. Costs for repairing failed items and re-testing shall be by the Contractor.

9.1 The Contractor shall conduct the following tests under the lump sum contract.

- A. LN<sub>2</sub> (V.J./LN<sub>2</sub> Piping) - Pressure decay for supply piping at 1.1 design pressure.(N2)
- B. Cooling Water - Pressure decay at 1.1 design pressure.
- C. Instrument Air - Pressure decay at 1.1 design press.
- D. Class 100 Air - Press decay at 1.1 design press.

9.2 The Contractor Shall assist the Buyer in other testing on a T&M basis as requested.

Typical tests:

- Helium Leak Tests
- Equipment bakeout (including blanket installation)
- 100 hour pumpdown test
- RGA Leak Testing

<b>SPECIFICATION</b>	
Number	Rev
<b>A</b> V049-2-021	<b>3</b>

9.3 Testing Equipment/Supplies

9.3.1 The Contractor shall provide equipment and gases/supplies required for leak testing on a T&M basis.

9.4 Leak Testing After Rework

9.4.1 Costs for additional pneumatic and leak testing due to defects or errors by the Contractor shall be performed at no additional cost to the Buyer.

9.5 Test Records

9.5.1 Written records in the form of log book entries or reports of leak detection tests will be made and retained for transfer to Buyer after acceptance.

**10.0 MATERIAL/SERVICES PROVIDED BY CONTRACTOR**

10.1 Unless specified as furnished by the Buyer, the Contractor shall provide materials, equipment, etc., including but not limited to the following:

10.1.1 Materials indicated on the Drawings or required by the Specifications and not indicated as by others.

10.1.2 Corner station pipe bridge by contractor

10.1.3 Materials required to perform pneumatic testing.

10.1.4 Equipment and materials (gases, etc.) required to perform leak detection by Helium Sensitive Mass Spectrometer (on a T&M basis).

Quan: 2

Type: Mass spectrometers helium leak detector (dry type/no oil flooded pumps or bearings) with a minimum sensitivity of  $2 \times 10^{-10}$  torr-liters/sec.

10.1.5 Commodities required for the electrical work.

10.2 The following shall also be provided by the Contractor:

10.2.1 Consumables such as weld filler materials, backing gases, test gases, concrete anchors, shims and grout.

10.2.2 Cranes, hoists, welding machines, and other construction equipment and tools including small tools and expendable items necessary to execute the scope of work.

10.2.3 Class 100 O.D. tubing, vacuum header O.D. tubing, annulus O.D. tubing to include all fittings, gaskets, flex hoses and bolt-up hardware.

**SPECIFICATION**

Number

**A** V049-2-021

Rev

**3**

Title: SPECIFICATION FOR LIGO VACUUM EQUIPMENT INSTALLATION AND COMMISSIONING  
WASHINGTON SITE

- 10.3 The Contractor shall be responsible for receiving and storing materials, including those supplied by Buyer, associated with this Work. Material receiving and inspection reports shall be made available to the Buyer at his request.
- 10.4 Pipe supports provided by the Contractor. All pipe supports and gate valve supports as indicated on the piping GA's indicated by the designations PS-1 thru PS-6 (see dwgs. V049-4-072; 073, 074, 075, 076, 082 and gate valve supports per drawings V049-4-033 and 034) are to be supplied by the Contractor per the PSI drawings at the locations shown. The pipe supports as shown, are for the stainless steel O.D. vacuum and class 100 air piping headers, or LN<sub>2</sub> piping on Tee posts, these spans range from approx. 12ft to 18ft.

NOTE: Supports PS-2, PS-4, and PS-4A are intended to also provide support for electrical conduits and wire ways.

NOTE: Additional support (PS-2 type) will need to be provided at intermediate intervals, between the supports shown, to support the 1" or 1/2" dia. copper cooling water/instrument air tubing or electrical conduits.

These intermediate supports should provide max. unsupported spans of (6) six feet for 1/2" copper, and (8) eight feet for 1" copper.

The Contractor is to include in his scope the materials, fabrication, painting of any carbon steel supports, and installation of all the supports mentioned in this paragraph.

10.4.1 Supports for tubing running under the Beam Tube Manifold are not allowed to be supported off the vacuum equipment legs. Pipe supports are to be supported off the floor.

10.4.2 All supports are to have vibration isolation rubber pads between the tube and the support metal, except insulated piping which is to be supported outside the insulation per Fig. D4, in insul. spec. V049-2-163

10.4.3 Pipe guides using nickel plated u-bolts are required on all headers at a maximum of 30 ft. intervals. The u-bolt must be isolated from the support member and u-bolt by adding an 1/8" thick silicon rubber 360 wrapper at each u-bolt. See detail "A" on revised drawing V049-4-073. This is also required on bare piping supported by tee post supports outside of buildings.

10.4.4 Support points for insulated piping inside and outside the buildings, the Contractor is to provide high density support cradles as shown in Figure D4 of Specification V049-2-163.

**SPECIFICATION**

Number

**A V049-2-021**

Rev

**3**

## 11.0 MATERIALS FURNISHED BY OTHERS/BUYER

The following material and facilities are provided by others:

- 11.1 Major Equipment items as shown on P&ID's. (See Attachment C)
- 11.2 Control valves, relief valves, rupture discs, automatic on/off - valves shown on P&ID's, Piping Drawings and Project Documents.
- 11.3 Hand valves - shown on P&ID's, Piping Drawings and Project Documents.
- 11.4 Special materials (SP symbol on P&ID) shown on P&ID's, Piping Drawings and Project Documents.
- 11.5 Vacuum jacketed piping systems as shown on piping Drawings and project Documents.
- 11.6 Instruments as shown on the P&ID.
- 11.7 Bolts, nuts and washers to bolt up equipment and beam tube manifold spool flanges.
- 11.8 Site buildings and roads.
- 11.9 Class 100 clean rooms.
- 11.10 Site utilities (cooling water, electricity, etc.).
- 11.11 Liquid nitrogen.

NOTE: The Contractor shall return to the Buyer any shipping skids and surplus materials furnished by the Buyer.

NOTE: Special bolts and washers are needed to bolt spool flanges to 44 in. & 48 in. gate valves. The bolts and washers will be supplied in each building bill of materials. Shipping bolts shall not be used to attach spools to the gate valves. The gate valves have 1 in. deep tapped holes. Use bolts PSI part no. 203567 with washers PSI part no. 203568

## 12.0 PROJECT DOCUMENTS LIST

The Contract Documents shall be as shown in Attachment A.

SPECIFICATION	
Number	Rev
<b>A</b> V049-2-021	<b>3</b>



**13.0 SCHEDULE OF THE WORK**

The installation phase shall be completed in 26 weeks starting from joint occupancy. The joint occupancy is currently defined by the Purchase Order. The Contractor will be required to attend an Installation Readiness Review one month prior to joint occupancy. The Contractor is also expected to be mobilized prior to joint occupancy and ready to start work at joint occupancy.

**14.0 BASIS OF BID**

14.1.1 See Equipment Installation Commercial Requirements V049-2-170 for complete terms and conditions and project tax status.

14.1.2 The Firm Total Lump Sum Bid (subject to labor escalation only) is to include all direct and indirect costs, including all profit associated with performing the Scope of Work associated with the project specifications, together with each and every item of expense for all supervision, tools, construction equipment, labor, materials, and other services necessary to perform the Work.

Labor rates use by the Contractor shall be per Spec. V049-2-170. Changes in labor rates from these levels will form a basis for changes to the lump sum price.

14.1.3 Price is to be fixed lump sum, valid for a period of 10 months from time of submittal to the Buyer.

14.1.3.1 The Fixed Lump Sum Price Labor(L) and Material(M)for each building's work shall be broken out separately with direct labor hours specified. The Contractor will submit, separate Price Breakdowns as listed on the RFQ pricing sheet.

14.1.3.2 Scope change pricing formula is to be provided and shall be utilized for evaluating and costing any revisions, additions, and deletions and new drawings issued to the Contractor's scope to provide.

14.1.3.3 Contractor will propose a method/formula for changes in labor rates specified herein V049-2-170 Attachment B.

**SPECIFICATION**

Number

**A** V049-2-021

Rev

**3**

**15.0 SELECTION OF THE CONTRACTOR**

Selection of a contract will be made from proposals submitted under this inquiry with special consideration given to the ability of the Contractor to who presents his understanding of what is required to perform this Scope of Work and complete the Work in accordance with the Schedule. Bidders under consideration may be required to review their estimate in the Buyer's office prior to contract award. The review will include a review of takeoff quantities sufficient to assure Buyer that the Contractor understands the Scope of Work. The Buyer reserves the right to reject any and all bids for any reason.

**SPECIFICATION**

Number	Rev
<b>A</b> V049-2-021	<b>3</b>

**ATTACHMENT "A" SPEC. V049-2-021**  
**PROJECT INSTALLATION/COMMISSIONING**  
**DOCUMENT LIST – WASHINGTON SITE**

<b>WASHINGTON SITE</b>	<b>DRAWING SIZE</b>	<b>DOCUMENT NUMBER</b>
<b>P&amp;ID's</b>		
Legend/Station Diagrams (3 Shts.)	D	V049-0-001
Beam Splitter Chamber All But Corner Vertex Arms	D	V049-0-002
Beam Splitter Chamber Corner Vertex Arms	D	V049-0-003
Horizontal Access Module	D	V049-0-004
112cm & 122cm Gate Valves	D	V049-0-005
80K Cryopump	D	V049-0-006
Chamber Pressurization System	D	V049-0-007
WA Left End Station	D	V049-0-010
WA Left Mid Station	D	V049-0-011
WA Left Beam Manifold	D	V049-0-012
WA Vertex Section	D	V049-0-013
WA Diagonal Section	D	V049-0-014
WA Right Beam Manifold	D	V049-0-015
WA Right Mid Station	D	V049-0-016
WA Right End Station	D	V049-0-017
WA Corner Station Mechanical Room	D	V049-0-018
Washing Station	D	V049-0-031
<b>DRAWING/ BOM STRUCTURE</b>		
General Project (Sht. 1 of 3)	D	V049-0-100
Washington Site (Sht. 2 of 3)	D	V049-0-100

**ATTACHMENT**

Number: <b>A V049-2-021</b>	Rev. <b>3</b>
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**ELECTRICAL DRAWINGS**

For Electrical Drawing List See Drawing V049-3-001  
Rev. 2 Sheet 1 of 2 and 2 of 2

**APPLICABLE SPECIFICATIONS**

For Spec. Revision Level see Gen.Doc. List V049-0-000

- Anchor Bolt Installation Procedure
- Leak Check Procedure
- Installation/Commissioning Spec.
- Electrical and Instrument Construction Spec.
- Project Safety Plan
- Project Q.A. Plan
- Piping Design and Material Specification
- Welding Procedures
  
- Material/Welding Repair Procedure
- Isolatable Section Bakeout Procedure
- Clean Room Activities
- Contamination Control Plan
- Raw Material Handling Procedure
- Component Packaging, Handling and Shipping
- Control of Non-Conformance
- Visual Inspection Procedure
- Black Light Test Procedure
- Site Piping Cleaning Procedure
- Site Vacuum Surface Re-Cleaning Procedure
- RGA Calibration
- Structural Carbon Steel Fabrication and Painting
- Thermal Insulation – Piping
- 80K Pump Relief Valve Spec.
- Conflat Flange Assembly Procedure
- O-Ring Installation and Flange Assembly Procedure
- Component Alignment Procedure
- Vacuum Pump Field Installation Procedure

**DOCUMENT NO.**

- V049-1-101
- V049-2-014
- V049-2-021
- V049-2-022
- V049-2-023
- V049-2-029
- V049-2-037
- V049-2-070
- V049-2-071
- V049-2-072
- V049-2-073
- V049-2-074
- V049-2-116
- V049-2-118
- V049-2-119
- V049-2-120
- V049-2-123
- V049-2-124
- V049-2-128
- V049-2-130
- V049-2-131
- V049-2-132
- V049-2-137
- V049-2-139
- V049-2-163
- V049-2-164
- V049-2-168
- V049-2-169
- V049-2-174
- V049-2-175

**ATTACHMENT**

Number:	<b>A V049-2-021</b>	Rev.	<b>3</b>
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**II. COMPONENT ACCEPTANCE TESTS PROCEDURES**

For Spec. Revision Level see Gen.Doc. List  
V049-0-000

**DOCUMENT NO.**

80K Pumps	V049-2-102
Roughing Pumps	V049-2-104
Turbomolecular Pumps	V049-2-105
Ion Pumps	V049-2-106
Large Gate Valves	V049-2-107
6, 10, 14" Gate Valves	V049-2-108
Clean Air Supplies	V049-2-109
Portable Soft Wall Cleanrooms	V049-2-110
Small Valves	V049-2-111
Bakeout System Blankets and Carts	V049-2-112

**III. System Acceptance Test Procedures**

Corner Stations	V049-2-113 (Later)
Mid Stations	V049-2-114 (Later)
End Stations	V049-2-115 (Later)

**ATTACHMENT**

Number:	<b>A V049-2-021</b>	Rev.	<b>3</b>
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**WASHINGTON SITE**

**MECHANICAL DRAWINGS**

For Spec. Revision Level see Gen.Doc. List V049-0-000

	<b>DRAWING SIZE</b>	<b>DOCUMENT NUMBER</b>
Mechanical Drawing Index	D	V049-4-000
BSC Over All Assembly	D	V049-4-001
BSC Shell Weldment/Machining (4 Sheets)	D	V049-4-003
Horizontal Access Module (HAM) (5 Sheets)	D	V049-4-002
80K Cryopump, Long Left Hand (2 Sheets)	D	V049-4-004
80K Cryopump, Short Right (2 Sheets)	D	V049-4-005
80K Cryopump, Long Right Hand (2 Sheets)	D	V049-4-006
80K Cryopump, Short Left Hand (2 Sheets)	D	V049-4-007
Roughing Pump Cart Arrangements	D	V049-4-010
Turbo Pump Cart Arrangements	D	V049-4-011
Base Extension - Turbo Pump Cart	D	V049-4-012
Cover, BSC Type I	D	V049-4-014
48 1/4" I.D. Flange Detail (Grooved)	C	V049-4-018
44 1/4" I.D. Flange Detail (Grooved)	C	V049-4-017
60 1/2" I.D. BSC Flange Detail (Grooved)	C	V049-4-019
72 1/4" I.D. Flange Detail (Grooved)	C	V049-4-020
84 1/4" I.D. Flange Detail (Grooved)	C	V049-4-021
104 1/2" I.D. Flange Detail (Grooved)	C	V049-4-022
BSC Support Assy.	D	V049-4-023
BSC Annulus Piping	D	V049-4-025
72 1/4" I.D. Flange Detail (Flat Faced)	C	V049-4-028
48 1/4" I.D. Flange Detail (Flat Faced)	C	V049-4-029
60 1/2" I.D. HAM Flange Detail (Grooved) Sltd	C	V049-4-031
60 1/2" I.D. Flange Detail (Flat Faced)	C	V049-4-032
44" Gate Valve Support Frame	D	V049-4-033
48" Gate Valve Support Frame	D	V049-4-034
BSC Internal Platform Details	D	V049-4-036
HAM Tie Rod Assembly	D	V049-4-040
104 1/2" I.D. Flange Detail (Flat Faced)	C	V049-4-041
44 5/8" I.D. Flange Detail (Flat Face)	C	V049-4-042
Pipe Bridge - Corner Station	D	V049-4-043
BSC RGA/Aux. Turbo Conn. Assembly	C	V049-4-045
BSC RGA/Aux. Turbo/Gauge Pair Assy	C	V049-4-046
44 5/8" ID x 80 O.D. Flange Detail (Flat Faced)	C	V049-4-047
Vessel Support (HAM)	D	V049-4-052
Expansion Joint (HAM)	C	V049-4-053

**ATTACHMENT**

Number:	Rev.
<b>A V049-2-021</b>	<b>3</b>

**WASHINGTON SITE**

**MECHANICAL DRAWINGS**

For Spec. Revision Level see Gen.Doc. List V049-0-000

	<b>DRAWING SIZE</b>	<b>DOCUMENT NUMBER</b>
HAM Annulus Piping	D	V049-4-054
60 1/2" I.D. Ring Detail Reducing Union	C	V049-4-055
30 1/2" x 68.25 O.D. Flange Detail (Flat Faced)	C	V049-4-056
30 1/2" x 68.25 O.D. Flange Detail (Grooved)	C	V049-4-057
44 5/8" ID x 60 1/2" ID Flange Detail	C	V049-4-058
Shipping Cover with Air Filter	D	V049-4-059
44/25 ID Flange Detail (Grooved/Slotted)	C	V049-4-060
3/4" O.D. Elbow x 2 3/4" C.F. Flg Annulus Conn	B	V049-4-061
60.5" ID x 68.5 OD BE-3A Flange (Flat)	C	V049-4-064
60.5" ID x 72.25 OD Offset Flange (BE3A)	C	V049-4-066
61.31"ID x 72.25 OD BE-3A Flange (Grooved)	C	V049-4-067
48 1/4" ID x 60 1/2" ID Offset Flange	C	V049-4-068
48.81 ID x 68.25 OD Flg. Detail (Flat)	C	V049-4-070
48.81 ID x 80. OD Flg. Detail (Flat)	C	V049-4-071
PS-1 Pipe Support Tee Post (LN <sub>2</sub> Piping)	C	V049-4-072
PS-2 Pipe Support	C	V049-4-073
PS-3 Pipe Support Tee Post	C	V049-4-074
PS-4 Pipe/Electrical Support	C	V049-4-075
PS-5 Pipe Support @ 80K Long Pump	C	V049-4-076
75 L/S Ion Pump/Manifolds	D	V049-4-077
25 L/S Ion Pump/Manifolds	D	V049-4-078
48 1/4" ID x 68.25 OD Flange Detail	C	V049-4-079
Shipping Cover Assy	D	V049-4-080
80K Pump Reservoir Suppt, Assy, Short	D	V049-4-094
80K Pump Reservoir Suppt, Assy, Long	D	V049-4-095
25 L/S Annulus Tubing-44" G.V. Type III	C	V049-4-106
25 L/S Ion Pump Valve Support	D	V049-4-107
25 L/S Annulus Tubing 48" G.V. Type I	C	V049-4-108
Annulus Tubing & Ion Pump Assembly. 44" G.V.	D	V049-4-109
25 L/S Annulus Tubing 48"G.V. Type II	C	V049-4-110
80K Long - Shield Assy, RH/LH (3 SHTS)	D	V049-4-114
80k Short - Shield Assy, RH/LH (3 SHTS)	D	V049-4-117
Bellows Tie-Rod Assembly	D	V049-4-124
84" ID Access Cover - HAM	D	V049-4-127
BSC Clean Room Assembly - Style #1 & 3	D	V049-4-133
BSC Clean Room Weldment - Style #1 & 3	D	V049-4-134
BSC Clean Room Assembly - Style #2	D	V049-4-135

**ATTACHMENT**

Number:	Rev.
<b>A V049-2-021</b>	<b>3</b>

**WASHINGTON SITE**

**MECHANICAL DRAWINGS**

For Spec. Revision Level see Gen.Doc. List V049-0-000

	<b>DRAWING SIZE</b>	<b>DOCUMENT NUMBER</b>
Clean Room Assembly - HAM	D	V049-4-136
Clean Room Structure Weldment-HAM	D	V049-4-137
BSC Clean Room Weldment	D	V049-4-138
16 1/2" OD Conflat Reducing Flanges	B	V049-4-142
LN2 Tank Base Template	D	V049-4-145
Lifting Lug	D	V049-4-159
80K Pump 2" Jacketed Line	D	V049-4-161
Gate Value Fin Clamp	B	V049-4-163
25 L/S Annulus Tubing - 44" G.V. Type I	C	V049-4-164
Annulus Tubing & Ion Pump Assy 48" G.V.	D	V049-4-165
25 L/S Annulus Tubing - 44" G.V. Type II	C	V049-4-166
Assembly Back To Air Cart 50 cfm	D	V049-4-168
Assembly Back To Air Cart 100 cfm	D	V049-4-175
Regen. Electric Heater Assembly 4 in. dia.	D	V049-4-176
Regen. Electric Heater Assembly 6 in. dia.	D	V049-4-177
12" O.D. CF Blank x 2.75 O.D. CF	B	V049-4-194
12" O.D. CF Blank x 25 KF	B	V049-4-195
8" O.D. CF Blank x 25 KF	B	V049-4-196
10" O.D. Tube Bellows-Turbo Pump	B	V049-4-197
BSC Shipping skid Assembly	D	V049-4-199
BSC Annulus Tube Support	B	V049-4-203
BSC Air Filter Assembly	D	V049-4-204
HAM Annulus Tube Shipping Support	B	V049-4-206
BSC Test/Ship Assembly-Two Door	D	V049-4-302
BSC Test/Ship Assembly-Three Door	D	V049-4-303
BSC Test/Ship Assembly-No Doors	D	V049-4-304
BSC Test/Ship Assembly-One Door	D	V049-4-305
Adapter A-1, 44.62" ID x 72.25 ID, 3 Sheets	D	V049-4-A1
Adapter A-3, 48.25" ID x 60.5 ID, 2 Sheets	D	V049-4-A3
60" HAM Cover, Grooved Type A4, 2 Sheets	D	V049-4-A4
Adapter A-6, 48.25" ID x 60.5 ID, 2 Sheets	D	V049-4-A6
Adapter A-7A, 60.5" ID x 72.25 ID, 5 Sheets	D	V049-4-A7A
Adapter A-7B, 60.5" ID x 72.25 ID, 5 Sheets	D	V049-4-A7B
BSC End Cover 60.5" Type All	D	V049-4-A11
Adapter A-12, 48.25" ID x 60.5 ID, 2 Sheets	D	V049-4-A12
Adapter A-13, 60.5" ID x 72.25 ID, 2 Sheets	D	V049-4-A13
Adapter A-14, 44.62" ID x 60.5 ID, 2 Sheets	D	V049-4-A14

**ATTACHMENT**

Number:	<b>A V049-2-021</b>	Rev.	<b>3</b>
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**WASHINGTON SITE**

**MECHANICAL DRAWINGS**

For Spec. Revision Level see Gen.Doc. List V049-0-000  
 Adapter A-15, 48.25" ID x 60.5 ID, 2 Sheets

**DRAWING**

**SIZE**

**DOCUMENT**

**NUMBER**

	D	V049-4-A15
Spool B-1, 72.25 ID, 3 Sheets	D	V049-4-B1
Spool B-2A, 30.5 ID x 60.5 ID, 5 Sheets	D	V049-4-B2A
Spool B-2B, 30.5 ID x 60.5 ID, 5 Sheets	D	V049-4-B2B
Spool B-3A, 30.5 ID x 60.5 ID, 5 Sheets	D	V049-4-B3A
Spool B-4, 48.25" ID, 2 Sheets	D	V049-4-B4
Spool B-5A, 30.5 ID x 60.5 ID, 5 Sheets	D	V049-4-B5A
Spool B-6, 48.25" ID, 2 Sheets	D	V049-4-B6
Spool B-7, 48.25" ID, 2 Sheets	D	V049-4-B7
Spool B-8, 72.25" ID, 3 Sheets	D	V049-4-B8
Spool B-9, 72.25" ID, 4 Sheets	D	V049-4-B9
Spool BE-2, 60.5" ID, 2 Sheets	D	V049-4-BE2
Off Set Spool BE-3, 60.5" ID x 60.5 ID, 2 Sheets	D	V049-4-BE3
Off Set Spool BE-3A, 60.5" ID x 60.5 ID, 2 Sheets	D	V049-4-BE3A
Spool, BE-4, 44.62" ID, 2 Sheets	D	V049-4-BE4
Spool, BE-5, 72.25" ID, 5 Sheets	D	V049-4-BE5
Spool, BE-6, 72.25" ID, 5 Sheets	D	V049-4-BE6
Equipment Arr't. Plan, Corner Station WA Sht 1of 2	D	V049-5-001
Equipment Arr't. Elevation, Sht 2 of 2	D	V049-5-001
Equipment Arr't ISO, Corner Station, WA	D	V049-5-002
Equipment Arr't , Right Mid Station, WA	D	V049-5-004
Equipment Arr't , Right End Station, WA	D	V049-5-005
Equipment Arr't , Left Mid Station, WA	D	V049-5-006
Equipment Arr't , Left End Station, WA	D	V049-5-007
Equipment Arr't ISO, Right Mid Station, WA	D	V049-5-010
Equipment Arr't ISO, Right End Station, WA	D	V049-5-011
Piping Arr't, Plan Corner Station/WA (4 Shts)	D	V049-5-012
Piping Arr't, Elevation, Corner Station/WA	D	V049-5-013
Piping Arr't, Sections, Corner Station/WA	D	V049-5-014
Piping Arr't, Plan, Right Mid Station/WA (4 Shts)	D	V049-5-017
Piping Arr't, Elevation, Right Mid Station/WA 2Shts	D	V049-5-018
Piping Arr't, Sections, Right Mid Station/WA	D	V049-5-019
Piping Arr't, Plan, Right End Station/WA (2 Shts)	D	V049-5-021
Piping Arr't, Elevation, Right End Station/WA	D	V049-5-022
Piping Arr't, Sections, Right End Station/WA	D	V049-5-023
Piping Arr't. Plan Left Mid Station/WA (4 Sheets)	D	V049-5-026

**ATTACHMENT**

Number:

**A V049-2-021**

Rev.

**3**

**WASHINGTON SITE**

**MECHANICAL DRAWINGS**

	<b>DRAWING SIZE</b>	<b>DOCUMENT NUMBER</b>
For Spec. Revision Level see Gen.Doc. List V049-0-000		
Piping Arr't Elevation Left Mid Station/WA(2 Shts)	D	V049-5-027
Piping Arr't, Sections, Left Mid Station/WA	D	V049-5-028
Piping Arr't. Plan Left End Station/WA (2 Sheets)	D	V049-5-030
Piping Arr't Elevation Left End Station/WA	D	V049-5-031
Piping Arr't, Sections, Left End Station/WA	D	V049-5-032
Overall Flange Arr't, Corner Station, WA	D	V049-5-033
Overall Flange Arr't, Mid Station, WA	D	V049-5-035
Overall Flange Arr't, Type End Station	D	V049-5-036
Clean Room with BSC Assembly	D	V049-5-037
Survey Benchmarks-Corner Station-Washington	B	V049-5-050
Survey Benchmarks-Mid Station-WA & LA	B	V049-5-051
Survey Benchmarks-End Station-WA & LA	B	V049-5-052

**ATTACHMENT**

Number:	<b>A V049-2-021</b>	Rev.	<b>3</b>
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**ATTACHMENT "B"**  
**TO**  
**V049-2-021**  
**BUILDING CRANE COVERAGE**

**ATTACHMENT**

Number:	<b>A V049-2-021</b>	Rev.	<b>3</b>
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**CRANE DATA SHEET-1**  
**(3-Interferometer Version)**

1. Location: LVEA Corner Station
2. Number Required: One (1)
3. Tag No.: W-CS-102-CR-01
4. Arrangement: Refer to Figures 1 and 2
5. Type: Electric, Double-Girder Under-Running, 3-Runway
6. Number of Hoists: One(1)
7. Class: CMAA, Class A
8. Capacity: 5-Ton
9. Span: 61'-6" with 8'-0" girders overhang from each side
10. Height of Lift: 26'-6", true vertical lift
11. Bridge Travel Speed: Variable speed to 100 fpm, maximum
12. Trolley Travel Speed: Variable speed to 75 fpm, maximum
13. Hoisting Speed: Variable speed to 15 fpm, maximum
14. Runway Rail: S 18 x 70 # (see Note below)
15. Runway Length: 197'-6" (approximately.)
16. Control: Pendant, Traveling Type
17. Electrification: Cable festooning or cable reel
18. Power Supply: 460-Volt, 3-Phase, 60 Hertz
19. Environmental Condition: Indoor, Clean Room, Temperature: 72°F, Humidity:  
40% RH
20. Interlock With: Cranes W-CS-103-CR-01, W-CS-104-CR-01  
and W-CS-105-CR-01
21. Special Requirements: Girders to be overhung approximately 8'-0" from  
each side of the crane in order to achieve the hook  
coverage indicated on Figures 1 and 2.  
Lighting fixtures shall be attached to underside of  
bridge.

**NOTE:** "LOUDEN" Rail No. 605.1850 may be used instead the specified.

**CRANE DATA SHEET-1**  
**(3-Interferometer Version)**

1. Location: LVEA Corner Station
2. Number Required: One (1)
3. Tag No.: W-CS-103-CR-01
4. Arrangement: Refer to Figures 3
5. Type: Electric, Single-Girder Under-Running, 3-Runway
6. Number of Hoists: One(1)
7. Class: CMAA, Class A
8. Capacity: 5-Ton
9. Span: 75'-6"
10. Height of Lift: 26'-6", true vertical lift
11. Bridge Travel Speed: Variable speed to 100 fpm, maximum
12. Trolley Travel Speed: Variable speed to 75 fpm, maximum
13. Hoisting Speed: Variable speed to 15 fpm, maximum
14. Runway Rail: S 18 x 70 # (see Note below)
15. Runway Length: 127'-0", approximately
16. Control: Pendant, Traveling Type
17. Electrification: Cable festooning or cable reel
18. Power Supply: 460-Volt, 3-Phase, 60 Hertz
19. Environmental Condition: Indoor, Clean Room, Temperature: 72°F, Humidity: 40% RH
20. Interlock With: Crane W-CS-102-CR-01
21. Special Requirements: Lighting fixtures attached to underside of bridge

**NOTE:** "LOUDEN" Rail No. 605.1850 may be used instead the specified.

**CRANE DATA SHEET-1**  
**(3-Interferometer Version)**

- |                              |  |
|------------------------------|--|
| 1. Location:                 | LVEA Corner Station  |
| 2. Number Required:          | One (1)  |
| 3. Tag No.:                  | W-CS-104-CR-01   |
| 4. Arrangement:              | Refer to Figures 3   |
| 5. Type:                     | Electric, Single-Girder Under-Running                      |
| 6. Number of Hoists:         | One(1)   |
| 7. Class:                    | CMAA, Class A  |
| 8. Capacity:                 | 5-Ton  |
| 9. Span:                     | 37'-6"   |
| 10. Height of Lift:          | 26'-6", true vertical lift                                 |
| 11. Bridge Travel Speed:     | Variable speed to 100 fpm, maximum                         |
| 12. Trolley Travel Speed:    | Variable speed to 75 fpm, maximum                          |
| 13. Hoisting Speed:          | Variable speed to 15 fpm, maximum                          |
| 14. Runway Rail:             | S 18 x 70 # (see Note below)                               |
| 15. Runway Length:           | 100'-0", approximately                                     |
| 16. Control:                 | Pendant, Traveling Type                                    |
| 17. Electrification:         | Cable festooning or cable reel                             |
| 18. Power Supply:            | 460-Volt, 3-Phase, 60 Hertz                                |
| 19. Environmental Condition: | Indoor, Clean Room, Temperature: 72°F, Humidity:<br>40% RH |
| 20. Interlock With:          | Crane W-CS-102-CR-01                                       |
| 21. Special Requirements:    | Lighting fixtures attached to underside of bridge          |

**NOTE:** "LOUDEN" Rail No. 605.1850 may be used instead the specified.

**CRANE DATA SHEET-1**  
**(3-Interferometer Version)**

1. Location: LVEA Corner Station
2. Number Required: One (1)
3. Tag No.: W-CS-105-CR-01
4. Arrangement: Refer to Figures 3
5. Type: Electric, Single-Girder Under-Running
6. Number of Hoists: One(1)
7. Class: CMAA, Class A
8. Capacity: 5-Ton
9. Span: 35'-6"
10. Height of Lift: 26'-6", true vertical lift
11. Bridge Travel Speed: Variable speed to 100 fpm, maximum
12. Trolley Travel Speed: Variable speed to 75 fpm, maximum
13. Hoisting Speed: Variable speed to 15 fpm, maximum
14. Runway Rail: S 18 x 70 # (see Note below)
15. Runway Length: 127'-0", approximately
16. Control: Pendant, Traveling Type
17. Electrification: Cable festooning or cable reel
18. Power Supply: 460-Volt, 3-Phase, 60 Hertz
19. Environmental Condition: Indoor, Clean Room, Temperature: 72°F, Humidity:  
40% RH
20. Interlock With: Crane W-CS-102-CR-01
21. Special Requirements: Lighting fixtures attached to underside of bridge

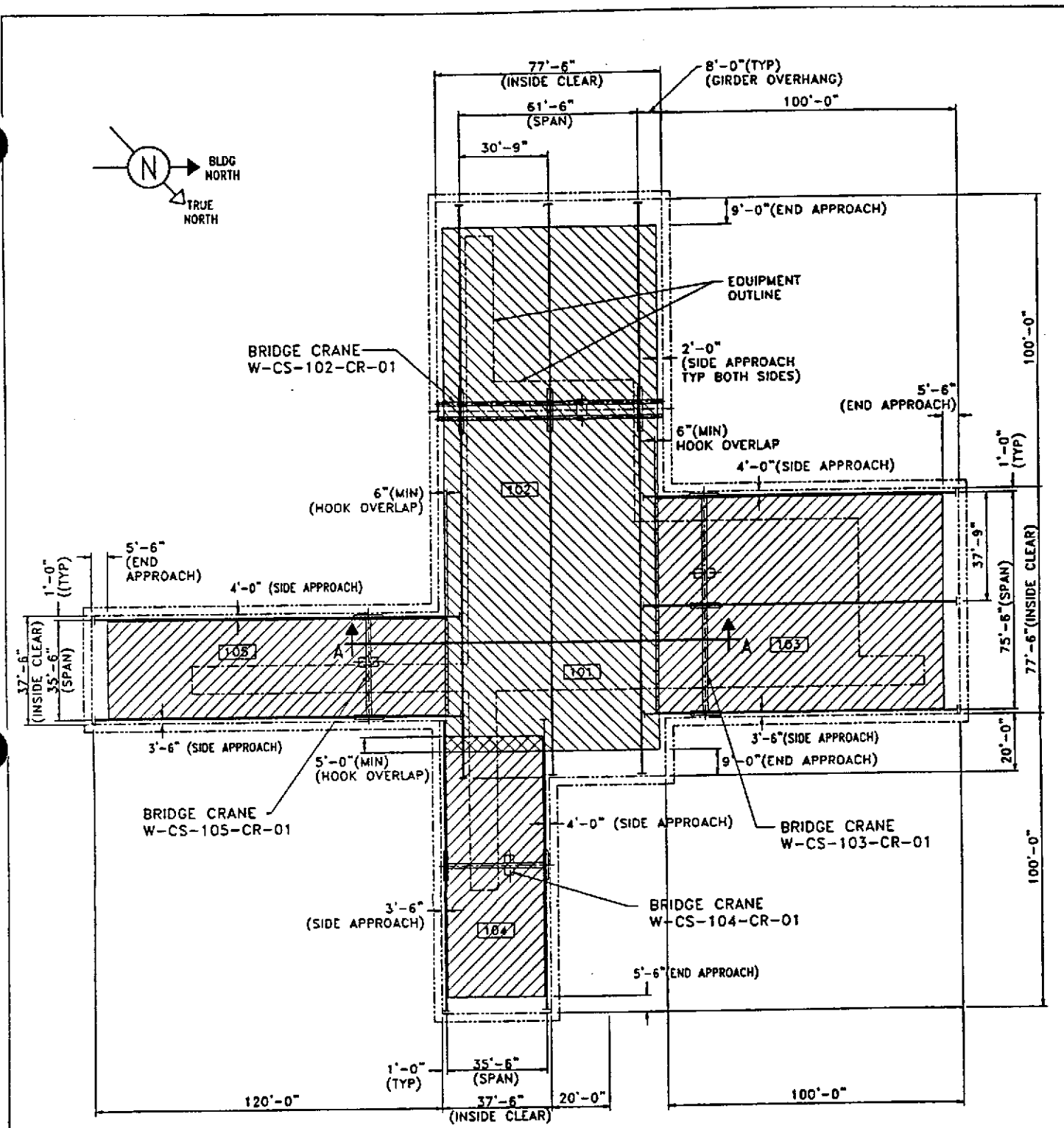
**NOTE:** "LOUDEN" Rail No. 605.1850 may be used instead the specified.

**CRANE DATA SHEET-1**  
**(3-Interferometer Version)**

1. Location: LVEA Mid and End Stations
2. Number Required: Four (4)
3. Tag No.: W-MA-202-CR-01, in Mid Station-A  
W-MB-202-CR-01, in Mid Station-B  
W-EA-302-CR-01, in End Station -A  
W-EB-302-CR-01, in End Station-B
4. Arrangement: Refer to Figures 4
5. Type: Electric, Single-Girder Under-Running
6. Number of Hoists: One(1)
7. Class: CMAA, Class A
8. Capacity: 5-Ton
9. Span: 33'-6"
10. Height of Lift: 26'-6", true vertical lift
11. Bridge Travel Speed: Variable speed to 100 fpm, maximum
12. Trolley Travel Speed: Variable speed to 75 fpm, maximum
13. Hoisting Speed: Variable speed to 15 fpm, maximum
14. Runway Rail: S 18 x 70 # (see Note below)
15. Runway Length: 57'-6", approximately
16. Control: Pendant, Traveling Type
17. Electrification: Cable festooning or cable reel
18. Power Supply: 460-Volt, 3-Phase, 60 Hertz
19. Environmental Condition: Indoor, Clean Room, Temperature: 72°F, Humidity:  
40% RH
20. Special Requirements: Lighting fixtures attached to underside of bridge

**NOTE:** "LOUDEN" Rail No. 605.1850 may be used instead the specified.

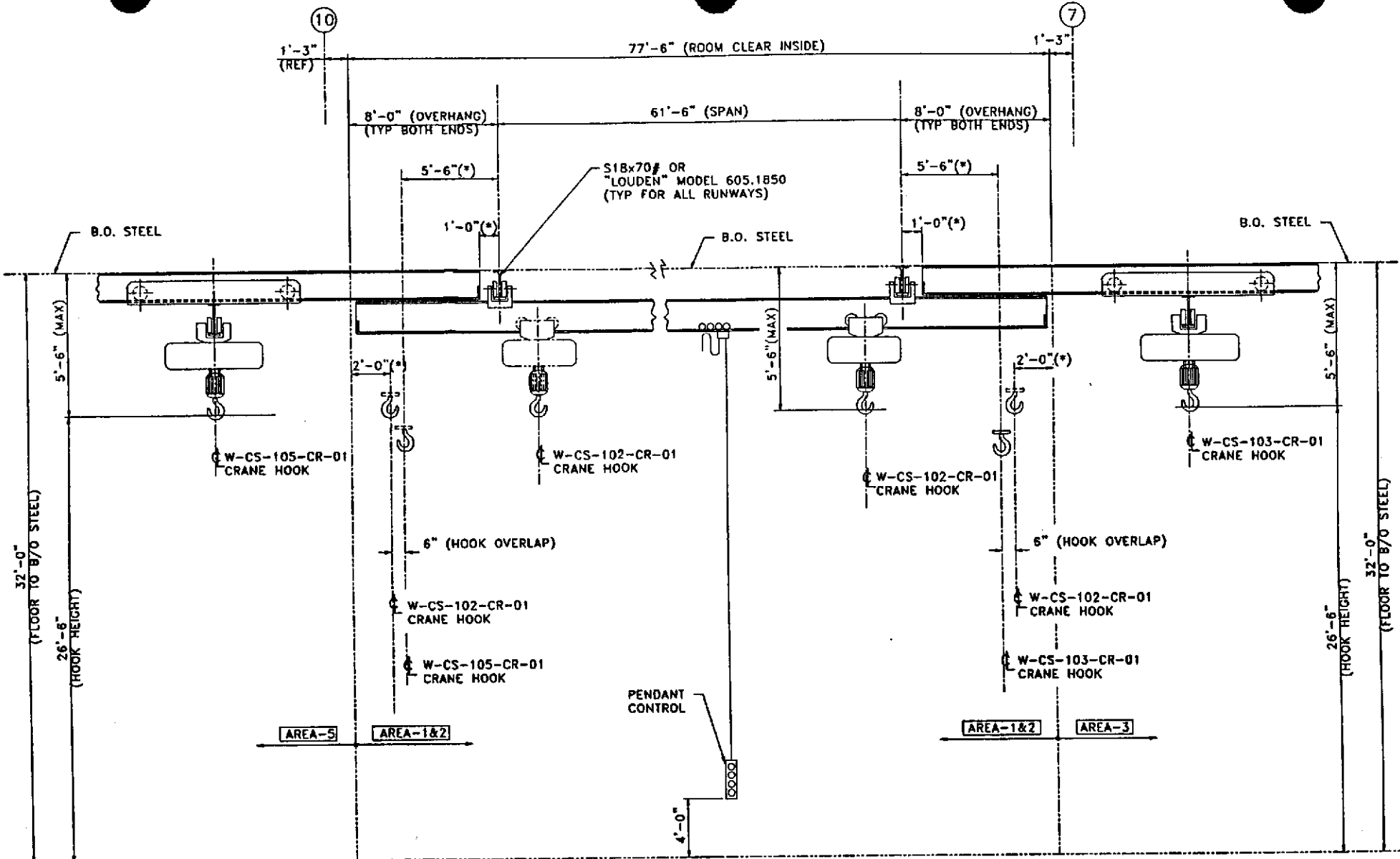




PLAN

- NOTES:
1. CROSS-HATCHED AREAS REPRESENT DIFFERENT CRANE HOOK COVERAGE AREAS.
  2. DIMENSIONS ARE NOMINAL. CONTRACTOR SHALL VERIFY ALL BUILDING AND CRANE DIMENSIONS.

FIGURE 1 - CRANE ARRANGEMENT AND HOOK COVERAGE  
 LVEA CORNER STATION  
 [3-INTERFEROMETER VERSION]

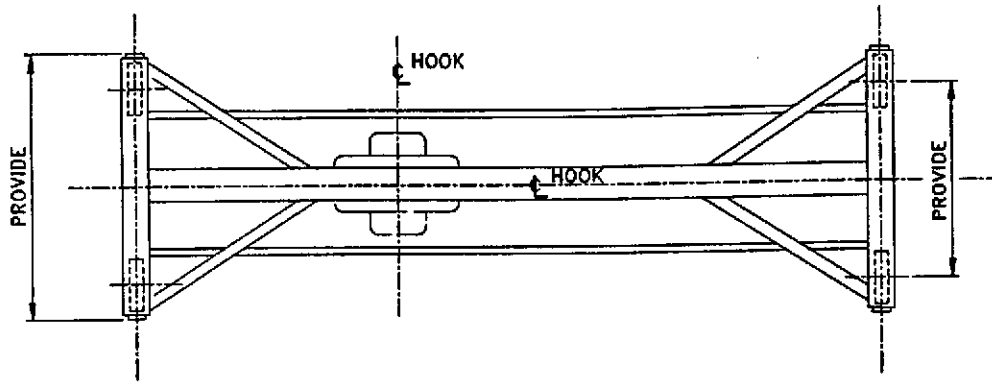


- NOTES:
1. DIMENSIONS ARE NOMINAL. CONTRACTOR SHALL VERIFY ALL BUILDING AND CRANE DIMENSIONS.
  2. DIMENSIONS INDICATED BY ASTERISKS(\*) TO BE ADJUSTED, IF REQUIRED, TO ACHIEVE THE SPECIFIED 6-INCH HOOK OVERLAPS.

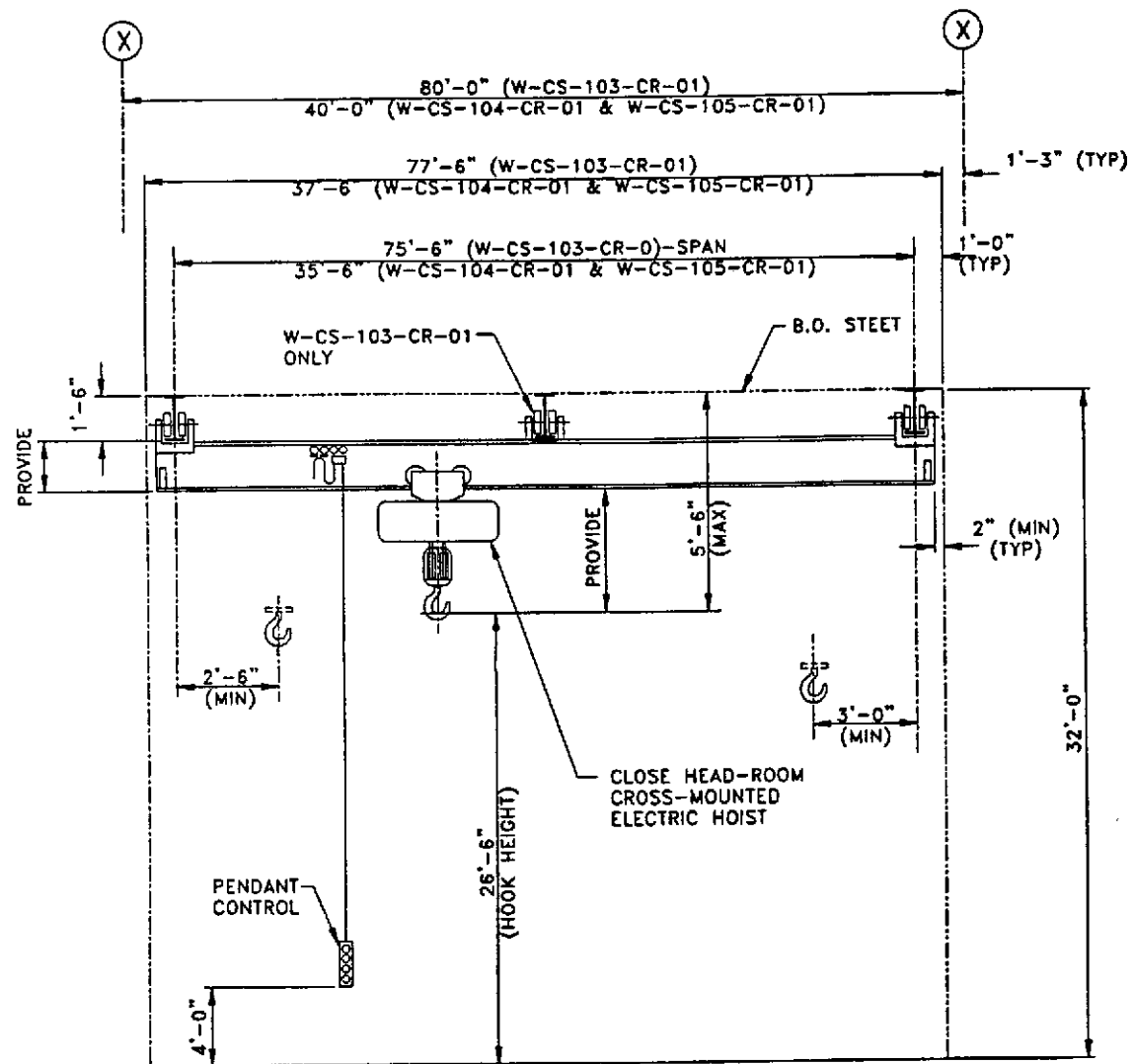
SECTION A-A  
(LOOKING WEST)

FIGURE 2 - CRANE HOOK OVERLAPPING ARRANGEMENT  
LVEA CORNER STATION  
(3-INTERFEROMETER VERSION)

PG 7 of 9



PLAN

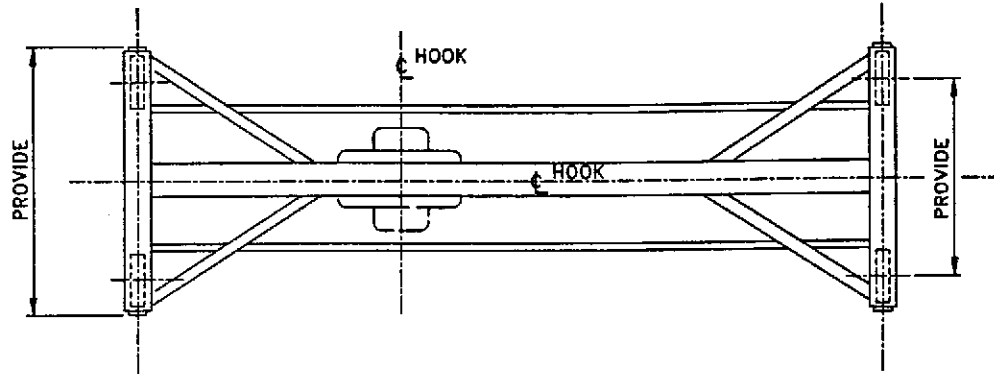


ELEVATION

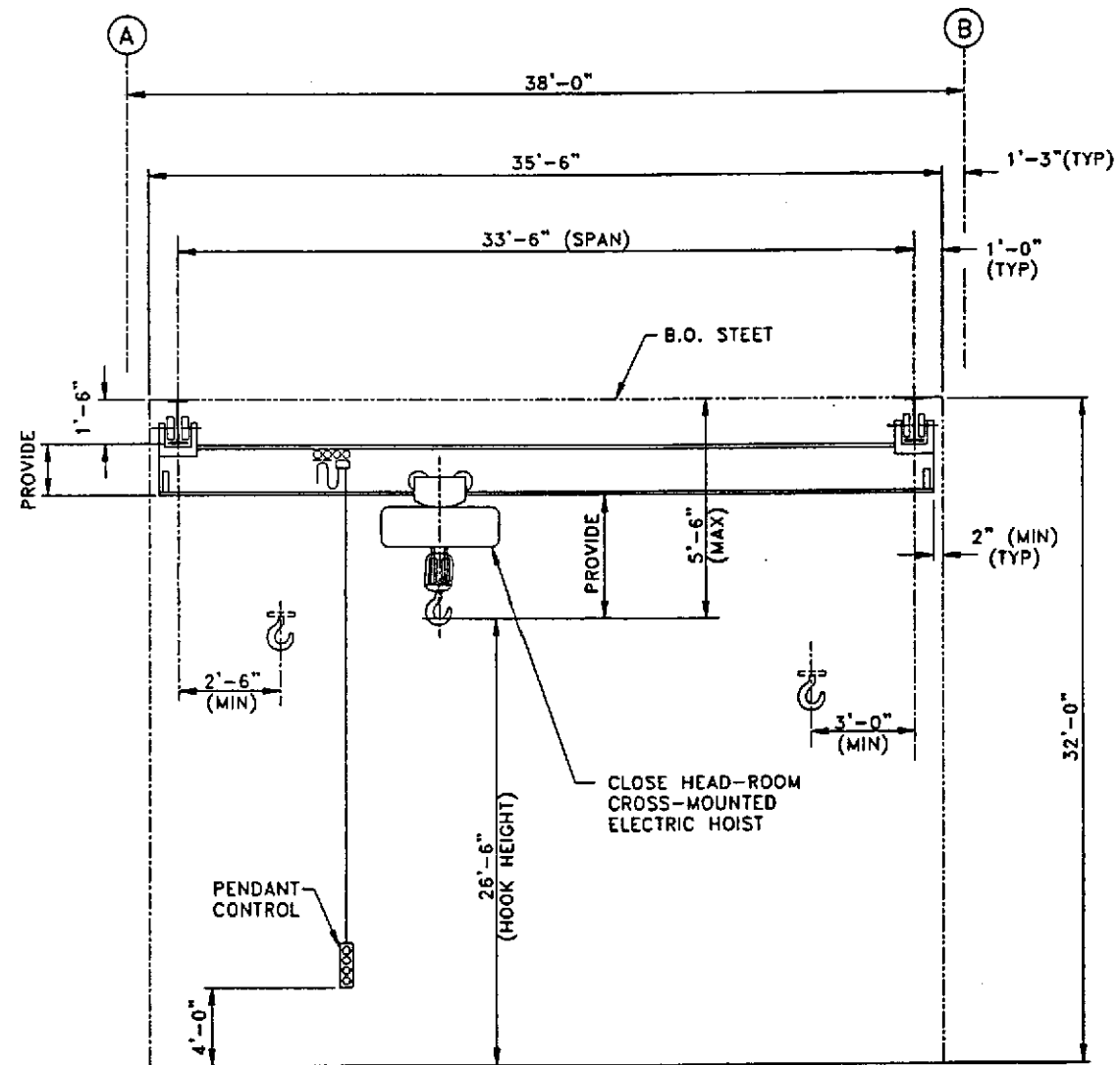
NOTES:

1. DIMENSIONS ARE NOMINAL. CONTRACTOR SHALL VERIFY ALL BUILDING AND CRANE DIMENSIONS.
2. SINGLE-GIRDER CRANE MAY BE WITH OR WITHOUT TRUSSES PROVIDING MEETS THE SPECIFIED DIMENSIONS.

FIGURE 3 - BRIDGE CRANE ARRANGEMENT  
LVEA CORNER STATION  
(3-INTERFEROMETER VERSION)



PLAN



ELEVATION

NOTES:

1. DIMENSIONS ARE NOMINAL. CONTRACTOR SHALL VERIFY ALL BUILDING AND CRANE DIMENSIONS.
2. SINGLE-GIRDER CRANE MAY BE WITH OR WITHOUT TRUSSES PROVIDING MEETS THE SPECIFIED DIMENSIONS.

FIGURE 4 - BRIDGE CRANE ARRANGEMENT  
LVEA MID & END STATIONS

**ATTACHMENT "C" SPEC. V049-2-021  
EQUIPMENT SUPPLIED BY THE BUYER**

**Equipment listed below is supplied by the Buyer for installation by the contractor**

NOTE: All valves shown on piping Dwgs. or P&ID's are supplied by the Buyer.

"X" = Item Tag No., see equipment location plans for building location.

Item	Description	Qty.	Estimated Shipping Weight (lbs.)
WBSCX	Beam Splitter Chamber	10	15,000
WHAMX	Horiz. Access Chamber	13	9,000
WCPX	80K Cryopump – Long	2	9,800
WCPX	80K Cryopump – Short	6	5,800
WIPX	Main Ion Pump (2500 l/s)	12	1,200
WGVX	44" Gate Valve	8	7,200
	(NOTE: (8) 44" gate valves exist installed by others)		
WGVX	48" Gate Valve	4	8,700
WTCX	Turbo Pump Cart Assy per Dwg. V049-4-011	6	1,300
V049-4-012	Base Extension-Turbo Cart	6	500
WRCX	Roughing Pump Cart Assy per Dwg. V049-4-010	2	3,300
V049-4-107	25 l/s Ion Pump Support at Gate Valves	12	50
V049-4-054	75 l/s Ion Pump/Valves-HAM	12	100
V049-4-077	75 l/s Ion Pump/Valves-BSC	10	150
V049-4-078	75 l/s Ion Pump-Support/Manifold	2	150
	6" Gate Valve w/ studs on both sides	4	50
	10" Gate Valve w/ studs on both sides	22	100
	14" Gate Valve w/ studs on both sides	12	350
V049-4-133	Clean Room Assy-BSC Style #1 & 3	5	5,500
V049-4-135	Clean Room Assy BSC Style #2	1	5,400
V049-4-136	Clean Room Assy-HAM	1	4,500
V049-2-157	Gowning Clean Room	5	1,500
V049-2-001/002	Roughing/Turbo Backing Tubing Flex Hoses	8	50
V049-4-168	50 CFM Back To Air Carts	4	300
V049-4-175	200 CFM Back To Air Carts	2	400
V049-2-009	Bake Out Blankets	later	later

All Items Shown on Attachment "J"

**ATTACHMENT**

Number:

**A V049-2-021**

Rev.

**3**

Title: LIGO VACUUM EQUIPMENT INSTALLATION AND COMMISSIONING - WASHINGTON SITE

Item	Description	Qty.	Estimated Shipping Weight(lbs.)
LWDX	LN <sub>2</sub> Tanks-14,000 Gal.	6	41,000
LWDX	LN <sub>2</sub> Tanks-17,260 Gal.	2	47,000
	Ambient Vaporizer 25,000 SCFH	2	2,200
	Ambient Vaporizer 10,000 SCFH	6	600
	50 CFM Compressor Skid	4	2,000
	200 CFM Compressor Skid	2	6,700
	Vacuum Jacketed LN <sub>2</sub> Piping Run (One per LN <sub>2</sub> Tank)		

NOTE: 1. Also see Attachment J - "Equipment Grouping for Shipping", for quantity, shipping cover size, and est. weight of combined spools as shipped to the site.

All Items Shown on Attachment "J"

<b>ATTACHMENT</b>	
Number:	Rev.
<b>A V049-2-021</b>	<b>3</b>

**ATTACHMENT "D"**

**TO**

**V049-2-021**

**ELECTRICAL AND INSTRUMENT CONSTRUCTION WORK V049-2-022**

**ATTACHMENT**

Number:

**A V049-2-021**

Rev.

**3**





Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

SPECIFICATION  
FOR  
ELECTRICAL & INSTRUMENT CONSTRUCTION WORK  
LIGO VACUUM EQUIPMENT

Hanford, Washington



EXPIRES July 1998

*Fadi Bark*

PREPARED BY Daniel J. Parenti Jr.  
 ELECTRICAL Fadi Bark  
 QUALITY ASSURANCE Al Bradbrook  
 TECHNICAL DIRECTOR D. A. 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.

REV LTR	BY—DATE	APPD—DATE	DESCRIPTION OF ACTION
2	<i>DP 6/30/97</i>	<i>REB 7-1-97</i>	<i>RELEASED FOR CONSTRUCTION NEO # 0510</i>
1	RJW 12/2/96	REB 12/2/96	Released for Constr. RFQ per DEO #0377
0	DP 4/29/96	REB 4/29/96	Released for Review and Comment per DEO #0149

<b>PROCESS SYSTEMS INTERNATIONAL, INC</b>				<b>SPECIFICATION</b>		
INITIAL APPROVALS	PREPARED BY D. Parenti	DATE 4/29/96	APPROVED BY REB	DATE 4/29/96	Number A V049-2-022	Rev 2

**CONTENTS**

**GENERAL REQUIREMENTS**

1 CONSTRUCTION DOCUMENTS . . . . . 3  
 2 SCOPE OF WORK . . . . . 3  
 3 INTENT . . . . . 3  
 4 DEFINITIONS . . . . . 4  
 5 CODES, STANDARDS, AND PERMITS . . . . . 5  
 6 LABELED EQUIPMENT . . . . . 5  
 7 INSTALLATION RESTRICTIONS . . . . . 5  
 8 SPECIFIED EQUIPMENT AND SUBSTITUTIONS . . . . . 5  
 9 PROPOSED EQUIPMENT SUBMITTALS . . . . . 6  
 10 TEMPORARY POWER . . . . . 6  
 11 RECORD DRAWINGS . . . . . 7

**EQUIPMENT AND INSTALLATION**

12 CABLE TRAY SYSTEMS . . . . . 7  
 13 CONDUIT SYSTEMS . . . . . 8  
 14 BOXES, CONDUIT BODIES, AND WIREWAYS . . . . . 9  
 15 WIRE AND CABLE . . . . . 10  
 16 WIRING IDENTIFICATION . . . . . 11  
 17 WIRING TERMINATIONS . . . . . 12  
 18 WIRING DEVICES . . . . . 13  
 19 GROUNDING . . . . . 13  
 20 INSTRUMENT AIR/GAS AND PROCESS TUBING . . . . . 13  
 21 EQUIPMENT FURNISHED BY OTHERS . . . . . 13  
 22 SUPPORTS . . . . . 14  
 23 TESTING . . . . . 14  
 — ATTACHMENT A: ELECTRICAL DRAWING LIST  
 — ATTACHMENT B: FURNISHED ELECTRICAL EQUIPMENT LIST  
 — ATTACHMENT C: SUBMITTAL LIST

**SPECIFICATION**

Number	Rev
<b>A</b> V049-2-022	2

**GENERAL REQUIREMENTS**

**1 CONSTRUCTION DOCUMENTS**

- 1.1 Specification for Installation/Commissioning V049-2-021
- 1.2 Attachments to the Specification (see Table of Contents).

**2 SCOPE OF WORK**

- 2.1 Provide labor, tools, materials, and equipment necessary for a complete installation of the Work as specified and as indicated on Drawings.
- 2.2 Receive, store, and handle equipment furnished by others and required to be installed under this Contract.
- 2.3 Through PSI's representative, coordinate Work activities provided under this Contract with work provided by others.

**2.4 SUMMARY OF ELECTRICAL WORK**

- 2.4.1 Work as indicated on the Drawings takes place at two sites. The Washington site consists of one corner station, two mid stations, and two end stations.
- 2.4.2 Provide power, instrument, and control wiring installed in conduit or cable tray; receptacles and equipment connections as indicated. Panelboards and below grade conduits are provided by others unless otherwise indicated.
- 2.4.3 Install gages, switches, electronic transmitters, and other instruments; control cabinets; and other equipment furnished by others (see — ATTACHMENT B: *FURNISHED ELECTRICAL EQUIPMENT LIST*).
- 2.4.4 Provide instrument air/gas tubing between pneumatically operated devices and supply lines and connections as indicated. Provide process tubing between electronic transmitters and process points and connections as indicated.
- 2.4.5 Field Tests
  - Test power wiring for grounds and shorts.
  - Test instrument and control wiring for point-to-point continuity, grounds, and shorts.
  - Check instrument gas and process tubing for leaks.
  - Field Calibrations

**3 INTENT**

- 3.1 Intent of the Drawings and Specification is to assist and guide the Contractor and to establish minimum requirements.
- 3.2 Drawings indicate arrangement and approximate location of equipment. When necessary to deviate from the arrangement indicated to meet structural conditions or to clear other work, inform PSI's representative of proposed deviation before proceeding.

<b>SPECIFICATION</b>	
Number	Rev
<b>A V049-2-022</b>	<b>2</b>

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

- 3.3 Comply with specific, detailed requirements indicated on drawings in lieu of generally stated requirements.
- 3.4 All conflicts shall be brought to the attention of PSI's representative.
- 3.5 Drawings and Specification do not undertake to indicate every item necessary to produce a complete installation of the Work indicated or specified.

4 DEFINITIONS (ALSO SEE THE GENERAL CONDITIONS & THE NEC)

<u>By Others</u>	Work not under this Contract.
<u>Contractor</u>	Company doing electrical and instrumentation work as defined in the Contract Documents.
<u>PSI</u>	Process Systems International, Inc.
<u>Indicated</u>	Shown or noted.
<u>Install</u>	Place, secure, and connect.
<u>Labeled</u>	Equipment marked with an identifying symbol authorized by a nationally recognized testing company such as UL, FM, ETL indicating sample of product has been tested and determined it complies with their safety standards.
<u>Owner</u>	California Institute of Technology and The US Government
<u>Owner's Representative</u>	Persons designated by Owner
<u>Permitted</u>	As by code, Contract Documents, or PSI.
<u>Provide</u>	Furnish and install.
<u>Required</u>	As by code, Contract Documents, or prevailing conditions.
<u>Submittal</u>	Information required to show that the proposed equipment complies with project requirements.
<u>Use</u>	Provide material or equipment referenced.
<u>Work</u>	Material and equipment and their installation and other requirements as established in the Contract Documents.
<u>Wire (Verb)</u>	Connect to equipment indicated and provide wiring required for connection.
<u>Wiring</u>	Conductors, raceways, and accessories as required for a complete installation.

SPECIFICATION

Number	Rev
A V049-2-022	2

**5 CODES, STANDARDS, AND PERMITS**

5.1 Comply with authorities having legal jurisdiction and applicable parts of the latest (unless otherwise required) publications by the following jurisdictions and organizations:

- Applicable federal, state, and local codes.
- Federal Occupational Safety and Health Act (OSHA)
- American National Standards Institute, Inc. (ANSI)
- National Fire Protection Association (NFPA)
- Institute of Electrical and Electronics Engineers (IEEE)
- National Electrical Manufacturers Association (NEMA)
- Insulated Cable Engineers Association (ICEA)
- Underwriter's Laboratories (UL), Factory Mutual Engineering Corp (FM), Electrical Testing Laboratories, Inc. (ETL), or other nationally recognized testing companies' equipment and installation safety standards

5.2 The Drawings and Specification do not undertake to repeat requirements written in the above codes, ordinances, and standards.

5.3 Arrange and pay for necessary permits, licenses, inspections, and certificates applicable to the performance of the Work. At conclusion of the Project, deliver certificates of inspection to PSI's representative.

**6 LABELED EQUIPMENT**

Provide labeled equipment and assemblies where recognized national testing company safety standards exist.

**7 INSTALLATION RESTRICTIONS**

7.1 Do not cut structural members or walls without written acknowledgment from the Owner obtained via PSI's representative. All wall penetrations shall be through wall block-outs provided by others.

7.2 Do not weld supports and equipment to building steel without written acknowledgment from the Owner obtained via PSI's representative.

7.3 Arrange equipment to allow accessibility to installations likely to need inspection, calibration, repair, and maintenance.

**8 SPECIFIED EQUIPMENT AND SUBSTITUTIONS**

8.1 The manufacturer of the equipment specified is used as the basis of the design and to establish quality required for this project. Unless no substitutions is stated, other manufacturers of equivalent equipment may also be proposed by the Contractor.

8.2 The description following a catalog number is basically to identify the product, but the description may also call

<b>SPECIFICATION</b>	
Number	Rev
<b>A V049-2-022</b>	<b>2</b>

for accessories, options, and modifications which are beyond the cataloged product.

- 8.3 Submit proposed substitutions to PSI's representative for acceptance. With submittal, provide details of necessary changes to accommodate substitutions. Submit samples if requested.

**9 PROPOSED EQUIPMENT SUBMITTALS**

Before delivering equipment to the job site and installing it, complete the submittal process as follows:

- 9.1 Equipment List: As soon as practicable, submit for review a list of equipment proposed for installation with each item identified by Specification paragraph number or where applicable by Drawing number. Include manufacturer's name with catalog or model number for each item.
- 9.2 Product Data: Where required by specification of the product, submit catalog data sheets or other published materials showing appearances, electrical ratings, performance characteristics, dimensions, installation methods, and space requirements of proposed equipment.
- 9.3 Shop Drawings: Where required by specification of the product, submit shop drawings, drawn to scale, indicating physical size and arrangement, construction details, provisions for conduits, access requirements for installation and maintenance, finishes, and materials used in fabrication. Supplement shop drawings with wiring diagrams and information as previously described under product data.
- 9.4 Mark submittals to clearly identify proposed equipment including accessories, options, and features and to exclude parts not applicable to the Project.
- 9.5 If proposed equipment deviates from the Specification or Drawings, indicate those differences and provide sufficient data to justify acceptance.
- 9.6 Provide products of one manufacturer for each classification of equipment.
- 9.7 Stamp submittals indicating that they have been checked and that they comply with Project requirements including physical restrictions before submitting.
- 9.8 Submittals reviews by PSI does not relieve the contractor from the responsibility of complying with the Specification and Drawings.
- 9.9 Unless otherwise required, provide two copies of submittals and deliver to PSI's representative. Where practicable submit all product data and shop drawings at one time. Arrange submittal in three-ring binders with loose-leaf dividers separating categories of equipment.
- 9.10 At the job site, maintain the latest equipment submittals showing the action taken by PSI's representative. Make these submittals available to Owner's and PSI's representatives.

**10 TEMPORARY POWER**

- 10.1 The Owner will provide electrical power, without charge. Make connections to the Owner's system where permitted.
- 10.2 Provide distribution of power as project needs require.

**SPECIFICATION**

Number

**A** V049-2-022

Rev

**2**

10.3 When temporary power is no longer required, remove that portion provided under this Contract.

**11 RECORD DRAWINGS**

11.1 At the site, maintain a set of prints marking them to accurately reflect the actual installation including changes in sizes, locations, dimensions, and circuiting as the work progresses.

11.2 On a daily basis, trace over the prints with a highlighter (transparent marker) to indicate work installed. Make these prints available to Owner's and PSI's representative.

11.3 At completion of project, deliver marked prints to PSI's representative.

**EQUIPMENT AND INSTALLATION**

**12 CABLE TRAY SYSTEMS**

Where indicated, provide cable trays as follows:

12.1 MANUFACTURERS: PW Industries, B-Line, or MP Husky.

12.2 TRAYS: NEMA VE1; channel and ladder type trays as indicated; ladder tray with rungs on 12 inch centers unless otherwise indicated.

12.3 MATERIAL: 6063-T6 aluminum

12.4 LOAD AND SPAN: rated for 50 pounds per linear foot or more and span to suit tray supports.

12.5 ACCESSORIES:

12.5.1 expansion fittings in accordance with manufacturer's recommendations to accommodate building expansion joints and thermal expansion of tray in ambient temperature range of 0°C to 50°C

12.5.2 bonding jumpers

12.5.3 end plates where applicable

12.5.4 drop-out fittings where conduit is not required

12.5.5 divider strips (barriers) where indicated with curved fittings and hold-down clips

12.5.6 other fittings to best suit each application

12.6 SUBMITTALS

12.6.1 Submit product data of each cable tray component for review.

12.6.2 Submit shop drawings of support system for review.

**SPECIFICATION**

Number	Rev
<b>A V049-2-022</b>	<b>2</b>

12.7 INSTALLATION

- 12.7.1 Support horizontal and vertical trays by each side rail using hold-down clamps to prevent lateral or vertical displacement. Provide support brackets, channels/struts, 3/8 inch or larger hanger rods, and fittings to best suit installation (see *SUPPORTS*, Article 22).
- 12.7.2 Ensure that trays are effectively bonded to electrical equipment served by wiring in cable tray.
  - Where applicable, bond tray to building steel with #2 AWG copper conductor at two locations.
  - Bonding jumpers at expansion and adjustable fittings.
- 12.7.3 At approximate 20-foot intervals, identify instrument, and control cable tray with vinyl, self-adhesive signs with one inch high lettering or, similarly, with stencil and paint. Lettering shall read *24VDC INSTRUMENT AND CONTROL*.
- 12.7.4 At approximate 10-foot intervals, identify channel tray with high voltage, ion pump wiring with vinyl, self-adhesive signs with one inch high lettering or, similarly, with stencil and paint. Lettering shall read *DANGER—HIGH VOLTAGE*.

13 CONDUIT SYSTEMS  
(ELECTRICAL RACEWAY OF CIRCULAR CROSS SECTION)

- 13.1 INTERMEDIATE METAL CONDUIT (IMC): Galvanized IMC conforming to UL 1242 standard may be provided as indicated on drawings..
- 13.2 ELECTRICAL METALLIC TUBING (EMT): At indoor locations, EMT conforming to ANSI C80.3 and UL 797 standards may be provided as indicated on drawings.
- 13.3 FLEXIBLE METAL CONDUIT (FMC): At connections to motors, transformers, and other vibrating equipment and instruments, provide thermoplastic covered, liquidtight FMC conforming to UL 360 standard and fittings to best suit application.
- 13.4 ACCESSORIES:
  - 13.4.1 Provide fittings to best suit each application.
  - 13.4.2 Provide expansion fittings as required in accordance with manufacturer's recommendations to accommodate building expansion joints indoors and thermal expansion of conduit in ambient temperature range of 0°C to 50°C. Where conduit system is discontinuous, provide bonding jumper, #12 of larger conductor.
- 13.5 INSTALLATION:
  - 13.5.1 Restrictions: Where practicable, keep instrument wiring at least 12 inches away from other wiring and minimize paralleling instrument wiring with power or control wiring.
  - 13.5.2 Arrangement: Make raceway offsets and bends symmetrically and uniformly.
  - 13.5.3 Supports:
    - Fasten conduits to building with one-hole malleable iron conduit clamps with screw or bolt.

**SPECIFICATION**

Number	Rev
A V049-2-022	2



- Where applicable and where two, three, or more conduits are routed together, provide trapeze hangers made of 3/8 inch minimum hanger rods and channels/struts with conduit clamps.
- Support 1-1/2 inch or larger suspended conduits with 3/8 inch minimum hanger rods with conduit clamp.
- Provide supports as specified under *SUPPORTS*, Article 22, p.14.

13.5.4 Pull boxes: Provide pull boxes required for proper conductor installation in addition to boxes indicated.

13.5.5 Terminating conduits:

- Attach IMC to equipment by threading into integral cast hub, compression fitting, or double locknuts with bushing.
- Attach EMT with either set-screw or compression type fittings and connectors with integral insulating liners.

13.5.6 Flexible conduit connections:

- Connect to motors, transformers, and other vibrating equipment with 18 to 30 inches of FMC.
- At equipment mounted on vibrating isolators, provide 90° bend in the FMC.
- Connect to instruments with 18 to 30 inches of FMC.

13.5.7 Grounding: Where grounding conductor or bonding is applicable at locknut installations, provide threaded bushings with insulating liner and grounding lug.

13.5.8 Close openings: Keep conduits closed when not accessing them to prevent rain, dirt, and debris from entering.

#### 14 BOXES, CONDUIT BODIES, AND WIREWAYS

14.1 PULL AND SPLICE BOXES:

14.1.1 Where indicated and as required to install wiring without damaging insulation or stretching conductors, provide galvanized or finished with gray baked enamel boxes with screw-on covers unless otherwise required.

14.1.2 Where applicable, provide galvanized or finished with gray baked enamel box barriers to maintain separation of wiring systems.

14.2 OUTLET AND JUNCTION BOXES

14.2.1 Provide cast-metal boxes with threaded hubs unless otherwise specified.

14.2.2 At outdoor locations, provide gaskets.

14.2.3 At indoor locations, sheet-metal boxes may be provided in lieu of cast-metal boxes and conduit bodies unless otherwise required.

### SPECIFICATION

Number	Rev
A V049-2-022	2

**Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK**

**14.3 CONDUIT BODIES:**

14.3.1 Where applicable, cast-metal conduit bodies with threaded hubs may be used in lieu of boxes unless otherwise required.

14.3.2 At outdoor locations, provide gaskets.

**14.4 WIREWAYS AND AUXILIARY GUTTERS:**

14.4.1 Where required, provide galvanized or finished with gray baked enamel wireways and gutters with screw-on covers unless otherwise required.

14.4.2 Where applicable, provide galvanized or finished with gray baked enamel box barriers to maintain separation of wiring systems.

14.5 ACCESSORIES: Provide fittings to best suit each application.

**14.6 INSTALLATION:**

**14.6.1 General requirements:**

- Arrange boxes neatly and symmetrically to adjacent components and architectural features.
- Identify wire and cables by tag numbers with indelible felt tipped marker pen or as specified under wiring systems.
- Provide supports as specified under *SUPPORTS*, Article 22.
- When not accessing, close equipment to prevent rain, dirt, and debris from entering.

14.6.2 Wireway and gutters: Where wireway or gutter is discontinuous, bond each section with #12 or larger conductor.

14.6.3 Pull and splice boxes: Provide supports to prevent conductors from resting on removable bottom covers.

14.6.4 Outlet and junction boxes: Rigidly fasten boxes directly to structure, to support channels/struts, or in framed constructions to bar hangers.

**15 WIRE AND CABLE**

**15.1 POWER WIRE (up through 600 volts):**

15.1.1 Provide #12 AWG or larger single; stranded copper; type THHN, THHN-THWN, THWN, or XHHW conductors rated 90°C, 600 volts unless otherwise specified.

Use colored coded insulation in sizes up to #8 AWG, except up to #6 AWG for grounding conductors, and black insulated conductors in larger sizes (see *WIRING IDENTIFICATION*, Article 16).

**15.2 CONTROL WIRE (discrete signals):**

15.2.1 120 VAC: Provide #14 AWG or larger, stranded copper, type THHN-THWN, multiconductor cable rated 90°C, 600 volts unless otherwise indicated.

15.2.2 24 VDC: Provide #18 AWG or larger, stranded copper,

**SPECIFICATION**

Number

**A V049-2-022**

Rev

**2**

multiconductor cables rated 90°C and 300 volts unless otherwise indicated.

15.3 INSTRUMENT WIRE (analog signals):

15.3.1 4-20mA: Provide #18 AWG or larger, stranded copper, individually shielded twisted pairs, single or multipair cables rated 90°C, 300 volts unless otherwise indicated.

15.3.2 Thermocouple: Provide #18 AWG single pair and #20 AWG multipair ANSI type (as indicated), solid thermocouple extension cable shielded, rated 105°C, 300 volts unless otherwise indicated.

15.4 TRAY CABLE: In addition to above, provide cable tray installations with cable labeled for cable tray use.

15.5 SUBMITTALS: Provide product data of each wire and cable.

15.6 INSTALLATION:

15.6.1 Where practicable, keep instrument wiring at least 12 inches away from other wiring and minimize paralleling instrument wiring with power or control wiring

15.6.2 Install wiring without splices.

15.6.3 Simultaneously install conductors and multiconductor cables which occupy same conduit .

15.6.4 Only cable manufacturer approved pulling lubricant shall be used.

15.6.5 Use woven cable grips.

15.6.6 Do not to exceed manufacturer's recommended pulling tension and cable bending radius.

15.6.7 Seal cables exposed to weather or other harmful environments until cable is terminated.

15.6.8 Provide sufficient wire length at each end of pull to permit grouping and training the wires and cables. Where applicable, use self-locking nylon wire ties; cut off loose ends. 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.

15.7 See TESTING, Article 23, p.14.

16 WIRING IDENTIFICATION

16.1 POWER WIRE:

16.1.1 Color code single conductors as follows:

Line	208/120V	480/277V
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
N	White	Gray
G	Green	Green

16.1.2 Where applicable, color code conductors using one-inch wide colored plastic adhesive tape wrapped with two full

SPECIFICATION

Number	Rev
A V049-2-022	2

turns.

16.1.3 Identify each conductor end with panel designation and circuit number or with applicable identification to suit other type of circuits. Use printed, adhesive wire marker strips.

16.2 INSTRUMENT AND CONTROL WIRE:

16.2.1 Tag each end of single conductors and cable pairs with schematic wire number unless otherwise directed.

16.2.2 Tag each spare cable end with unique identification.

16.2.3 Use printed sleeve markers.

16.3 SUBMITTALS: Provide product data of printed sleeve markers.

17 WIRING TERMINATIONS

17.1 POWER WIRE:

17.1.1 Splices:

- #10 AWG and smaller conductors, provide insulated spring connectors.
- #8 AWG and larger conductors, provide either compression (crimp) connectors using matching installing tool or mechanical screw type connectors. Cover splices with insulating material made for connector where available; otherwise, cover with at least three layers of electrical, vinyl tape to attain insulation rating equivalent to that of the conductor.

17.1.2 Terminations:

- #10 AWG and smaller conductors to buses, enclosures, and similar applications, provide compression (crimp) terminals.
- #8 AWG and larger conductors, provide either compression (crimp) connectors using matching installing tool or mechanical screw type connectors.
- Where more than one conductor requires termination and terminals are not provided as part of the equipment, provide screw or pressure type insulated terminal blocks.

17.1.3 Motor Leads: To connect to motor leads, use split-bolt connectors. Cover splices with insulating material made for connector where available; otherwise, cover with at least three layers of electrical, vinyl tape to attain insulation rating equivalent to that of the conductor.

17.1.4 Where applicable, tighten screw type hardware in accordance with manufacturer's published torque values. If not available, comply with UL 486A standards.

17.2 INSTRUMENT AND CONTROL WIRE:

17.2.1 At instrument end of cable, strip and cutoff shielding back to edge of overall jacket. Then wrap two full turns of electrical plastic tape or placed heat shrinkable insulating sleeve half on conductors and half on overall jacket . At other end of cable, secure shielding to junction box terminal. (Shielding connects only to a single ground reference point at the electrical source.)

**SPECIFICATION**

Number

**A V049-2-022**

Rev

**2**

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

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

**18 WIRING DEVICES**

Provide devices as indicted on the Drawings.

**19 GROUNDING**

19.1 EQUIPMENT GROUNDING: Bond each end of equipment grounding conductors to the grounding bushing, the grounding bus, grounding lug, or the enclosure, respectively.

19.2 GROUNDING CONNECTIONS:

19.2.1 Use mechanical connectors to make grounding connections.

Completely remove paint, dirt, and corrosion down to bare metal at connection areas.

**20 INSTRUMENT AIR/GAS AND PROCESS TUBING**

Where indicated, provide the following:

20.1 INSTRUMENT AIR/GAS TUBING: Provide 1/4 inch, type L, or larger copper tubing, brass compression connectors, and copper clips (Design: 200PSI @ -20F - +150F).

20.2 PROCESS TUBING: Provide 3/8 inch, 0.035 WT, or larger 304 stainless steel, seamless tubing, stainless steel compression connectors, and stainless steel clips

20.3 INSTALLATIONS: Arrange tubing neatly and symmetrically to adjacent components. Use bending tools to make bends in tubing.

20.4 SUBMITTALS: Provide product data of tubing and accessories.

**21 EQUIPMENT FURNISHED BY OTHERS**

(SEE — ATTACHMENT B: FURNISHED ELECTRICAL EQUIPMENT LIST)

21.1 Receive, store (in clean, dry location), and handle equipment furnished by others and required to be installed under this Contract.

21.2 Set equipment in place and bolt free standing equipment to floor as specified under *SUPPORTS*, Article 22.

21.3 Make power, instrument, and control wiring and tubing connections as indicated.

21.4 Where practicable, keep instrumentation wiring 12 inches away from other wiring and minimize paralleling instrument wiring with power or control wiring.

21.5 Where necessary, cut holes in electrical boxes to accommodate conduit, cable, and tubing connections.

**SPECIFICATION**

Number

**A V049-2-022**

Rev

**2**

**22 SUPPORTS**

- 22.1 Where applicable, provide steel channels/struts with galvanized or painted finish.
- 22.2 Fasten equipment and supports with corrosion resistant hardware.
- 22.3 Provide support systems of suitable strength to hold intended equipment in place.
- 22.4 Fabricate supports from structural steel or steel channels/struts rigidly welded or bolted. Paint cut ends of supports with rust inhibitor matching existing finish.
- 22.5 Secure free-standing equipment to concrete pad or floor with at least four 1/2 inch or larger bolts. Provide drilled concrete anchors where applicable.
- 22.6 Secure surface-mounted panels and cabinets weighing 75lbs. or less with at least four 1/2 inch or larger toggle bolts.

**23 TESTING**

- 23.1 No equipment shall be energized without consent of PSI's representative.
- 23.2 It is the Contractor's responsibility to conduct tests without damage to equipment.
- 23.3 POWER WIRE TESTING (up through 600 volts):
  - 23.3.1 Test each new conductor installed and existing conductor reconnected to ground using 1000-volt megger.
  - 23.3.2 Provide written test report listing resistance by feeder and branch circuit.
  - 23.3.3 Replace conductors measuring less than 25 megohm and retest.
- 23.4 CONTROL AND INSTRUMENT WIRE TESTING:
  - 23.4.1 Check point-to-point continuity of each conductor to ensure that wiring is intact and terminated at the proper place at both ends. After wiring has been terminated,
    1. lift one conductor at a time off of its terminal at both ends;
    2. establish an isolated return path (not ground, but may be one of the cable conductors);
    3. check conductor continuity;
    4. reconnect wire to terminals, or if defective, correct, recheck, and reconnect;
    5. with highlighter, mark wiring diagram or schedule to indicate that wire and connection has been verified; and
    6. proceed to next conductor.
  - 23.4.2 Using highlighter, indicate on terminal wiring diagrams or schedules that each wire and connection has been verified. Make these sheets available to Owner's and PSI's representatives.
  - 23.4.3 Replace defective wiring and retest.

**SPECIFICATION**

Number	A V049-2-022	Rev	2
--------	--------------	-----	---

23.5 MOTORS TESTING:

23.5.1 Before connecting, measure motor winding resistance and ground resistance.

23.5.2 PSI will test each three-phase motor for proper rotary direction. Where necessary, correct circuit connections per PSI's representative.

23.6 RECEPTACLES TESTING: PSI will test polarity and grounding of each receptacle device used with equipment furnished under this Work. Where necessary, correct circuit connections per PSI's representative.

23.7 INSTRUMENT GAS AND PROCESS TUBING TESTING:

23.7.1 Check tubing and connectors for leaks.

23.7.2 PSI will check gas operated valves for proper opening and closing or positioning of pneumatically operated device.

23.7.3 Make repairs as necessary and retest.

23.8 VALVES TESTING:

23.8.1 Valve cycling to verify proper operation of limit switches, pneumatic operators, and positioning operators is by PSI.

23.8.2 Make electrical and pneumatic repairs as necessary and retest.

23.9 CALIBRATION:

23.9.1 Calibrate instrumentation as required.

23.10 SCHEDULING, NOTIFYING, AND WITNESSING TESTING: Provide the PSI's representative with at least three days notification of scheduled testing. With the notification, include a list of proposed tests and the expected time to perform these tests.

— END —

**SPECIFICATION**

Number

**A V049-2-022**

Rev

**2**

ATTACHMENT "A"  
D R A W I N G   L I S T S

<u>DRAWING</u>	<u>DESCRIPTION</u>
V049-3-002	OVERALL SITE PLAN
V049-3-101	INSTRUMENT PLAN—VERTEX SECTION
V049-3-102	INSTRUMENT PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-103	INSTRUMENT PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-104	INSTRUMENT PLAN—DIAGONAL SECTION
V049-3-106	CABLE TRAY PLAN—VERTEX SECTION
V049-3-107	CABLE TRAY PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-108	CABLE TRAY PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-109	CABLE TRAY PLAN—DIAGONAL SECTION
V049-3-110	CABLE TRAY DETAILS-CORNER STATION
V049-3-111	INSTRUMENT/ELECTRICAL PLAN—VERTEX SECTION
V049-3-112	INSTRUMENT/ELECTRICAL PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-113	INSTRUMENT/ELECTRICAL PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-114	INSTRUMENT/ELECTRICAL PLAN—DIAGONAL SECTION
V049-3-116	POWER PLAN—VERTEX SECTION
V049-3-117	POWER PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-118	POWER PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-119	POWER PLAN—DIAGONAL SECTION
V049-3-120	DISTRIBUTION SYSTEM FEEDER SCHEDULE
V049-3-123	CDS INTERFACE DIAGRAM—CORNER STATION
V049-3-124	CONDUIT STUB-UP PLAN—CORNER STATION
V049-3-125	VACUUM CART INTERFACE PLAN—CORNER STATION
V049-3-127	DATA HIGHWAY PLAN— VERTEX STATION
V049-3-128	DATA HIGHWAY PLAN— LEFT BEAM MANIFOLD STATION

**ATTACHMENT "A"**

Number	Rev
<b>A</b> V049-2-022	<b>2</b>



**Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK**

<u>DRAWING</u>	<u>DESCRIPTION</u>
V049-3-129	DATA HIGHWAY PLAN— RIGHT BEAM MANIFOLD STATION
V049-3-130	DATA HIGHWAY PLAN— DIAGONAL STATION
V049-3-131	DATA HIGHWAY INTERCONNECT DIAGRAM— CORNER STATION
V049-3-133	GROUNDING PLAN - VERTEX SECTION
V049-3-134	GROUNDING PLAN - LEFT BEAM MANIFOLD
V049-3-135	GROUNDING PLAN - RIGHT BEAM MANIFOLD
V049-3-136	GROUNDING PLAN - DIAGONAL SECTION
V049-3-201	INSTRUMENT PLAN—LEFT MID STATION
V049-3-202	CABLE TRAY PLAN—LEFT MID STATION
V049-3-203	INSTRUMENT/ELECTRICAL PLAN—LEFT MID STATION
V049-3-204	POWER PLAN—LEFT MID STATION
V049-3-205	CONDUIT STUB-UP PLAN - LEFT MID STATION
V049-3-206	VACUUM CART INTERFACE PLAN—LEFT MID STATION
V049-3-208	CDS INTERFACE DIAGRAM—LEFT MID STATION
V049-3-209	GROUNDING PLAN—LEFT MID STATION
V049-3-301	INSTRUMENT PLAN—RIGHT MID STATION
V049-3-302	CABLE TRAY PLAN—RIGHT MID STATION
V049-3-303	INSTRUMENT/ELECTRICAL PLAN—RIGHT MID STATION
V049-3-304	POWER PLAN—RIGHT MID STATION
V049-3-305	CONDUIT STUB-UP PLAN—RIGHT MID STATION
V049-3-306	VACUUM CART INTERFACE PLAN—RIGHT MID STATION
V049-3-308	CDS INTERFACE DIAGRAM—RIGHT MID STATION
V049-3-309	GROUNDING PLAN—RIGHT MID STATION
V049-3-401	INSTRUMENT PLAN—LEFT END STATION
V049-3-402	CABLE TRAY PLAN—LEFT END STATION
V049-3-403	INSTRUMENT/ELECTRICAL PLAN—LEFT END STATION

**ATTACHMENT "A"**

Number	Rev
<b>A V049-2-022</b>	<b>2</b>

DRAWING	DESCRIPTION
V049-3-404	POWER PLAN—LEFT END STATION
V049-3-405	CONDUIT STUB-UP PLAN - LEFT END STATION
V049-3-406	VACUUM CART INTERFACE PLAN—LEFT END STATION
V049-3-408	CDS INTERFACE DIAGRAM—LEFT END STATION
V049-3-409	GROUNDING PLAN—LEFT END STATION
V049-3-501	INSTRUMENT PLAN—RIGHT END STATION
V049-3-502	CABLE TRAY PLAN—RIGHT END STATION
V049-3-503	INSTRUMENT/ELECTRICAL PLAN—RIGHT END STATION
V049-3-504	POWER PLAN—RIGHT END STATION
V049-3-505	CONDUIT STUB-UP PLAN—RIGHT END STATION
V049-3-506	VACUUM CART INTERFACE PLAN—RIGHT END STATION (2 SHEETS)
V049-3-508	CDS INTERFACE DIAGRAM—RIGHT END STATION
V049-3-509	GROUNDING PLAN—RIGHT END STATION

**ATTACHMENT "A"**

Number	Rev
<b>A</b> V049-2-022	<b>2</b>

DRAWING	DESCRIPTION
V049-3-001	GENERAL NOTES & LEGEND
V049-3-006	ELECTRICAL INSTALLATION DETAILS
V049-3-007	INSTRUMENT ELECTRICAL INSTALLATION DETAILS
V049-3-008	INSTRUMENT INSTALLATION DETAILS
V049-3-009	GROUNDING DETAILS

**REFERENCE DRAWING LIST\***

DRAWING	DESCRIPTION
V049-3-004	ION CONTROLLER CABINET (2 SHEETS)
V049-3-121	PNL-100A & 100B ASSEMBLY
V049-3-122	PNL-100A & 100B WIRING DIAGRAM
V049-3-207	PNL-200 WIRING DIAGRAM
V049-3-307	PNL-300 WIRING DIAGRAM
V049-3-407	PNL-400 WIRING DIAGRAM
V049-3-507	PNL-500 WIRING DIAGRAM

\* Reference drawings, used by others to fabricate equipment, are furnished to supplement installation details and indicate wiring terminations.

**ATTACHMENT "A"**

Number	Rev
<b>A</b> V049-2-022	<b>2</b>

**ATTACHMENT "B"**

**FURNISHED ELECTRICAL EQUIPMENT LIST**

ITEM	INSTRUMENT TAG/EQUIPMENT DESIGNATION	
	V INDICATES VACUUM ENVIRONMENT LOCATION	DESCRIPTION (INDICATED ON DRAWING/SHEET)
1	FI-104	— CRYOPUMP WCP1 FLOW INDICATOR (V049-3-102)
2	FI-154	— CRYOPUMP WCP2 FLOW INDICATOR (V049-3-103)
3	FI-204	— CRYOPUMP WCP3 FLOW INDICATOR (V049-3-201)
4	FI-254	— CRYOPUMP WCP4 FLOW INDICATOR (V049-3-201)
5	FI-304	— CRYOPUMP WCP5 FLOW INDICATOR (V049-3-301)
6	FI-354	— CRYOPUMP WCP6 FLOW INDICATOR (V049-3-301)
7	FI-404	— CRYOPUMP WCP7 FLOW INDICATOR (V049-3-401)
8	FI-504	— CRYOPUMP WCP8 FLOW INDICATOR (V049-3-501)
9	LT-100	— CRYOPUMP WCP1 LEVEL TRANSMITTER* (V049-3-102)
10	LT-105	— CRYOPUMP WCP1 DEWAR LEVEL TRANSMITTER* (V049-3-102)
11	LT-150	— CRYOPUMP WCP2 LEVEL TRANSMITTER* (V049-3-103)
12	LT-155	— CRYOPUMP WCP2 DEWAR LEVEL TRANSMITTER* (V049-3-103)
13	LT-200	— CRYOPUMP WCP3 LEVEL TRANSMITTER* (V049-3-201)
14	LT-205	— CRYOPUMP WCP3 DEWAR LEVEL TRANSMITTER* (V049-3-201)
15	LT-250	— CRYOPUMP WCP4 LEVEL TRANSMITTER* (V049-3-201)
16	LT-255	— CRYOPUMP WCP4 DEWAR LEVEL TRANSMITTER* (V049-3-201)
17	LT-300	— CRYOPUMP WCP5 LEVEL TRANSMITTER* (V049-3-301)
18	LT-305	— CRYOPUMP WCP5 DEWAR LEVEL TRANSMITTER* (V049-3-301)
19	LT-350	— CRYOPUMP WCP6 LEVEL TRANSMITTER* (V049-3-301)
20	LT-355	— CRYOPUMP WCP6 DEWAR LEVEL TRANSMITTER* (V049-3-301)
21	LT-400	— CRYOPUMP WCP7 LEVEL TRANSMITTER* (V049-3-401)
22	LT-405	— CRYOPUMP WCP7 DEWAR LEVEL TRANSMITTER* (V049-3-401)

\* Furnished with accessories.

**ATTACHMENT "B"**

Number	Rev
<b>A V049-2-022</b>	<b>2</b>

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

ITEM	INSTRUMENT TAG/EQUIPMENT DESIGNATION	
	✓ INDICATES VACUUM ENVIRONMENT LOCATION	
	✓ DESCRIPTION (INDICATED ON DRAWING/SHEET)	
23	LT-500	— CRYOPUMP WCP8 LEVEL TRANSMITTER* (V049-3-501)
24	LT-505	— CRYOPUMP WCP8 DEWAR LEVEL TRANSMITTER* (V049-3-501)
25	PNL-100A	— CORNER STATION ION CONTROLLER PANEL (V049-3-116)
26	PNL-100B	— CORNER STATION ION CONTROLLER PANEL (V049-3-116)
27	PNL-200	— LEFT MID STATION ION CONTROLLER PANEL (V049-3-204)
28	PNL-300	— RIGHT MID STATION ION CONTROLLER PANEL (V049-3-304)
29	PNL-400	— LEFT END STATION ION CONTROLLER PANEL (V049-3-404)
30	PNL-500	— RIGHT END STATION ION CONTROLLER PANEL (V049-3-504)
31	PT-101	— CRYOPUMP WCP1 PRESSURE TRANSMITTER* (V049-3-102)
32	PT-151	— CRYOPUMP WCP2 PRESSURE TRANSMITTER* (V049-3-103)
33	PT-201	— CRYOPUMP WCP3 PRESSURE TRANSMITTER* (V049-3-201)
34	PT-251	— CRYOPUMP WCP4 PRESSURE TRANSMITTER* (V049-3-201)
35	PT-301	— CRYOPUMP WCP5 PRESSURE TRANSMITTER* (V049-3-301)
36	PT-351	— CRYOPUMP WCP6 PRESSURE TRANSMITTER* (V049-3-301)
37	PT-401	— CRYOPUMP WCP7 PRESSURE TRANSMITTER* (V049-3-401)
38	PT-501	— CRYOPUMP WCP8 PRESSURE TRANSMITTER* (V049-3-501)
39	TE-103A, 102A, 102B	— CRYOPUMP WCP1 THERMOCOUPLE (V049-3-102)
40	TE-153A, 152A, 152B	— CRYOPUMP WCP2 THERMOCOUPLE (V049-3-103)
41	TE-203A, 202A, 202B	— CRYOPUMP WCP3 THERMOCOUPLE (V049-3-201)
42	TE-253A, 252A, 252B	— CRYOPUMP WCP4 THERMOCOUPLE (V049-3-201)
43	TE-303A, 302A, 302B	— CRYOPUMP WCP5 THERMOCOUPLE (V049-3-301)

\* Furnished with accessories

**ATTACHMENT "B"**

Number	Rev
<b>A V049-2-022</b>	<b>2</b>

ITEM

INSTRUMENT TAG/EQUIPMENT DESIGNATION

V INDICATES VACUUM ENVIRONMENT LOCATION

DESCRIPTION (INDICATED ON DRAWING/SHEET)

44	TE-353A, 352A, 352B	—	CRYOPUMP WCP6 THERMOCOUPLE (V049-3-301)
45	TE-403A, 402A, 402B	—	CRYOPUMP WCP7 THERMOCOUPLE (V049-3-401)
46	TE-503A, 502A, 502B	—	CRYOPUMP WCP8 THERMOCOUPLE (V049-3-501)

ATTACHMENT "B"

Number

A V049-2-022

Rev

2

**ATTACHMENT "C"**  
**S U B M I T T A L L I S T**

Submit for review the proposed equipment submittals and reports as required under the Specification and listed below:

1. Equipment substitutions (Article 8.3, page 6)

Submit proposed substitutions PSI's representative for acceptance. With submittal, provide details of necessary changes to accommodate substitutions. Submit samples if requested.

2. List of proposed equipment (Article 9.1, page 6)

As soon as practicable, submit for review a list of equipment proposed for installation with each item identified by Specification paragraph number or where applicable by Drawing number. Include manufacturer's name with catalog or model number for each item.

3. Cable tray (Article 12.6, page 7)

Product data of each cable tray component.  
Shop drawings of support systems.

4. Wire and cable (Article 15.5, page 11)

Product data of each wire and cable.

5. Wiring identification (Article 16.3, page 12)

Product data of printed sleeve markers.

6. Instrument air/gas and process tubing (Article 20.4, page 13)

Product data of tubing and accessories.

7. Testing (Article 23.3.2, page 14)

Written test report listing resistance by feeder and branch circuit.

**ATTACHMENT "C"**

Number

**A** V049-2-022

Rev

**2**





**ATTACHMENT "E"**  
**TO**  
**V049-2-021**  
**FINAL DESIGN REPORT VOLUME IV INSTALLATION/COMMISSIONING**  
**V049-1-100**  
**"SHIPPED LOOSE"**

**ATTACHMENT**

Number: **A V049-2-021**

Rev. **3**

**ATTACHMENT "F"**  
**TO**  
**V049-2-021**  
**PSI WASHINGTON SITE DRAWING PACKAGE**

**"DRAWINGS SHIPPED LOOSE"**  
See Attachment "A" of Spec. V049-2-021 for Drawing List

For the latest drawing revision levels see the latest revision of drawing V049-0-000

**ATTACHMENT**

Number:

**A V049-2-021**

Rev.

**3**

**ATTACHMENT "G"**  
**TO**  
**V049-2-021**  
**LIGO BUILDING DRAWING PACKAGE**

**"DRAWINGS SHIPPED LOOSE"**

**( 31 Sheets Total )**

<b>ATTACHMENT</b>	
Number:	Rev.
<b>A V049-2-021</b>	<b>3</b>

**ATTACHMENT "H"**  
**TO**  
**V049-2-021**  
**VENDOR EQUIPMENT DRAWING PACKAGE**

**"DRAWINGS SHIPPED LOOSE"**  
(List attached)

<b>ATTACHMENT</b>	
Number:	Rev.
<b>A V049-2-021</b>	<b>3</b>

**ATTACHMENT "H"**  
**SPEC. V049-2-021**  
**VENDOR DRAWINGS LIST**

	Description	Drawing No.	Rev.	Document Size	Vendor
1.	50 CFM Compressor	X-156	A-8	B	Campbell/Power Ex.
2.	200 CFM Compressor	KAC1841	D	C	Rodgers
3.	44" Gate Valve – Assembly G44 Pneumatic	104065	B	A	GNB
4.	44" Gate Valve – Assembly G44 Electric	104063	B	A	GNB
5.	GA Roughing Pump Cart	D-4526-1	1	D	Edwards
6.	Main Turbo Cart	D-4507		D	Edwards
7.	Base Extension – Turbo Cart	V049-4-012	1	D	PSI
8.	Aux. Turbo Pump Cart	D-4508		D	Edwards
9.	48" Gate Valve – Assembly G48ESB	103849		A	GNB
10.	Pipe Bridge	V049-4-043	0	B	PSI
11.	Ion Pumps:				
	2500 L/S	03.649239	--	E	Varian
	75 L/S	Sketch	--	--	Varian
	25 L/S	03.649218	--	--	Varian
12.	6" Gate Valve	LI 21-081D	--	--	Varian
13.	10" Gate Valve	U21173B	--	--	Varian

<b>ATTACHMENT</b>	
Number:	Rev.
<b>A V049-2-021</b>	<b>3</b>

Title: LIGO VACUUM EQUIP. INSTALLATION AND COMMISSIONING – WASHINGTON SITE

	Description	Drawing No.	Rev.	Document Size	Vendor
14.	14" Gate Valve	M21170C	--	A	Varian
15.	LN <sub>2</sub> Tanks – Outline	CS-12004, 2 Sheets	4	C	Process Engineering
15A.	LN <sub>2</sub> Tank – Ext. Piping Assy.	D45682	3	D	Process Engineering
16.	Ambient Vaporizer 25A/30F (25,000 SCFH)	FIN-A-005	--	--	FINNCO
17.	Ambient Vaporizer 10A/12F (10,000 SCFH)	FIN-A-20	--	--	FINNCO
18.	Regen. Heater – 14 kW	V049-4-176	1	B	PSI
19.	Regen. Heater – 28 kW	V049-4-177	1	B	PSI
20.	LN <sub>2</sub> Vacuum Jacketed Piping	303250-5001	0	D	PSI
21.	200 CFM Air Filter	53-01079	A	A	Ultra Filter
22.	50 CFM Air Filter	Catalog	--	A	Ultra Filter
23.	Fisher-Rosemount Pressure Relief Valves & Pressure Regulators	PSI Doc. #V049-8-673 42 Pages			
24.	Burst Disk Assembly	48-6759	A	C	Hydrodyne

**ATTACHMENT**

Number:	Rev.
<b>A V049-2-021</b>	<b>3</b>

**ATTACHMENT "I"**  
**TO**  
**V049-2-021**  
**CARBON STEEL SUPPORTS SUPPLIED BY THE BUYER**

PSI Part No.	Description	Washington Qty.
V049-4-A7AP37	Beam Manifold Spool	4
V049-4-A7BP37	Beam Manifold Spool	4
V049-4-B1P17	Beam Manifold Spool	4
V049-4-B2AP17	Beam Manifold Spool	2
V049-4-B2AP18	Beam Manifold Spool	2
V049-4-B2BP17	Beam Manifold Spool	2
V049-4-B2BP18	Beam Manifold Spool	2
V049-4-B3AP17	Beam Manifold Spool	2
V049-4-B3AP18	Beam Manifold Spool	2
V049-4-B5AP17	Beam Manifold Spool	2
V049-4-B5AP18	Beam Manifold Spool	2
V049-4-B6P7	Beam Manifold Spool	2
V049-4-B7P7	Beam Manifold Spool	2
V049-4-B9P12	Beam Manifold Spool	4
V049-4-B9P13	Beam Manifold Spool	4
V049-4-BE5P9	Beam Manifold Spool	2
V049-4-BE6P9	Beam Manifold Spool	2
V049-4-140	80K Cryopump-Long	4
V049-4-141	80K Cryopump-Short	12
V049-4-012	Turbo Pump Cart Base	6

**ATTACHMENT**

Number:

**A V049-2-021**

Rev.

**3**

**ATTACHMENT "J"**

**EQUIPMENT GROUPING FOR SHIPPING**

A. Chambers shipped separately: (Also, see Item "C" below)

| All BSC's - see drawings V049-4-302 thru 305 for door/shipping cover configurations.

NOTE: BSC'S are shipped horizontal on a structural steel skid.

Total shipping weight of vessel plus skid = 20,000 lbs.

All HAM's - NOTE: 4 HAMs are shipped with 1 permanent cover and 1 shipping cover

8 HAMs are shipped with 2 shipping covers.

Est. ship wt. of (1) HAM = 9,000 lbs.

B. The following pieces of equipment will be shipped fully bolted together as listed below:

These pieces will be shipped on wooden cradles with bolt-on support legs shipped loose for field assembly. See the Attachment I to determine the quantity of support legs to be field assembled.

B.1 Corner Station

The following spools will be shipped assembled as one piece.

Item	No. & Sz. of Shipping Covers	Est. Total Ship Weight
WA12A, B4A	(1) 60"x (1) 48" shipping covers	2700 lbs.
WA12B, B4B	(1) 60"x (1) 48" shipping covers	2600 lbs.
WB6, A6	(1) 60"x (1) 48" shipping covers	3650 lbs.
WB7, A6	(1) 60"x (1) 48" shipping covers	3700 lbs.
WA15A&B, (2) Separate pieces	(1) 60"x (1) 48" shipping covers	2400 lbs.
WA3A&B, (2) Separate pieces	(1) 60"x (1) 48" shipping covers	2400 lbs.
WB-5A	(2) 60" shipping covers	6800 lbs.
WBE-3B	(2) 60" shipping covers	2400 lbs.
WB-3A	(2) 60" shipping covers	6800 lbs.
WBE-3A1	(2) 60" shipping covers	2400 lbs.
WB-2A	(2) 60" shipping covers	6800 lbs.
WBE-3A2	(2) 60" shipping covers	2400 lbs.
WB-2B	(2) 60" shipping covers	6800 lbs.
WBE-3C	(2) 60" shipping covers	2400 lbs.
WCP1, BE-4A (Long) 80K	(2) 44" shipping covers	12000 lbs.
WCP2, BE-4B (Long) 80K	(2) 44" shipping covers	12,000 lbs.
WA13A, B8A, B1A	(1) 72"x (1) 60" shipping covers	7400 lbs.

**ATTACHMENT**

Number:

**A V049-2-021**

Rev.

**3**



**ATTACHMENT "J"**

**EQUIPMENT GROUPING FOR SHIPPING (Cont'd)**

WA13B, B8B, B1B	(1) 72"x (1) 60" shipping covers	7400 lbs.
WBE-5	(2) 72" shipping covers	9000 lbs.
WBE-6	(2) 72" shipping covers	9000 lbs.
WB-9A, WA1A	(1) 72"x (1) 44" shipping covers	10,500 lbs.
WB-9B, WA1B	(1) 72"x (1) 44" shipping covers	10,500 lbs.
WBE-2A	(2) 60" shipping covers	1700 lbs.
WBE-2B	(2) 60" shipping covers	1700 lbs.
BSC's & HAM's see item "A" Above		

**B.2 Each Mid Station - 2 Required as shown**

Item	No. & Sz. of Shipping Covers	Est. Total Ship Weight
Short Cryopump A, WBE-4	(2) 44" shipping covers	9000 lbs.
Short Cryopump B, WBE-4	(2) 44" shipping covers	9000 lbs.
WA1, A-7	(1) 44" X (1) 60" shipping covers	6500 lbs.
WA14	(1) 44" X (1) 60" shipping covers	1800 lbs.
BSC	(2) 60" shipping covers	15,000 lbs.

**B.3 Each End Station - 2 Required as shown**

Item	No. & Sz of Shipping Covers	Est. Total Ship Weight
Short Cryopump, WBE-4	(2) 44" shipping covers	9000 lbs.
WA1, A-7	(1) 44" X (1) 60" shipping covers	6500 lbs.
BSC	(1) 60" Shipping cover	15,000 lbs.

C. The following BSC's will require relocation of one 60" cover from its shipping position to the operating position as shown on Drawings V049-4-302, 303, 304, & 305.

WBSC1, WBSC3, WBSC5, WBSC6, WBSC9, WBSC10

<b>ATTACHMENT</b>	
Number: <b>A V049-2-021</b>	Rev. <b>3</b>

D. In addition to the above equipment, the following truck loads will be shipped to the site:

- |   |                     |                     |
|---|---------------------|---------------------|
| 1. 12 Shipping crates (valves, instrs.,<br>ion pumps, blankets, o-rings<br>(COMMON CARRIER TRUCK).                  | 3,500 lbs<br>each   | 4'x4'x4' Ea.        |
| 2. 1 Truckload of vac. pump equip. air<br>compr + misc. items (airride, closed<br>trailer).                         | 20,000 lbs<br>total | 7'Wx8'Hx30' Lg.     |
| 3. 1 Truckload misc. equip. (airride,<br>closed trailer).   | 20,000 lbs<br>total | 7'Wx8'Hx40'Lg.      |
| 4. 1 Return trip from Handord., WA.<br>to Westboro, MA.<br>6-BSC skids & ship covers<br>stacked with cradles loose. | 28,000 lbs<br>total | 11'-6"Wx9'Hx30' Lg. |

E. PSI reserves the right to make changes to the above groupings, without cost impact to PSI

**ATTACHMENT**

Number:

**A V049-2-021**

Rev.

**3**

**ATTACHMENT "J"  
TO  
V049-2-021**

**LIGO Equipment Installation and Shipping Data**

**Washington Corner Station:**

Tag No.	Shp. Wt.	Shp. Dim.	Onsite Date
WBSC 1	20000 lbs.	11 ft.6 in. Wx11 ft.6 in. Hx22 ft.6 in. L	Per P.O.
WBSC 2	20000 lbs.	11 ft.6 in. Wx11 ft.6 in. Hx22 ft.6 in. L	
WBSC 3	20000 lbs.	11 ft.6 in. Wx11 ft.6 in. Hx22 ft.6 in. L	
WBSC 4	20000 lbs.	11 ft.6 in. Wx11 ft.6 in. Hx22 ft.6 in. L	
WBSC 7	20000 lbs.	11 ft.6 in. Wx11 ft.6 in. Hx22 ft.6 in. L	
WBSC 8	20000 lbs.	11 ft.6 in. Wx11 ft.6 in. Hx22 ft.6 in. L	
WHAM 1	9000 lbs.	10 ft. W x 9ft. H x 9 ft. L	
WHAM 2	9000 lbs.	10 ft. W x 9ft. H x 9 ft. L	
WHAM 3	9000 lbs.	10 ft. W x 9ft. H x 9 ft. L	
WHAM 4	9000 lbs.	10 ft. W x 9ft. H x 9 ft. L	
WHAM 5	9000 lbs.	10 ft. W x 9ft. H x 9 ft. L	
WHAM 6	9000 lbs.	10 ft. W x 9ft. H x 9 ft. L	
WHAM 7	9000 lbs.	10 ft. W x 9ft. H x 9 ft. L	
WHAM 8	9000 lbs.	10 ft. W x 9ft. H x 9 ft. L	
WHAM 9	9000 lbs.	10 ft. W x 9ft. H x 9 ft. L	
WHAM 10	9000 lbs.	10 ft. W x 9ft. H x 9 ft. L	
WHAM 11	9000 lbs.	10 ft. W x 9ft. H x 9 ft. L	
WHAM 12	9000 lbs.	10 ft. W x 9ft. H x 9 ft. L	
WHAM Spare	9000 lbs.	10 ft. W x 9ft. H x 9 ft. L	
WCP 1/WBE-4A	12000 lbs.	89 in. OD x 21 ft. L	
WCP 2/WBE-4B	12000 lbs.	89 in. OD x 21 ft. L	
WGV 1	Shipped to site by vendor		
WGV 2	Shipped to site by vendor		
WGV 3	Shipped to site by vendor		
WGV 4	Shipped to site by vendor		
WGV 5	Shipped to site by vendor		
WGV 7	Shipped to site by vendor		

**ATTACHMENT**

Number:	Rev.
<b>A V049-2-021</b>	<b>3</b>

Title: LIGO VACUUM EQUIP. INSTALLATION AND COMMISSIONING – WASHINGTON SITE

Washington Corner Station:

Tag No.	Shp. Wt.	Shp. Dim.	Onsite Date
WB-9A/WA-1A	10500 lbs.	80 in. OD x 39 ft.L	Per P.O.
WB-9B/WA-1B	10500 lbs.	80 in. OD x 39 ft.L	
WBE-5	9000 lbs.	80 in. OD x 34 ft.L	
WBE-6	9000 lbs.	80 in. OD x 34 ft.L	
WBE-2A	1700 lbs.	80 in. OD x 6 ft.6 in.L	
WBE-2B	1700 lbs.	80 in. OD x 6 ft.6 in.L	
WBE-3A1	2400 lbs.	73 in. OD x 4 ft.L	
WB-2A	6800 lbs.	69 in. OD x 37 ft.6 in.L	
WB-2B	6800 lbs.	69 in. OD x 37 ft.6 in.L	
WB-3A	6800 lbs.	69 in. OD x 37 ft.6 in.L	
WB-5A	6800 lbs.	69 ft. OD x 6 ft.L	
WA-13A/WB-8A/ WB-1A	7400 lbs.	80 in. OD x 21 ft.L	
WA-13B/WB-8B/ WB-1B	7400 lbs.	80 in. OD x 21 ft.6 in.L	
WBE-3A2	2400 lbs.	73 in. OD x 4 ft.L	
WBE-3B	6800 lbs.	73 in. OD x 4 ft.L	
WA-15A	2400 lbs	69 in. OD x 2 ft.6in. L	
WA-15B	2400 lbs	69 in. OD x 2 ft.6in. L	
WA-3A	2400 lbs.	69 in. OD x 3 ft.10 in. L	
WA-3B	2400 lbs	69 in. OD x 3 ft.10 in. L	
WB-7/WA-6A	3700 lbs	69 in. OD x 11 ft.6in. L	
WB-6/WA-6B	3650 lbs	69 in. OD x 11 ft.6in. L	
WA-12A/WB-4A	2700 lbs	69 in. OD x 9 ft.6in. L	
WA-12B/WB-4B	2600 lbs	69 in. OD x 9 ft.6in. L	
WBE-2A	1800 lbs.	80 in. OD x 6 ft.6 in.L	
WBE-2B	1800 lbs.	80 in. OD x 6 ft.6 in.L	
WBE-3A1	2500 lbs.	73 in. OD x 4 ft.L	
WBE-3A2	2500 lbs.	73 in. OD x 4 ft.L	
WBE-3C	2500 lbs.	73 in. OD x 4 ft.L	
WDW 1	46500 lbs.	10 ft. dia. X 46 ft.L	
WDW 2	46500 lbs.	10 ft. dia. X 46 ft.L	

**ATTACHMENT**

Number:

**A V049-2-021**

Rev.

**3**

Title: LIGO VACUUM EQUIP. INSTALLATION AND COMMISSIONING - WASHINGTON SITE

**Washington Corner Station:**

Tag No.	Shp.Wt.	Shp.Dim.	Onsite Date
WIP 1	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	Per P.O.
WIP 2	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	
WIP 3	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	
WIP 4	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	
WIP 5	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	
WIP 6	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	
WIP 7	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	
WIP 8	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	
2ea. HAM Clean Rms.	3000 lbs.	13 ft.4in.W x 16 ft.9in.L x 6 ft.5in.H	
6 in. gate valves			
10 in. gate valves			

**Washington Left Mid Station:**

Tag No.	Shipping Weight	Shipping Dimensions	Onsite Date
WBSC 6	20000 lbs.	11ft.6in.Wx 11ft.6 in.H x 22ft.6in.L	Per P.O.
WCP 3/WBE-4D	9000 lbs.	89 in. OD x13 ft.L	
WCP 4/WBE-4F	9000 lbs.	89 in. OD x13 ft.L	
WA-7B1/WA-1D	6500 lbs.	80 in. OD x 19 ft.L	
WA-14B	1800 lbs.	52 in. OD x 7 ft.3 in.L	
WGV 10	Shipped to site by vendor		
WGV 11	Shipped to site by vendor		
WIP 9	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	
WDW 3	40400 lbs.	10 ft. dia. X 40 ft.L	
WDW 4	40400 lbs.	10 ft. dia. X 40 ft.L	
3 ea. 10 in. gate valves			

**ATTACHMENT**

Number:

**A V049-2-021**

Rev.

**3**

Title: LIGO VACUUM EQUIP. INSTALLATION AND COMMISSIONING - WASHINGTON SITE

**Washington Left End Station:**

Tag No.	Shipping Weight	Shipping Dimensions	Onsite Date
WBSCV 10	20000 lbs.	11ft.6in.Wx 11ft.6 in.H x 22ft.6in.L	Per P.O.
WCP 7/WBE-4H	9000 lbs.	89 in. OD x13 ft.L	
WA-7B2/WA-1F	6500 lbs.	80 in. OD x 19 ft.L	
WGV 18	Shipped to site by vendor		
WDW 7	40400 lbs.	10 ft. dia. X 40 ft.L	
WIP 11	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	
2 ea. 10 in. gate valves			

**Washington Right Mid Station:**

Tag No.	Shipping Weight	Shipping Dimensions	Onsite Date
WBSC 5	20000 lbs.	11ft.6in.Wx 11ft.6 in.H x 22ft.6in.L	Per P.O.
WCP 5/WBE-4C	9000 lbs.	89 in. OD x13 ft.L	
WCP 6/WBE-4E	9000 lbs.	89 in. OD x13 ft.L	
WA-7A/WA-1C	6500 lbs.	80 in. OD x 19 ft.L	
WA-14A	1800 lbs.	52 in. OD x 7 ft.3 in.L	
WDW 5	40400 lbs.	10 ft. dia. X 40 ft.L	
WDW 6	40400 lbs.	10 ft. dia. X 40 ft.L	
WGV 14	Shipped to site by vendor		
WGV 15	Shipped to site by vendor		
WIP 10	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	
3 ea. 10 in. gate valves			

**ATTACHMENT**

Number:	Rev.
<b>A V049-2-021</b>	<b>3</b>

Title: LIGO VACUUM EQUIP. INSTALLATION AND COMMISSIONING - WASHINGTON SITE

**Washington Right End Station:**

Tag No.	Shipping Weight	Shipping Dimensions	Onsite Date
WBSC 9	20000 lbs.	11ft.6in.Wx 11ft.6 in.H x 22ft.6in.L	Per P.O.
WCP 8/WBE-4G	9000 lbs.	80 in. OD x13 ft.L	
WDW 8	40400 lbs.	10 ft. dia. X 40 ft.L	
WGV 20	Shipped to site by vendor		
WIP 12	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	

2 ea. 10 in. gate valves

**In addition to the above equipment, the following truck loads will be shipped to the site by Common Carrier truck with air ride closed trailer:**

- A. 12 Shipping crates (valves, instrs., ion pumps, blankets, o-rings) 3,500 lbs 4ft.Wx 4ft.Hx 4ft.L
- B. 1 Truckload of vac. pump equip. air compr and misc. items 20,000 lbs 7ft.Wx8ft.Hx 30ft. L
- C. 1 Truckload misc. equip. 20,000 lbs 7ft.Wx8ft.Hx40ft.L
- D. 1 Return trip from Handord., WA. to Westboro, MA. 6-BSC skids and ship covers stacked with cradles loose. 28,000 lbs 11ft.6in.Wx9ft.Hx30ft.L

**ATTACHMENT**

Number:	Rev.
<b>A V049-2-021</b>	<b>3</b>





**ATTACHMENT "K"**  
**TO**  
**V049-2-021**  
**FABRICATED CLASS 100 VACUUM AND AIR PIPING**  
**V049-2-178**

<b>ATTACHMENT</b>	
Number:	Rev.
<b>A V049-2-021</b>	<b>3</b>

SPECIFICATION FOR  
PREFABRICATED VACUUM AND CLASS 100 AIR PIPING

FOR  
LIGO VACUUM EQUIPMENT

Hanford, Washington



*Raymond D. Ciatto 7/21/97*  
EXPIRES 8/5/99

INSTALLATION MANAGER:

*[Signature]*

STRUCTURAL ENGINEER:

*R. D. Ciatto*

TECHNICAL DIRECTOR:

*D. A. McWilliams*

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	MSE 16 JUL 97	REC 7/2/97	RELEASED FOR CONSTRUCTION PER AEO # 0535
P1	REC 12/20/96	12/20/96	ISSUED FOR QUOTES DEO 0393
REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number V049-2-178
	REC 12/20/96		<i>[Signature]</i>	12/20/96	Rev. Ø

Title

# SPECIFICATION FOR PREFABRICATED VACUUM AND CLASS 100 AIR PIPING

## TABLE OF CONTENTS

- 1.0 Purpose
- 2.0 Scope
- 3.0 Materials
- 4.0 Fabrication and Testing
- 5.0 Documentation

## ATTACHMENTS:

- A. Drawing List - See Attached List
- B. V049-2-037 " Specification for Piping Design and Material"
- C. V049-2-060 Specification for Clean Quarter Turn Valves
- D. V049-2-059 Specification for Small Vacuum Valves

Number

Rev.

## SPECIFICATION

Number

**A** V049-2-178

Rev.

0

**1.0 PURPOSE**

This specification defines the scope of work to be provided by the contractor for the supply of the optional prefabricated Vacuum and Class 100 Air piping for the LIGO Vacuum Equipment. All requirements of V049-2-021 "Specification for Installation/Commissioning for LIGO Vacuum Equipment" applicable to this work.

**2.0 SCOPE**

2.1 The contractor is to provide all material and labor to detail design, procure, fabricate, test, and deliver to the site Vacuum and Class 100 Air piping and pipe supports as shown on the piping arrangement drawings and P&I Diagrams listed in Attachment A.

2.2 The Vacuum piping is comprised of the following:

Roughing Header (Corner Station only)

Turbo Headers

Annulus Piping

**3.0 MATERIALS**

All materials shall be in accordance with V049-2-037 "Specification for Piping Design and Materials"

**4.0 FABRICATION AND TESTING**

4.1 Pipe spool sections shall be prefabricated using only approved welding procedures in lengths appropriate to allow installation in the vacuum equipment area without requiring welding. Fabrication shall be done in accordance with specified codes.

4.2 Each spool section run shall have one fixed and one rotatable CF flange to permit easy assembly of the piping system. Flex sections shall be provided as necessary. Branches shall terminate in fittings as designated on the P&I Diagrams. Blind flanges shall be provided as indicated including gaskets and hardware. Spool drawings shall be submitted to PSI for approval prior to fabrication.

4.3 Each spool section is to be helium leak checked after welding by evacuating and spraying with helium, and show no detectable with a helium mass spectrometer at a sensitivity of  $1 \times 10^{-9}$  torr l/s. Spools shall be given unique serial numbers (1 to \_\_\_) to control testing documentation.

**SPECIFICATION**

Number **A** V049-2-178

Rev. *Ø*

Page 3 of 4

Number

Rev.

**SPECIFICATION FOR PREFABRICATED VACUUM AND CLASS 100 AIR PIPING**

4.4 Each spool section shall be pressure washed with hot water using approved detergent (Oakite Inpro-Clean 1300)\* and then rinsed with dionized water to remove all dirt and hydrocarbons. After drying with clean, filtered hydrocarbon free air or nitrogen, the section shall be checked for contamination using a white glove. Any discoloration shall be cause for rejection and the piece shall be rewashed. If contamination is localized, the area may be cleaned using isopropyl alcohol and lint free cloths.

\* Per manufacturer's specifications and not to exceed 5% inpro-clean in solution.

4.5 After drying the section shall be properly labeled and capped to provide an airtight seal. The seal shall be maintained up to the time the section is to be installed.

**5.0 DOCUMENTATION**

The following documentation shall be provided.

- Material certification of all materials on pipe and fittings
- Leak Test Report
- Cleaning Report
- As built drawings

Number

Rev.

**SPECIFICATION**Number **A** V049-2-178Rev. *0*Page 4 of 4

Title

**SPECIFICATION FOR PREFABRICATED VACUUM AND CLASS 100 AIR PIPING**

SHT 1 OF 3

**ATTACHMENT "A" SPEC. V049-2-178**

**DOCUMENT LIST**

<i>TITLE</i>	<i>DRAWING SIZE</i>	<i>DOCUMENT NUMBER</i>	<i>REV.</i>
P&ID's	D		
Legend/Station Diagrams (3 Shts.)	D	V049-0-001	2
Beam Splitter Chamber All But Corner Vertex Arms	D	V049-0-002	2
Beam Splitter Chamber Corner Vertex Arms	D	V049-0-003	2
Horizontal Access Module	D	V049-0-004	2
112cm & 122cm Gate Valves	D	V049-0-005	2
80K Cryopump	D	V049-0-006	3
Chamber Pressurization System	D	V049-0-007	0
WA Left End Station	D	V049-0-010	2
WA Left Mid Station	D	V049-0-011	2
WA Left Beam Manifold	D	V049-0-012	2
WA Vertex Section	D	V049-0-013	2
WA Diagonal Section	D	V049-0-014	2
WA Right Beam Manifold	D	V049-0-015	2
WA Right Mid Station	D	V049-0-016	2
WA Right End Station	D	V049-0-017	2
WA Corner Station Mechanical Room	D	V049-0-018	2

Number

Rev.

**SPECIFICATION**

Number **A** V049-2-178

Rev. *[Signature]*

Title

**SPECIFICATION FOR PREFABRICATED VACUUM AND CLASS 100 AIR PIPING**

SHT 2 OF 3

<i>QTY</i>	<i>TITLE</i>	<i>DRAWING SIZE</i>	<i>DOCUMENT NUMBER</i>	<i>REV.</i>
<b>MECHANICAL DRAWINGS</b>				
6	25 L/S Annulus Tubing-44" G.V. Type III	C	V049-4-106	0
2	25 L/S Annulus Tubing 48" G.V. Type I	C	V049-4-108	0
8	Annulus Tubing & Ion Pump Assembly. 44" G.V.	D	V049-4-109	0
2	25 L/S Annulus Tubing 48"G.V. Type II	C	V049-4-110	0
2	25 L/S Annulus Tubing - 44" G.V. Type I	C	V049-4-164	0
4	Annulus Tubing & Ion Pump Assy 48" G.V.	D	V049-4-165	0
8	25 L/S Annulus Tubing - 44" G.V. Type II	C	V049-4-166	0
-	Left & Right Beam Manifold Annulus Headers	D	V049-5-012	Sht 1
1	Right Beam Manifold Annulus Header Per Line No. 2 1/2-PV-1174-T3			
1	Left Beam Manifold Header Per Line No. 2 1/2-PV-1158-T3			

Number

Rev.

**SPECIFICATION**

Number **A** V049-2-178

Rev 

Title

**SPECIFICATION FOR PREFABRICATED VACUUM AND CLASS 100  
AIR PIPING**

SHT 3 OF 3

*TITLE**DRAWING  
SIZE**DOCUMENT  
NUMBER**REV.***MECHANICAL DRAWINGS**

Equipment Arr't. Plan, Corner Station WA Sht 1 of 2	D	V049-5-001	1
Equipment Arr't. Elevation, Sht 2 of 2	D	V049-5-001	1
Equipment Arr't ISO, Corner Station, WA	D	V049-5-002	1
Equipment Arr't, Right Mid Station, WA	D	V049-5-004	1
Equipment Arr't, Right End Station, WA	D	V049-5-005	1
Equipment Arr't, Left Mid Station, WA	D	V049-5-006	1
Equipment Arr't, Left End Station, WA	D	V049-5-007	1
Equipment Arr't ISO, Right Mid Station, WA	D	V049-5-010	1
Equipment Arr't ISO, Right End Station, WA	D	V049-5-011	1
Piping Arr't, Plan Corner Station/WA (4 Shts)	D	V049-5-012	1
Piping Arr't, Elevation, Corner Station/WA	D	V049-5-013	1
Piping Arr't, Sections, Corner Station/WA	D	V049-5-014	1
Piping Arr't, Plan, Right Mid Station/WA (4 Shts)	D	V049-5-017	1
Piping Arr't, Elevation, Right Mid Station/WA (2 Shts)	D	V049-5-018	1
Piping Arr't, Sections, Right Mid Station/WA	D	V049-5-019	1
Piping Arr't, Plan, Right End Station/WA (2 Shts)	D	V049-5-021	1
Piping Arr't, Elevation, Right End Station/WA	D	V049-5-022	1
Piping Arr't, Sections, Right End Station/WA	D	V049-5-023	1
Piping Arr't. Plan Left Mid Station/WA (4 Sheets)	D	V049-5-026	1
Piping Arr't Elevation Left Mid Station/WA (2 Sheets)	D	V049-5-027	1
Piping Arr't, Sections, Left Mid Station/WA	D	V049-5-028	1
Piping Arr't. Plan Left End Station/WA (2 Sheets)	D	V049-5-030	1
Piping Arr't Elevation Left End Station/WA	D	V049-5-031	1
Piping Arr't, Sections, Left End Station/WA	D	V049-5-032	1
Overall Flange Arr't, Corner Station, WA	D	V049-5-033	0
Overall Flange Arr't, Mid Station, WA	D	V049-5-035	0
Overall Flange Arr't, Type End Station	D	V049-5-036	0

Number

Rev.

**SPECIFICATION**

Number

**A** V049-2-178

Rev.

Page 3 of 3



**ATTACHMENT "B"**

**TO**

**V049-2-178**

**SPECIFICATION FOR PIPING AND MATERIAL FOR LIGO VACUUM EQUIPMENT**

**V049-2-037**

**ATTACHMENT**

Number:

**A V049-2-178**

Rev.

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**SPECIFICATION FOR PIPING DESIGN AND MATERIAL**

Title:

**SPECIFICATION FOR  
PIPING DESIGN AND MATERIAL**

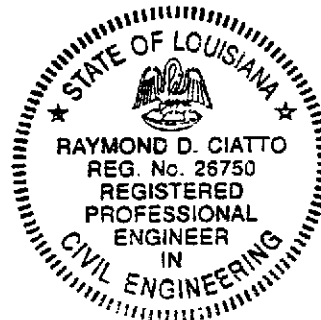
FOR

**LIGO VACUUM EQUIPMENT**

Hanford, Washington

And

Livingston, Louisiana



REVISED 8/5/99

7/21/97

PROCESS ENGINEER: Robert Tham

PROJECT ENGINEER: A. Moten

CIVIL/STRUC. ENGINEER: R. D. Ciatto

MANUFACTURING ENGINEER: Phillip Falgout

QUALITY ASSURANCE ENGINEER: Alan S. Burdlock

PROJECT MANAGER: Stan Byg

5	DM 11/14/97	DM 1-18-97	Clarified 1B1 flange/gasket requirements DEO # 0411
4	REL 11/27/96	DM 11-28	Revised T3 CLASS, MAT'L TO BE 304S/S, 17 WAS 304L. DEO 0369
3	DM 10/16/96	DM 10-17-96	Added "C2", Spec. SHT for cryogenic copper lines. Revised 1B1-FLANGES DEO # 0317
2	REL 8/24/96	DM 8/28/96	REVISED T4 SPEC SH7.17, 17EM5. DEO. 249 RELEASED FOR PURCHASE.
1	REL 7/26/96	REL 8/13/96	REVISED T4 SPEC. SH7.17 RELEASED FOR PURCHASE DEO # 0236
0	REL 1-19-96	DM 1-19-96	RELEASED FOR DESIGN & QUOTES DEO # 0044

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE			
PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION			
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number	Rev.
	R. Ciatto	1-11-96	D. M. W.	1-18-96	A V049-2-037	5

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

SPECIFICATION		
Number A	V049-2-037	Rev. 5

**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

Number

Rev.

**SPECIFICATION**

Number **A** V049-2-037

Rev. **5**

Page 3 of 20

**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**

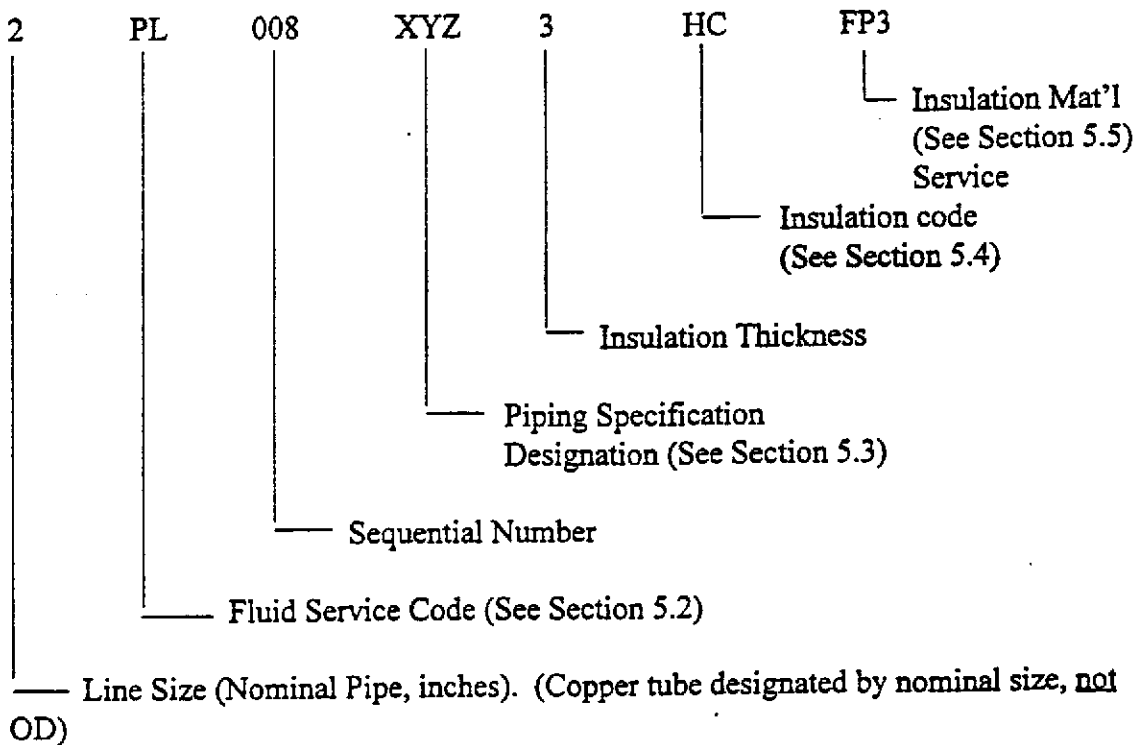
3.1 All materials used to manufacture the piping, tubing, flanges or fittings, as designated per this specification, are to be of U.S.A. origin and manufacture.

**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.

<b>SPECIFICATION</b>	
Number <b>A</b> V049-2-037	Rev. <b>5</b>

## 5.2 Fluid Codes

<u>Code</u>	<u>Fluid</u>
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

<u>Insulation Symbol</u>	<u>Insulation Service</u>
HC	Hot and Cold
C	Cold Conservation
PC	Personnel Protection COLD
PH	Personnel Protection HOT
VJ	Vacuum Jacketed

## SPECIFICATION

Number **A** V049-2-037Rev. **5**Page 5 of 20

Number

Rev.

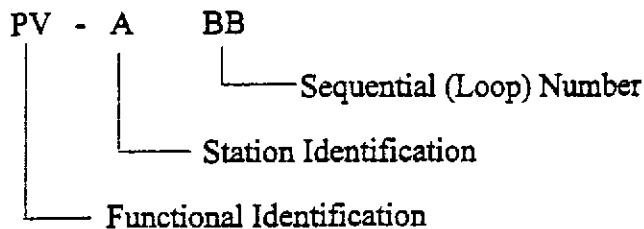
### 5.5 Insulation Material Codes

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, preceded 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

## SPECIFICATION

Number **A** V049-2-037

Rev. **5**

Title:

**SPECIFICATION FOR PIPING DESIGN AND MATERIAL**

VSOO Vacuum Seal-Off Valve Operator, SS

**1B1**

**PIPING DESIGN AND MATERIAL SPECIFICATION**

Service: Cryogenic  
Primary Rating: 150# ANSI 304 SSSL

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. Flanges on the vent line, (which mate to a flat faced flange on the vacuum equipment) shall be stainless steel raised-face design. Flanged joints shall have spiral wound, stainless steel gaskets, Flexitallic or equal.

Valves: Valves shall be furnished under their own unique specification.

Continued on Next Page

SPECIFICATION		
Number	V049-2-037	Rev.
A		5



Title

# SPECIFICATION FOR PIPING DESIGN AND MATERIAL

1B1

## 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

Number  
Rev.

## SPECIFICATION

Number **A** V049-2-037

Rev. **5**

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.

Number  
Rev.

<b>SPECIFICATION</b>		
Number	V049-2-037	Rev.
<b>A</b>		<b>5</b>

**1B2**

Branch Connections:

Run Size "											
1/2	04										04 - Tee
3/4	06	04									05 - Sockolet
1	12	06	04								06 - Tee Then
1 1/2	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	1/2	3/4	1	1 1/2	2	3	4	6	8	10	12

Note:

1. Piping and fittings to be internally cleaned, dried 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.

Number

Rev.

**SPECIFICATION**

Number **A** V049-2-037

Rev. **5**

Title

**SPECIFICATION FOR PIPING DESIGN AND MATERIAL**

**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.

**SPECIFICATION**

Number **A** V049-2-037

Rev. **5**

Title

**SPECIFICATION FOR PIPING DESIGN AND MATERIAL**

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.
-----------	---

<u>Tube Size (OD):</u>	<u>Minimum Wall Thickness (Inches)</u>
------------------------	--

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, dried 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.

Number  
Rev.

**SPECIFICATION**

Number **A** V049-2-037

Rev. **5**

Title

# SPECIFICATION FOR PIPING DESIGN AND MATERIAL

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.
-----------	--

<u>Tube Size (OD):</u>	<u>Minimum Wall Thickness (Inches)</u>
------------------------	--

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, dried 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.

Number

Rev.

### SPECIFICATION

Number **A** V049-2-037

Rev. **5**

Title

## SPECIFICATION FOR PIPING DESIGN AND MATERIAL

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 TP304 SMLS  
 1 1/2" and larger ASTM A26 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"

**Flanges:** All Flanges to be Conflat, ISO Large Flange or KF tube fittings 304 Stainless Steel.

Continued on next page.

## SPECIFICATION

Number A V049-2-037

Rev. 5

Page 14 of 20

Number

Rev.

Title

**SPECIFICATION FOR PIPING DESIGN AND MATERIAL**

**T3**

**Fittings:** All fittings to be 304 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, dried 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.

Number

Rev.

**SPECIFICATION**

Number **A** V049-2-037

Rev. **5**

Page 15 of 20



Title

## SPECIFICATION FOR PIPING DESIGN AND 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.

## SPECIFICATION

Number

A

V049-2-037

Rev.

5

Page 16 of 20

Number

Rev.

## 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, dried 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.

Number

Rev.

## SPECIFICATION

Number **A** V049-2-037Rev. **5**

Title

**SPECIFICATION FOR PIPING DESIGN AND MATERIAL**

**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.

Number  
Rev.

**SPECIFICATION**

Number <b>A</b>	V049-2-037	Rev. <b>5</b>
-----------------	------------	---------------

Title

**SPECIFICATION FOR PIPING DESIGN AND MATERIAL**

**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, dried 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. 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.

Number  
Rev.

**SPECIFICATION**

Number **A** V049-2-037

Rev. **5**

Title:

**SPECIFICATION FOR PIPING DESIGN AND 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**

**V049-2-037**

Rev. **5**

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:					SPEC NO: 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

REV. 5  
Pg. 20

**ATTACHMENT "C"**

**TO**

**V049-2-178**

**SPECIFICATION FOR CLEAN QUARTER TURN VALVES**

**V049-2-060**

**ATTACHMENT**

Number: **A V049-2-178**

Rev.

Title: SPECIFICATION FOR CLEAN QUARTER-TURN VALVES

SPECIFICATION FOR  
 CLEAN QUARTER-TURN VALVES  
 FOR  
 LIGO VACUUM EQUIPMENT

Hanford, Washington  
 and  
 Livingston, Louisiana

PREPARED BY: Thomas M. Stam  
 PROCESS ENGINEER: Po Lento Thaw  
 QUALITY ASSURANCE: Alan & Budbrook  
 TECHNICAL DIRECTOR: D. C. McWilliam  
 PROJECT MANAGER: Pat Bayley

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.

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
2	REC 07/10/97	D.M.W. 7-10-97	REVISED FOR PURCHASE TO ADD QTY. 12 - 1/2" VALVES DEO 0520
1	TMS 9-25-96	D.M.W. 9-26-96	REVISED FOR PURCHASE PER DEO 0274
0	TMS 3-1-96	D.M.W. 3-5-96	RELEASED FOR QUOTE PER DEO 077

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



Title:

# SPECIFICATION FOR CLEAN QUARTER-TURN VALVES

## 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.

SPECIFICATION		
Number		Rev.
A	V049-2-060	2

Title:

**SPECIFICATION FOR CLEAN QUARTER-TURN VALVES**

**2.0 SCHEDULE**

2.1 Equipment delivery shall be as follows:

	<u>Quantity</u>	<u>Date</u>	<u>PSI Part No.</u>
PSI, Westboro, MA:	21	11/29/96	V049BVCA20
PSI, Westboro, MA.	12	07/30/97	V049BVCA15 (80K purge)

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:

SPECIFICATION		
Number		Rev.
A	V049-2-060	2

Title:

**SPECIFICATION FOR CLEAN QUARTER-TURN VALVES**

**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.

<b>SPECIFICATION</b>		
Number	V049-2-060	Rev.
A		2

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*

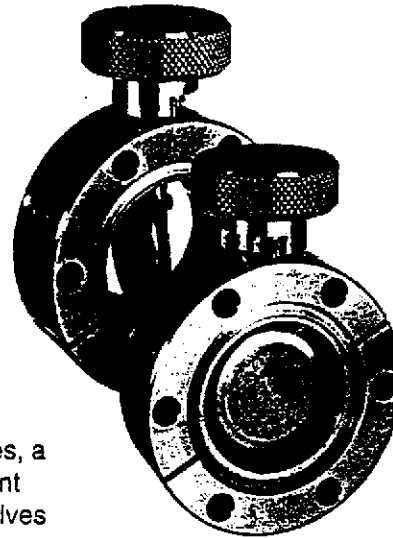
DESCRIPTION

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.

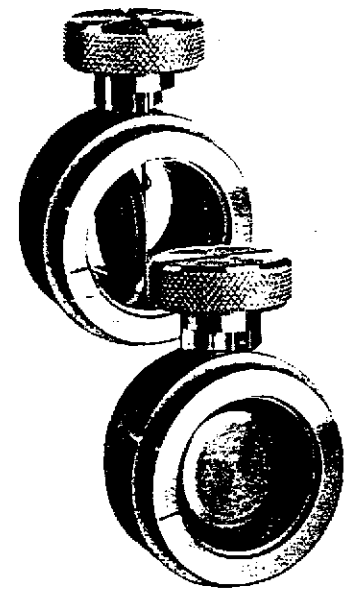
These quick-acting Butterfly Valves feature an improved sealing action. The opening in the body of the valve has been machined at a slight angle to the plane of the flapper. The flapper is set to rotate slightly off-center. On closure, this causes the sealing pressure to be applied more uniformly all 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*  
BFV-150



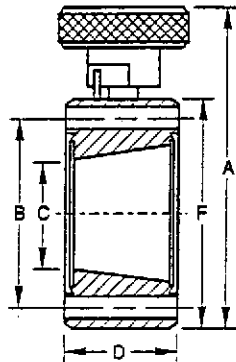
*Kwik-Flange Flange*  
KBV-150

Valves

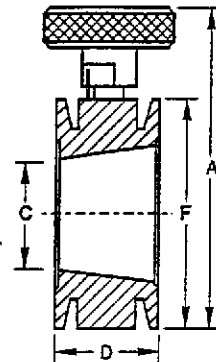
# Butterfly Valves

Toll Free Outside CA 1-800-443-8817

5-6



Del-Seal Flange



Kwik-Flange Flange

## ORDERING INFORMATION

Please order by Part Number

Valve Nqm I.D.	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

**ATTACHMENT "D"**  
**TO**  
**V049-2-178**

**SPECIFICATION FOR SMALL VACUUM VALVES**

**V049-2-059**

**ATTACHMENT**

Number:

**A V049-2-178**

Rev.

SPECIFICATION FOR  
SMALL VACUUM VALVES  
FOR  
LIGO VACUUM EQUIPMENT

Hanford, Washington  
and  
Livingston, Louisiana

PREPARED BY: Thomas M. Stern

PROCESS ENGINEER: Robert Thom.

QUALITY ASSURANCE: Alvin R. Bealbrook

TECHNICAL DIRECTOR: D. C. McCallister

PROJECT MANAGER: Barclay Bayly

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

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

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number
	T. Stern	2-29-96	RES	2/21/96	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.

## SPECIFICATION

Number	A	V049-2-059	Rev.	1
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Page 2 of 4

Number

Rev.



## 2.0 SCHEDULE

2.1 Equipment delivery shall be as follows:

	<u>Quantity</u>	<u>Date</u>	<u>PSI Part No.</u>
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 nor the seat leakage shall exceed  $1 \times 10^{-9}$  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.

## SPECIFICATION

Number

A

Rev.

1

V049-2-059

Page 3 of 4

Number

Rev.

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.

Number  
Rev.

<b>SPECIFICATION</b>	
Number <b>A</b>	Rev. <b>1</b>

**ATTACHMENT “L”**

**TO**

**V049-2-021**

**CONCRETE FLOOR REINFORCEMENT DETAILS AND LAYOUTS**

**“Shipped loose”**

Parsons Drawings

WA-S-001

WA-S-003

WA-S-208

WA-S-501

**ATTACHMENT**

Number:

**A V049-2-021**

Rev.

**3**

**ATTACHMENT "M"**

**TO**

**V049-2-021**

**CONCRETE ANCHOR INSTALLATION PROCEDURE**

**V049-1-101**

**ATTACHMENT**

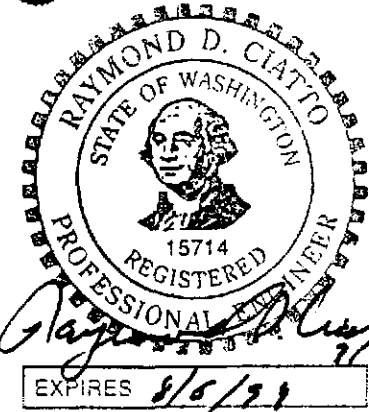
Number:

**A V049-2-021**

Rev.

**3**

Title: PROCEDURE FOR INSTALLATION OF CONCRETE ANCHORS



PROCEDURE FOR  
INSTALLATION OF CONCRETE ANCHORS  
FOR  
LIGO VACUUM EQUIPMENT

Hanford, Washington

PREPARED BY:

Raymond D. Ciatto

INSTALLATION MANAGER:

James M. [Signature]

QUALITY ASSURANCE:

Alan J. Bradbrook

TECHNICAL DIRECTOR:

D. A. [Signature]

PROJECT MANAGER:

Robert Bayler

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.

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	MS/BJK/RS	RES 7/17/97	RELEASED FOR CONSTRUCTION PER MED# 0537
0	-	-	ISSUED PER DEU 138 FOR EDR

PROCESS SYSTEMS INTERNATIONAL, INC.				PROCEDURE	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Rev.
	ROC	4/26/96	RES	4/24/96	1
				Number	V049-1-101

# CONCRETE ANCHOR INSTALLATION PROCEDURE

Title

## 1.0 PURPOSE

The purpose of this procedure is to define the necessary installation steps required to ensure that concrete anchors meet all project requirements.

## 2.0 GENERAL

Hilti HVA adhesive anchors will be used to fasten LIGO vacuum equipment to concrete floor slabs. Concrete anchors have been sized and arranged to restrain the equipment against operating and seismic loads, including unbalanced vacuum loads that occur during normal operation. Proper installation of the anchors is required to ensure satisfactory performance of the vacuum equipment.

Component base plates will be fastened to the floor slabs that are constructed of 3000 psi concrete. It is the intent of this procedure that the anchors be installed in accordance with the manufacturer's requirements.

## 3.0 RESPONSIBILITY

The installation contractor is responsible for implementing this procedure. Conflicts, if any, between this procedure and manufacturer's installation requirements shall be brought to the attention of PSI prior to the start of installation.

## 4.0 PROCEDURE

### 4.1 References:

1. Hilti Publication H-427, Technical Guide - Anchor and Powder Actuated Fastening, HVA Adhesive Anchor, Installation Instructions (HAS Threaded Rod - Option #1), Hilti Fastening Systems, Tulsa, OK, 1987, pp. 8-13.

2. Hilti Publication H-600, Systems and Solutions, Hilti Fastening Systems, Tulsa, OK, 1995, pp. 133-135.

## SPECIFICATION

Number	V049-1-101	Rev.	/
	<b>A</b>		

Page 2 of 4

Number

Rev

# CONCRETE ANCHOR INSTALLATION PROCEDURE

Title

- 4.2 Critical equipment shall be aligned per procedures V049-2-021 section 8.3 and V049-2-174 prior to drilling the anchor bolt hole. Critical equipment anchor bolt requirements are detailed in attachment A of this specification.
- 4.3 Locate and install anchor bolts in accordance with the this specification and the installation drawings. The hole location tolerance is +/- 1/16 in of position marked on concrete floor. Holes shall be plumb to within 1° of vertical. Embedment depths shown in this specification are minimum depths for the equipment listed. Drill holes using approved equipment to ensure full design bond strength and to maintain project cleanliness requirements. A Hilti PMH bit may be used to core drill holes for the HVA adhesive anchors. Rebar cutting is permitted.
- 4.4 Adhere to curing time required by Hilti before loading or disturbing anchors.
- 4.5 Step by step instructions:

Number

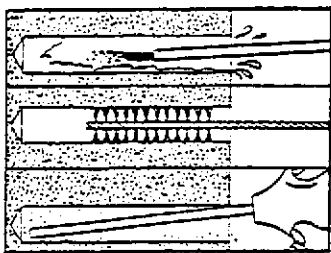
Rev

## SPECIFICATION

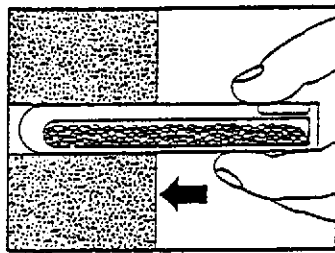
Number **A** V049-1-101

Rev. **1**

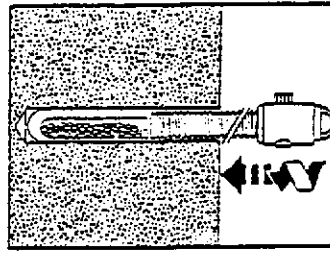
Installation Instructions (HAS Threaded Rod — Option #1)



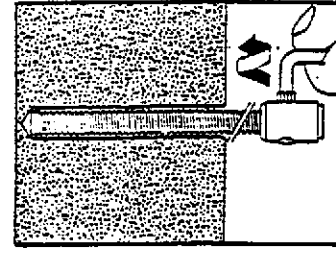
1. Set the drill depth gauge and drill the hole to the required hole depth. **IMPORTANT:** Clear out dust and fragments; preferably using a jet of water or compressed air and a wire brush. The hole may be damp, but the water should be blown out.



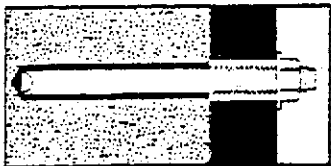
2. Insert the cartridge.



3. Insert the shaft in the rotary hammer chuck, screw the anchor rod in the adaptor and place the adaptor on the shaft. At the rotary hammer drilling setting, drive in the rod to the depth mark. Remove the drill and shaft assembly from the adaptor.



4. Rotate the hex bolt adaptor and unscrew the adaptor from the anchor rod immediately. When removing the adaptor, do not pull out the rod. If the adaptor is removed immediately, movement of the rod will not be detrimental to the fastening.



5. Setting and hardening time. The set anchor rod may not be disturbed or loaded during or before the end of the specified hardening time.

Number

Rev.

**SPECIFICATION**

Number **A** V049-1-101

Rev. **1**

Page 4 of 4



**ATTACHMENT "A" TO V049-1-101**

**REQUIRED CONCRETE ANCHORS FOR VACUUM EQUIPMENT**

Component Tag No.	Anchor Diameter	Minimum Embedment Depth	Notes
WBSC1	1"	8 1/4"	
WBSC2	1"	8 1/4"	
WBSC3	1"	8 1/4"	
WBSC4	1"	8 1/4"	
WBSC5	1"	8 1/4"	
WBSC6	1"	8 1/4"	
WBSC7	1"	8 1/4"	
WBSC8	1"	12 3/8"	2
WBSC9	1"	12 3/8"	2
WBSC10	1"	8 1/4"	3
WHAM1	1"	8 1/4"	3
WHAM2	1"	8 1/4"	4
WHAM3	1"	8 1/4"	
WHAM4	1"	8 1/4"	
WHAM5	1"	8 1/4"	
WHAM6	1"	8 1/4"	
WHAM7	1"	8 1/4"	4
WHAM8	1"	8 1/4"	4
WHAM9	1"	8 1/4"	
WHAM10	1"	8 1/4"	
WHAM11	1"	8 1/4"	
WHAM12	1"	8 1/4"	4
WHAM13	1"	12 3/8"	
WCP1	1"	12 3/8"	
WCP2	1"	12 3/8"	
WCP3	1"	12 3/8"	
WCP4	1"	12 3/8"	
WCP5	1"	12 3/8"	
WCP6	1"	12 3/8"	
WCP7	1"	12 3/8"	
WCP8	1"	12 3/8"	
WGV1	3/4"	6 5/8"	6
WGV2	3/4"	6 5/8"	6
WGV3	3/4"	6 5/8"	6
WGV4	3/4"	6 5/8"	6

**ATTACHMENT**

Number:

**A V049-1-101**

Rev.

**0**

Title: INSTALLATION OF CONCRETE ANCHORS

Component Tag No.	Anchor Diameter	Minimum Embedment Depth	Notes
WGV5	3/4"	6 5/8"	7
WGV6			5
WGV7	3/4"	6 5/8"	7
WGV8			5
WGV9			5
WGV10	3/4"	6 5/8"	7
WGV11	3/4"	6 5/8"	7
WGV12			5
WGV13			5
WGV14	3/4"	6 5/8"	7
WGV15	3/4"	6 5/8"	7
WGV16			5
WGV17	3/4"	6 5/8"	7
WGV18	3/4"	6 5/8"	7
WGV19			5
WGV20	3/4"	6 5/8"	7
WA-7A	1"	8 1/4"	
WB-1A	1"	8 1/4"	
WB-1B	1"	8 1/4"	
WB-2A	1"	8 1/4"	
WB-2B	1"	8 1/4"	
WB-3A	1"	8 1/4"	
WB-5A	1"	8 1/4"	
WB-6	1"	12 3/8"	8
WB-7	1"	12 3/8"	8
WB-9A	1"	8 1/4"	
WB-9B	1"	8 1/4"	
WBE-5	1"	8 1/4"	
WBE-6	1"	8 1/4"	
Pipe Bridge	3/4"	6 5/8"	

1. Install Hilti HVA anchors with HEA capsules and HAS standard rods, unless otherwise noted, in accordance with Specification V049-1-101.
2. Use 12 3/8" minimum embedment for all base plates of this component.
3. Use 12 3/8" minimum embedment for base plates at end of arm.
4. Use 12 3/8" minimum embedment for the four anchors at the end of the arm.
5. These gate valves are supported by others.
6. See Dwg. V049-4-034, for 48" gate valve anchor bolt locations.
7. See Dwg. V049-4-033 for 44" gate valve anchor bolt locations.
8. Use Hilti HAS Super Threaded Rod

**ATTACHMENT**

Number:

**A V049-1-101**

Rev.

**0**

**ATTACHMENT "N"**  
**TO**  
**V049-2-021**  
**EQUIPMENT SHIPPING, HANDLING AND RIGGING PROCEDURES**  
**VO49-2-123**

**ATTACHMENT**

Number:

**A V049-2-021**

Rev.

**3**

Title: COMPONENT PACKAGING, HANDLING AND SHIPPING

COMPONENT PACKAGING, HANDLING AND SHIPPING  
FOR  
LIGO VACUUM EQUIPMENT

Hanford, Washington

PREPARED BY: DAVID EVERS / REB  
MANUFACTURING ENGR: N/A  
QUALITY ASSURANCE: ALAN BRADBROOK / REB  
TECHNICAL DIRECTOR: D. A. McWilliams  
PROJECT MANAGER: Robert Bayly

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

REV	LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1		MSE 18 JUL 97	REB 7/18/97	RELEASED FOR CONSTRUCTION PER REQ # 0526
0		D.E. 5/6/96	REB 5/6/96	RELEASE PER DRO 176

REV	LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE
	D. E.	5/6/96	REB	5/6/96
Number A V049-2-123				Rev. 1

**TABLE OF CONTENTS**

- 1.0 Purpose
- 2.0 Shipping
- 3.0 Handling

**ATTACHMENTS**

1. Component Specific Lifting and Rigging Procedures:

PEI-LN2 Tank Lifting Diagram	PEI Dwg. B-30049
PEI-LN2 Tank Lifting Diagram	PEI Dwg. B-30050
* BSC Shipping Skid/Lifting Diagram	V049-4-199
HAM Shipping Assembly	V049-4-219
80K Short/ BE-4 Shipping Assembly	V049-4-222
Spool A-1/A-A7A & A-1/A-A7B	V049-4-224
Spool B-6/A-6, B-7/A-6A	V049-4-225
Spool B-4/A12	V049-4-225
Spool A-1/B-9	V049-4-226
Spool BE5 & BE6	V049-4-226
Adapter A-14	V049-4-229
Adapters A-15, A-13, A-12	V049-4-230
Spool BE-2	V049-4-231
Spools B2A, B2B, B3A, & B5A	V049-4-232
Spool WA13/WB-8/WB-1	V049-4-233
Spool LA-2/LB-1/LBE-13	V049-4-233
Offset Spool BE-3 & BE3A	V049-4-234
80K Long/BE-4	V049-4-235

\* "D" SIZE DRAWING SHIPPED LOOSE WITH PSI DRAWING PACKAGE.

**SPECIFICATION**

Number: **A V049-2-123**

Rev.  
1

**1.0 PURPOSE**

The purpose of this procedure is to provide basic guidelines for the safe transfer of vacuum equipment and components to the customer sites.

**2.0 GENERAL**

The primary objective of this procedure is to:

1. Provide sufficient supports to prevent damage to vacuum equipment and system components.
2. Provide protective closers on spools and valves.
3. Assure that the crates and skids are strong enough to stand shipping and handling hazards.
4. Assure that the crated/skidded equipment and components are properly packed and fastened, and that the contents of each container is properly identified on a packing list.
5. Make packages, crates and skids water tight and air tight to prevent damage from the elements.
6. Provide identification of the equipment and parts shipped including warning notes on crates skids and boxes.

**Crates, Crating and Skids**

Crates and skids shall be designed and constructed to comply with the military specification MIL-C-104B, Crates, Wood; Lumber and Plywood Sheathed, Nailed and Bolted.

The above specification provides reference tables relating weight of the objects to be crated, size of the crate and size of the crate frame members. It should be noted that crates constructed to MIL-C-104 specification develop their full strength after the side panels and top are installed in place. The specification also provides ample amount of sketches of the crate construction details.

The following points should be observed in the construction of crates and skids:

The crate/skid fabricator should be provided with information on each crate specifying the weight of the object to be crated, the internal dimensions of the crate (the crate shall clear the object by 2" on all sides) and any special data that may be useful such as the internal cross bracing of equipment.

The maximum allowable span dimension between skids and other frame members shall be avoided.

Rubbing strips of 4" thick lumber shall be installed on the underside of the crate bases to provide for sling and forklift truck handling.

Sufficient reinforcing joists of proper size shall be on the crate tops in the center of balance area to prevent crushing of the crate when it is lifted with a single set of slings.

**SPECIFICATION**

Number: **A V049-2-123**

Rev. 1

Crate liners shall be applied between the sheathing and the frame member of sides, ends and top. The liner material shall be polyethylene film at least 6 mils thick or any other approved waterproof material.

Visqueen polyethylene film, bags and shrinkwrap film are available in various widths and sizes and are readily from a variety of sources. This is a good choice for use as an initial layer of protection.

No ventilation holes shall be provided in the crates.

Drain holes shall be provided in the crate bases.

### **Crating and Skidding Of Piping, Spools, Valves And Miscellaneous Items**

Pipes, spools and valves with ends protected by pipe caps or blind flanges shall be secured to crates to prevent any movement during handling and shipment. In regard to large valves and automatic valve operators, each one shall be wrapped with water tight polyethylene enclosures. Small valves, bolting, and other small items can be wrapped in polyethylene bags and packed in water tight boxes. All items shall be properly marked.

### **Items To Be Removed And Crated Separately**

Delicate items such as small automatic valves, instrumentation and automatic valve operators should be removed and crated or covered with water tight wrapping, plywood or sheet metal.

### **Stretch Wrapping and Shrink Wrapping**

Stretch wrap and shrinkwrap (6 mil plastic) is available in various widths from 2" to 36" with applicators for wrapping of various components.

## **3.0 SHIPPING**

### **Truck Transport**

All vessels and components shall be transported on tractor/trailer combinations equipped with air ride suspensions.

## **SPECIFICATION**

Number: **A V049-2-123**

Rev.  
1

### Shipping Considerations For Components

The primary objective in the preparation of components for shipping is to minimize the chance for damage shipping can induce. Thoughtful planning is required in considering the causes of potential damage and its prevention.

The following recommendations shall be considered in preparing components for shipping:

All loads will be tarped irregardless of any coverings applied by PSI.

All pipes, nozzles, flanges and so forth, shall be sealed. Various methods and materials may be used, but all must be watertight. All components shipped under vacuum shall be marked with warning labels.

Suitable lifting lugs, correctly orientated to the shipping face, shall be provided and identified as the lift and or tie down points.

### **Attaching of chain or strap tie-downs to component door assembly lifting lugs is prohibited.**

Four point lifting chain or strap sets shall use a minimum lifting angle of 60 degrees

At times there may be special tie-down lugs required for securing a component on particular transport, or bigger holes may be required on the lifting lugs to accommodate the lifting equipment at particular site. Such requirements will be known after the PSI Project Manager has submitted the component shipping drawings to the shipping concern, and the transporter has been selected.

Two point loading with substantial shipping saddles evenly spaced about the center of gravity in areas of relative stiffness, such as external or internal stiffening rings, internal structural members, or near shell seams. Avoid supporting components at the mid-span of unsupported shells.

All shipments of components utilizing more than two point loading shall have the review and approval of the LIGO Project Manager. Refer to attachments for equipment specific lifting and rigging requirements.

Supports shall be as wide as required to distribute the load on the shell, but shall not be less than six (6) inches wide.

Supports shall only be the minimum height required to clear protrusions and stay within the shipping envelope.

## SPECIFICATION

Number: **A V049-2-123**

Rev.  
1



Supports shall be attached to the vessel. If wooden saddles are used they should be banded to the vessel. If steel saddles are used, they should be bolted to rings.

Use nylon slings for lifting. The use of chains is prohibited.

The type of transporter used will affect the design of supports.

### **Protective Storage And Identification**

Completed components shall be securely stored to prevent inadvertent movement (rolling). All nozzles shall be protected. Once protected, these components shall be stored indoors.

Any parts removed for shipping shall be clearly labeled. A loose parts list shall be generated and given to the person who will coordinate the delivery of these parts to the customer sites. The loose parts list shall accompany the shipping documents.

### **Marking and Special Instructions**

Establishment of a good marking system and good records is critical.

Identification shall be durable. The use of hand embossed metal tags produced on a Dymo tape writer is recommended where space is the limiting factor. In all other cases, stencil painting or writing with unwashable ink is recommended. Use of photographs showing details of equipment before disassembly is strongly recommended. A picture of each crate should be taken prior to closing the lid and side walls where applicable.

## **4.0 HANDLING**

All LIGO components and crated equipment will be loaded and off-loaded under the supervision of a PSI representative.

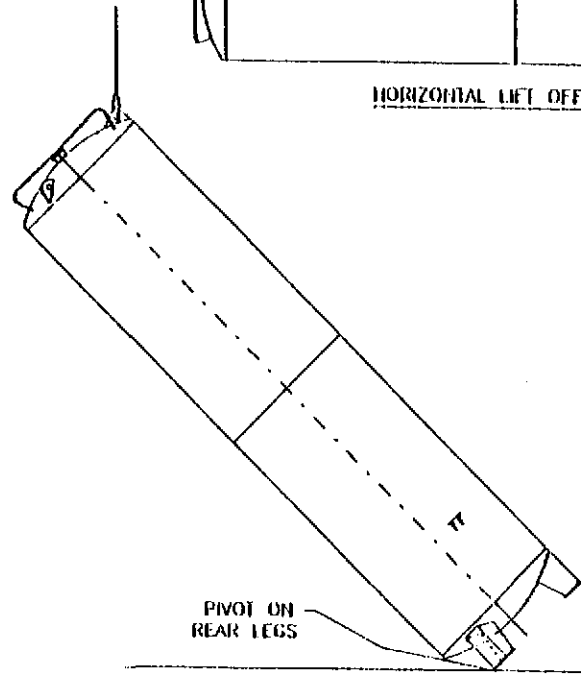
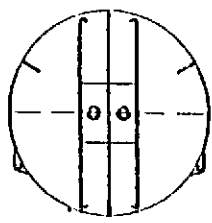
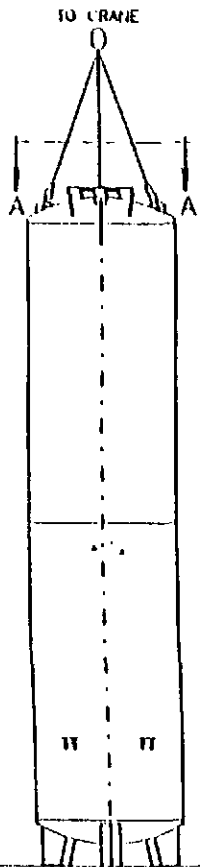
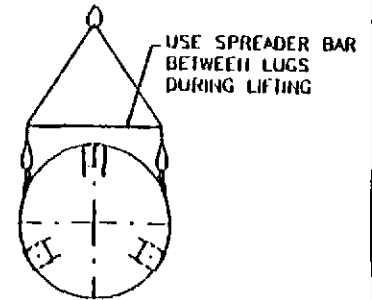
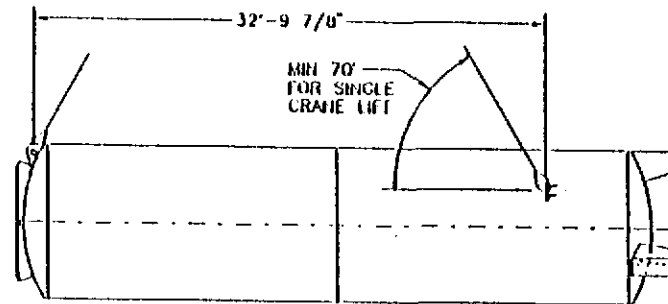
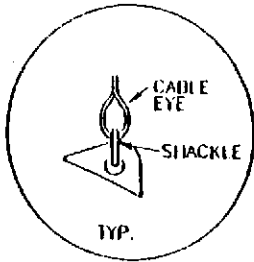
All LIGO components shall be handled (i.e. lifted, pulled, etc.) per the component handling data sheet. This sheet will detail weight, center of gravity, spreader beam requirements, rigging and offloading instructions, etc. Spreader beams shall be used on all Beam Splitter vessels.

Special shipping instructions such as "**USE SPREADER BAR WHEN LIFTING**" or shipping weight should be painted in the proper places and detailed instructions attached to the vessel if applicable. (See Attachments).

## **SPECIFICATION**

Number: **A V049-2-123**

Rev.  
1



HORIZONTAL LIFT OFF VEHICLE

ERECTING TANK **SHT 1 OF 14**

# CAUTION

THIS IS A THERMOS BOTTLE. DROPPING, ROLLING, OR EXCESSIVELY ROUGH HANDLING CAN BREAK THE CONNECTIONS BETWEEN THE INNER VESSEL AND OUTER VESSEL.

## LIFT AT LUGS ONLY DO NOT ROLL

- TO LIFT HORIZONTALLY OFF VEHICLE:  
USE TWO LOWER SIDE LIFTING LUGS AND SINGLE LUG ON TOP HEAD.
- TO RAISE VESSEL AND MOVE TO VERTICAL POSITION:  
USE TOP LIFTING LUG ABOVE FRONT LEG (TANK WILL PIVOT ON TWO REAR LEGS). TO LIFT INTO FINAL POSITION USE THREE (3) LUGS ON TOP HEAD.

TOTAL WEIGHT = 40,400 Lbs  
OVERALL HEIGHT = 39'-5"

VERTICAL LIFT TO SET TANK IN PLACE

NO	DATE	BY	REVISION

RECORD OF REVISION

TOLERANCES UNLESS OTHERWISE NOTED  
PER PEI STD.  
F-19 & TEMA STD.

TOLERANCES ON:  
2 IN. DECIMALS +/-  
3 IN. DECIMALS +/-  
ANGLES +/-  
FRACTIONS +/-

APPROVALS	BY	DATE
DRAWER	RI	5/12/82
CHECKER		
ENGINEERING DESIGN		
MANUFACTURING		
WELDING ENGINEERING		
QUALITY ASSURANCE		
MATERIALS PLANNING		

**PROCESS ENGINEERING**  
148 Main Street, PO Box 467  
Plaislow, NH 03885

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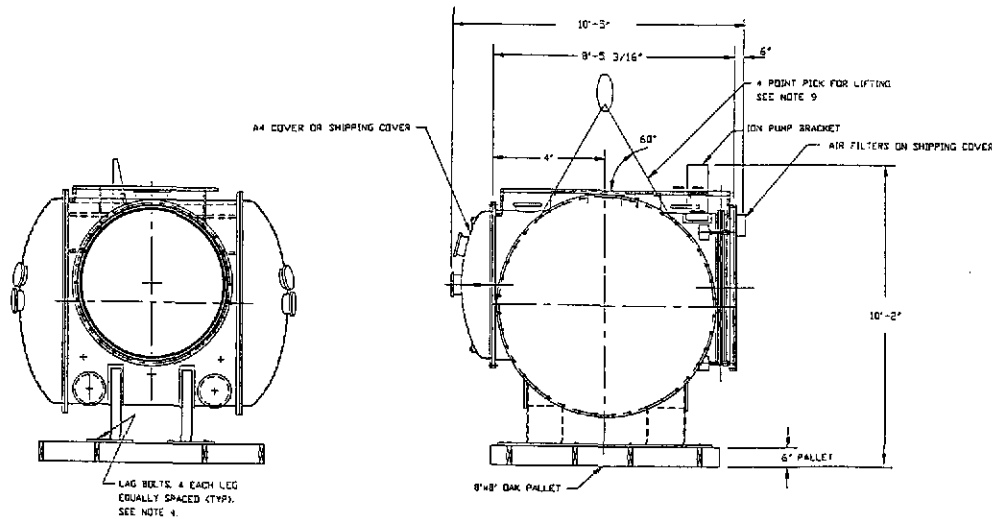
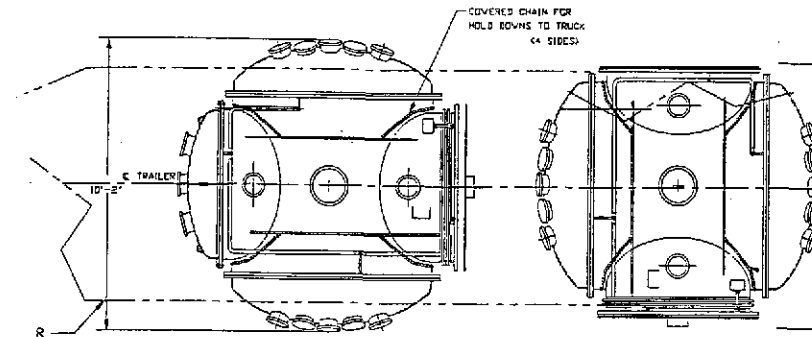
LIFTING DIAGRAM FOR MODEL 14400-8-50-LN2		
JOB No: C-090/09396	U/M	SCALE: NTS
PART No: 880.405	DRAWING No:	
SHEET No: 1 OF 1	B-30049	0 REV



**PACKAGING/LIFTING/SHIPPING INSTALLATION**

1. REFERENCE DOCUMENTS  
COMPONENT PACKAGING, HANDLING, SHIPPING  
PROCEDURE - V049-2-123  
CONTAMINATION CONTROL PLAN - V049-2-119
2. PROTECT BELLOWS BY WRAPPING WITH HEAVY  
PLASTIC STRIPS PRIOR TO BAGGING.
3. ENTIRE VESSEL TO BE SHRINK WRAPPED WITH 2 LAYERS  
OF 6 MIL POLYETHYLENE.
4. LAG VESSEL TO PALLET USING  
3/4" X 7" LONG LAG BOLTS.  
BOLTS TO BE LAGGED TO 4 X 6 SUPPORTS.
5. PALLETS TO BE 8 FT X 8 FT OAK CONSTRUCTION  
WITH 4 X 6 FRAMING & 2 X 6 ROUGH CUT PLANKS.  
4 X 6 FRAMING TO STRADDLE VESSEL LEGS  
AS SHOWN. ALLOW BY WIDE OPENING FOR  
FORK LIFT ACCESS.
6. VESSEL TO BE MOUNTED ON TRAILER IN  
ORIENTATION SHOWN.
7. CHAIN VESSEL TO TRUCK USING 1" CHAIN  
ATTACHED TO VESSEL AT LIFTING LUGS.  
TYPICAL 4 PLACES.
8. WRAP CHAIN IN 1/8" THK. 1 1/2" I.D.  
VINYL HOSE TO PROTECT VESSEL.  
TYPICAL 4 PLACES.
9. REMOVE FROM TRAILER AT SITE BY LIFTING  
FROM 4 LIFTING LUGS. MINIMUM CHAIN ANGLE  
60° AS SHOWN.
10. SECURELY ATTACH THESE LIFTING INSTRUCTIONS  
TO VESSEL IN A WATER PROOF  
POLYETHYLENE BAG.
11. VESSEL TO BE SHIPPED CHAINED TO TRUCK.
12. COVER WITH CLEAN TARPS DURING SHIPPING.
13. VESSEL TO BE SHIPPED VIA AIR RIDE  
TRAILOR ONLY.

PART OF  
ATTACHMENT "N"



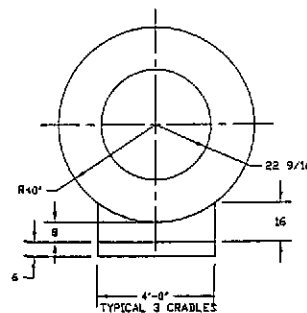
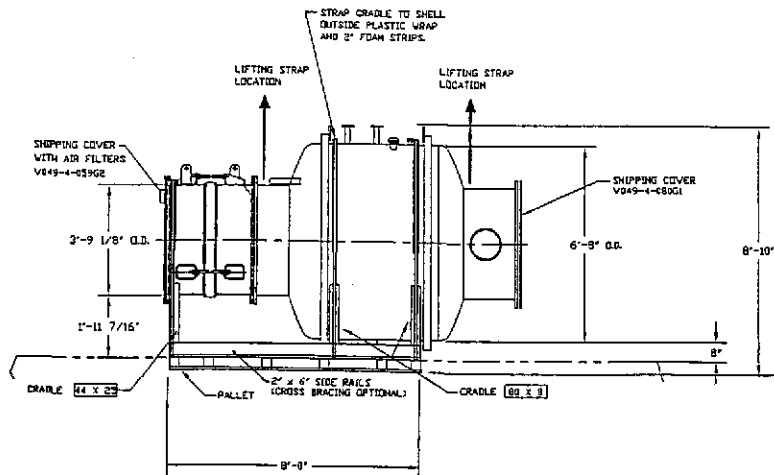
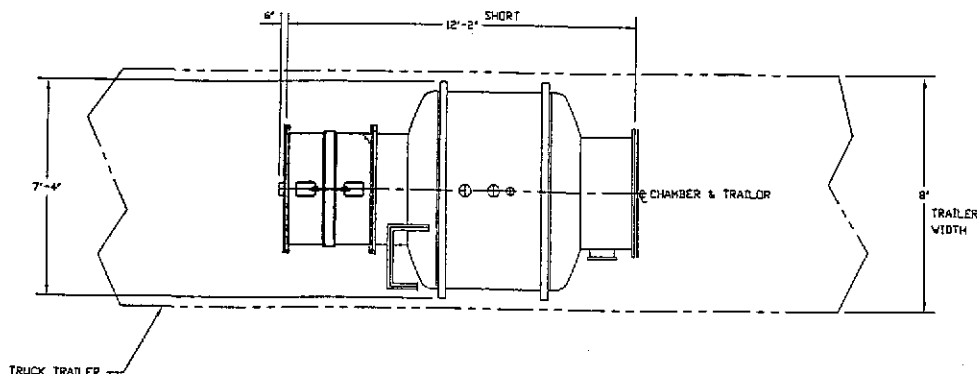
NOTE! THE TRUCK DRIVER IS TO ADD  
PROPER BRACING TO PREVENT FORWARD  
OR AFT MOVEMENT OF VESSELS  
DURING SHIPMENT.

SHT 3 of 14  
APPROX. WEIGHT = 9500#

<p>THIS DOCUMENT CONTAINS PROPRIETARY INFORMATION BELONGING TO PROCESS SYSTEMS INTERNATIONAL, INC. THE USE OF THIS INFORMATION FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT WAS SUPPLIED IS STRICTLY PROHIBITED. IF YOU ARE A CONTRACTOR OR SUBCONTRACTOR, YOU SHALL NOT BE CONSIDERED RESPONSIBLE FOR THE DISSEMINATION OF THIS INFORMATION TO ANY OTHER PARTY WITHOUT THE WRITTEN PERMISSION OF PROCESS SYSTEMS INTERNATIONAL, INC. THIS DOCUMENT IS THE PROPERTY OF PROCESS SYSTEMS INTERNATIONAL, INC. AND SHALL BE RETURNED UPON REQUEST.</p>		<p>UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. FRACTIONS: 1/8" INCREMENTS OF .001" SHALL BE USED UNLESS OTHERWISE SPECIFIED. DIMENSIONS ARE TO BE TAKEN FROM THE UNLESS OTHERWISE SPECIFIED. REMOVE ALL DIMENSIONS UNLESS OTHERWISE SPECIFIED.</p>		<p>DO NOT SCALE THIS DRAWING NEXT ASSY:</p>		<p>ISSUED FOR SHIPPING DATE: 6/2/97 BY: [Signature]</p>		<p>PROCESS SYSTEMS INTERNATIONAL, INC. 30 WILSON DR., WESTBOROUGH, MASSACHUSETTS 01581 USA</p>	
<p>REV. NO.</p>	<p>DESCRIPTION</p>	<p>DATE</p>	<p>BY</p>	<p>ISSUE DESCRIPTION</p>	<p>SCALE</p>	<p>SIZE</p>	<p>SHEET</p>		
0				ISSUED FOR SHIPPING	1/8"=1'-0"	0	0		

PACKAGING/LIFTING/SHIPPING INSTALLATION

1. REFERENCE DOCUMENTS  
COMPONENT PACKAGING, HANDLING, SHIPPING  
PROCEDURE - V049-2-123  
CONTAMINATION CONTROL PLAN - V049-2-119
2. PROTECT BELLOWS BY WRAPPING WITH HEAVY PLASTIC STRIPS  
PRIOR TO BAGGING.
3. ENTIRE VESSEL TO BE SHRINK WRAPPED WITH 2 LAYERS  
OF 6 MIL POLYETHYLENE.
4. VESSEL TO BE MOUNTED ON TRAILER IN  
ORIENTATION SHOWN.
5. TIGHTEN BELLOWS TIE RODS TO LOCK IN  
NEUTRAL LENGTH POSITION.
6. REMOVE FROM TRAILER AT SITE BY LIFTING  
WITH STRAPS AT LOCATIONS SHOWN.
7. SECURELY ATTACH THESE LIFTING INSTRUCTIONS  
TO VESSEL IN A WATER PROOF  
POLYETHYLENE BAG.
8. VESSEL TO BE SHIPPED STRAPPED TO TRUCK AT  
CRADLE LOCATIONS SHOWN.
9. COVER WITH CLEAN TIGHT TARPS DURING SHIPPING.
10. VESSEL TO BE SHIPPED VIA AIR RIDE  
TRAILOR ONLY.
11. CARE TO BE TAKEN WITH LIFTING STRAPS TO AVOID  
HITTING OR RUBBING AGAINST ANY NOZZLES.



NOTE: THE TRUCK DRIVER IS TO ADD  
PROPER BRACING TO PREVENT  
FORWARD OR AFT MOVEMENT OF  
VESSELS DURING SHIPMENT.

SHT 4 OF 14

SHIPPING WEIGHT=9000#

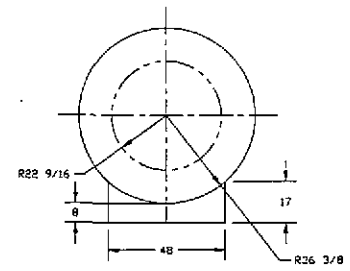
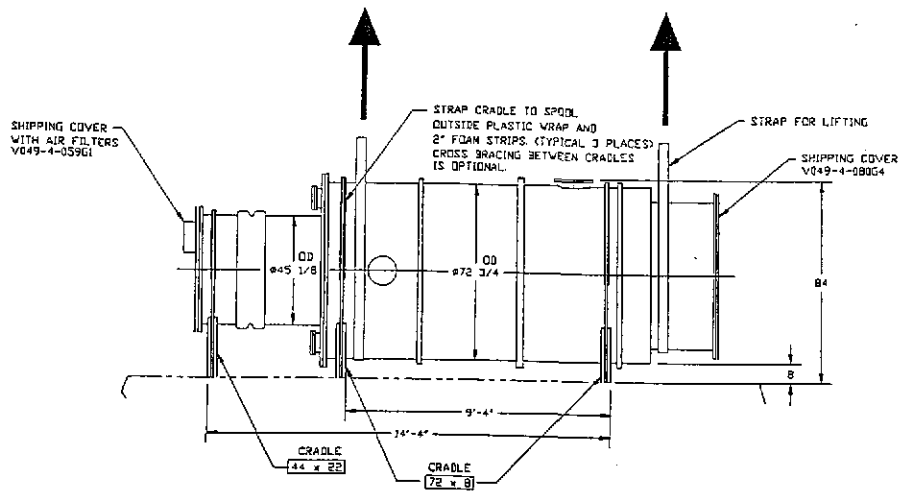
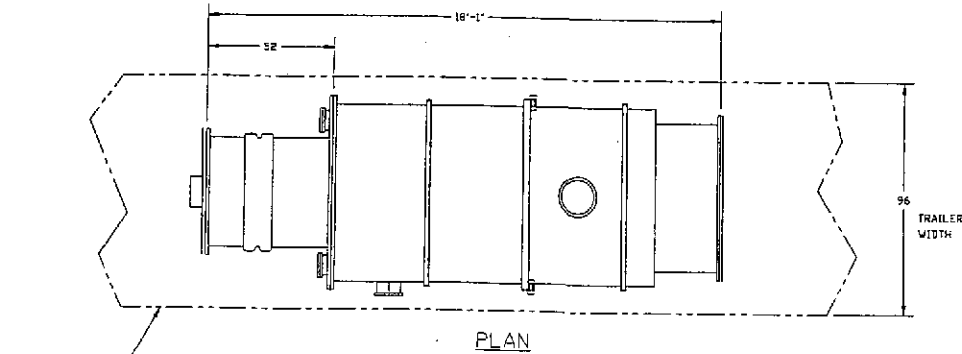
PROCESS SYSTEMS INTERNATIONAL, INC.  
30 WILSON DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

BOOK SHORT/BE-4  
SHIPPING ASSY.  
LIGO VACUUM EQUIPMENT

<p>UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONS ± DECIMALS ±0.005 INCHES THIS PLATE SHALL BE MADE OF 304 STAINLESS STEEL, 1/2 INCH THICK UNLESS OTHERWISE SPECIFIED. ALL DIMENSIONS ARE TO FACE UNLESS OTHERWISE SPECIFIED.</p>		<p>DO NOT SCALE THIS DRAWING USCS OR NEXT ASSY</p>		<p>ISSUED FOR SHIPPING DATE 6/23/97 BY [Signature]</p>		<p>SCALE 1/2"=1'-0"</p>	
<p>THIS DRAWING CONTAINS PROPRIETARY INFORMATION BELONGING TO PROCESS SYSTEMS INTERNATIONAL, INC. OR ITS AFFILIATES. ANY DISCLOSURE OR REPRODUCTION OF THIS DRAWING FOR ANY PURPOSE WITHOUT THE WRITTEN CONSENT OF PROCESS SYSTEMS INTERNATIONAL, INC. SHALL BE PROHIBITED. ANY VIOLATION OF THIS NOTICE SHALL BE SUBJECT TO LITIGATION AND DAMAGES. THIS DRAWING IS THE PROPERTY OF PROCESS SYSTEMS INTERNATIONAL, INC. AND SHALL BE RETURNED UPON REQUEST.</p>	<p>REV. NO.</p>	<p>DESCRIPTION</p>	<p>REV. NO.</p>	<p>DESCRIPTION</p>	<p>DATE</p>	<p>BY</p>	<p>SCALE</p>
<p>PROCESS SYSTEMS INTERNATIONAL, INC.</p>		<p>BOOK SHORT/BE-4 SHIPPING ASSY. LIGO VACUUM EQUIPMENT</p>		<p>DATE FILED V049-4-222</p>	<p>ISSUE NO. 0</p>	<p>REV. NO. V049-4-222</p>	<p>SCALE 1/2"=1'-0"</p>

**PACKAGING/LIFTING/SHIPPING INSTALLATION**

1. REFERENCE DOCUMENTS  
COMPONENT PACKAGING, HANDLING, SHIPPING  
PROCEDURE - V049-2-123  
CONTAMINATION CONTROL PLAN - V049-2-119
2. PROTECT BELLOWES BY WRAPPING WITH HEAVY PLASTIC STRIPS  
PRIOR TO BAGGING.
3. ENTIRE VESSEL TO BE SHRUNK WRAPPED WITH 2 LAYERS  
OF 5 MIL POLYETHYLENE.
4. VESSEL TO BE MOUNTED ON TRAILER IN  
ORIENTATION SHOWN.
5. TIGHTEN BELLOWES TIE RODS TO LOCK IN  
NEUTRAL LENGTH POSITION.
6. REMOVE FROM TRAILER AT SITE BY LIFTING  
WITH STRAPS AT LOCATIONS SHOWN.
7. SECURELY ATTACH THESE LIFTING INSTRUCTIONS  
TO VESSEL IN A WATER PROOF  
POLYETHYLENE BAG.
8. VESSEL TO BE SHIPPED STRAPPED TO TRUCK AT  
CRADLE LOCATIONS SHOWN.
9. COVER WITH CLEAN TIGHT TARPS DURING SHIPPING.
10. VESSEL TO BE SHIPPED VIA AIR RIDE  
TRAILER ONLY.
11. CARE TO BE TAKEN WITH LIFTING STRAPS TO AVOID  
HITTING OR RUBBING AGAINST ANY NOZZLES.



NOTE: THE TRUCK DRIVER IS TO ADD PROPER BRACING TO PREVENT FORWARD OR AFT MOVEMENT OF VESSELS DURING SHIPMENT.

SHT 5 OF 14  
SHIPPING WEIGHT 6600# EA

<p><b>PROPERTY AND CONFIDENTIALITY</b></p> <p>THIS DOCUMENT CONTAINS PROPRIETARY INFORMATION BELONGING TO PROCESS SYSTEMS INTERNATIONAL, INC. AND ITS AFFILIATED COMPANIES. IT SHALL BE USED ONLY FOR THE PURPOSES FOR WHICH IT WAS SUPPLIED. IF YOU, OR ANY OTHER PERSON, ARE IN POSSESSION OF THIS DOCUMENT, YOU SHALL, UPON REQUEST, RETURN IT TO THE PERSON TO WHOM IT WAS SUPPLIED. IF YOU ARE IN POSSESSION OF THIS DOCUMENT AND YOU ARE NOT THE PERSON TO WHOM IT WAS SUPPLIED, YOU SHALL, UPON REQUEST, RETURN IT TO THE PERSON TO WHOM IT WAS SUPPLIED. THIS DOCUMENT IS THE PROPERTY OF PROCESS SYSTEMS INTERNATIONAL, INC. AND SHALL BE RETURNED UPON REQUEST.</p>		<p><b>UNLESS OTHERWISE SPECIFIED</b></p> <p>DIMENSIONS ARE IN INCHES</p> <p>1/2" NAME &amp; FINISHES</p> <p>ANGLES APPROX. UNLESS NOTED OTHERWISE</p> <p>THREE PLACE DECIMALS UNLESS OTHERWISE NOTED</p> <p>UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES</p>		<p>ISSUED FOR SHIPPING</p> <p>DATE: 6/28/97</p> <p>BY: [Signature]</p>	
<p>DWG. NO. 1</p>	<p>DESCRIPTION</p>	<p>DWG. NO.</p>	<p>DESCRIPTION</p>	<p>REV</p>	<p>DESCRIPTION</p>
<p>REFERENCE DRAWINGS</p>		<p>ISSUE DESCRIPTION</p>		<p>DATE</p>	

PROCESS SYSTEMS INTERNATIONAL, INC.  
30 WILSON DR. METROLOGUE, WASHINGTON, DC 20007 USA

SHIPPING SPOOL A-1/A-7A  
SHIPPING SPOOL A-1/A-7B  
SHIPPING CRITERIA  
LIGO VACUUM EQUIPMENT

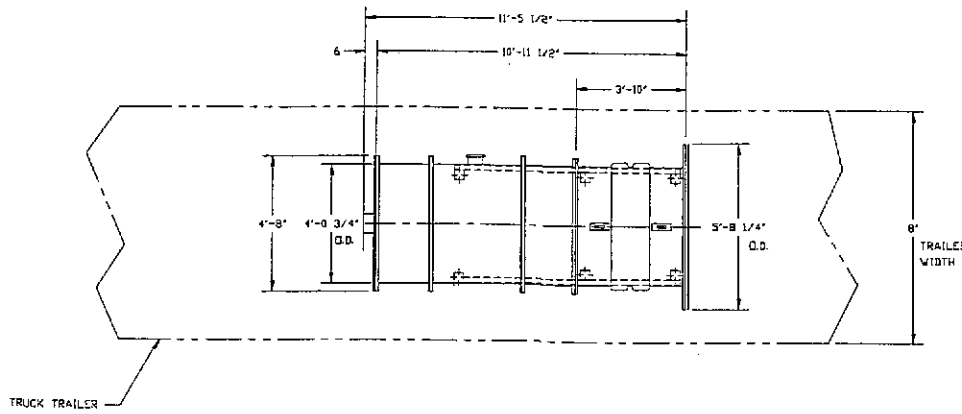
DWG. NO. V049-4-224

REV. 0

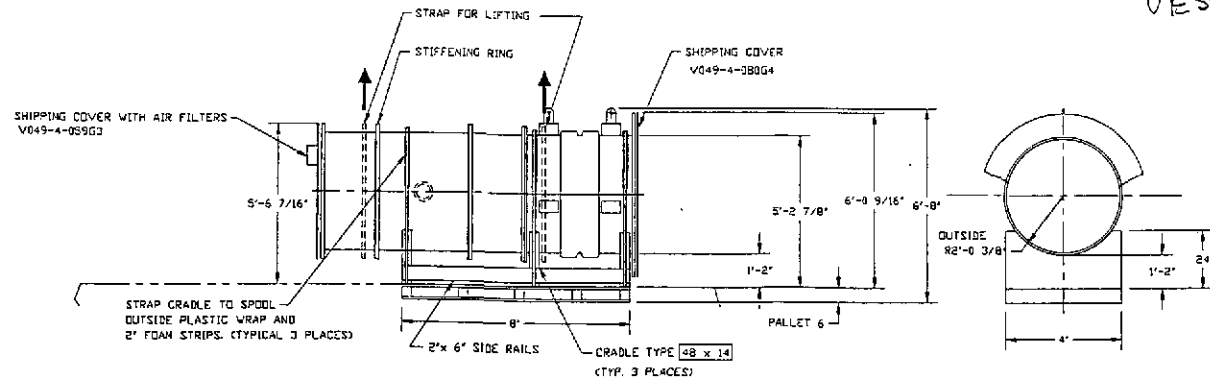
DATE: 1/28/97

**PACKAGING/LIFTING/SHIPPING INSTALLATION**

1. REFERENCE DOCUMENTS  
COMPONENT PACKAGING, HANDLING, SHIPPING  
PROCEDURE - V049-2-123  
CONTAMINATION CONTROL PLAN - V049-2-119
2. PROTECT BELLOWS BY WRAPPING WITH HEAVY PLASTIC STRIPS  
PRIOR TO BAGGING.
3. ENTIRE VESSEL TO BE SHRINK WRAPPED WITH 2 LAYERS  
OF 6 MIL POLYETHYLENE.
4. VESSEL TO BE MOUNTED ON TRAILER IN  
ORIENTATION SHOWN.
5. TIGHTEN BELLOWS TIE RODS TO LOCK IN  
NEUTRAL LENGTH POSITION.
6. REMOVE FROM TRAILER AT SITE BY LIFTING  
WITH STRAPS AT LOCATIONS SHOWN.
7. SECURELY ATTACH THESE LIFTING INSTRUCTIONS  
TO VESSEL IN A WATER PROOF  
POLYETHYLENE BAG.
8. VESSEL TO BE SHIPPED STRAPPED TO TRUCK AT  
CRADLE LOCATIONS SHOWN.
9. COVER WITH CLEAN TIGHT TARPS DURING SHIPPING.
10. VESSEL TO BE SHIPPED VIA AIR RIDE TRAILER ONLY.



NOTE: THE TRUCK DRIVER IS TO  
ADD PROPER BRACING TO PREVENT  
FORWARD OR AFT MOVEMENT OF  
VESSEL DURING SHIPMENT.

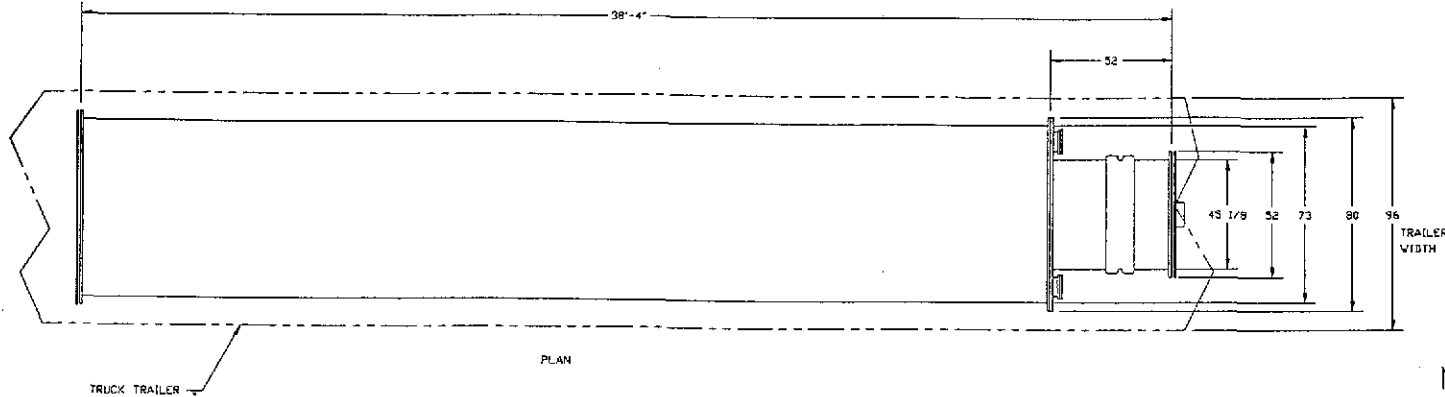


SHT 6 OF 14  
SHIPPING WEIGHT: 4000# EA.

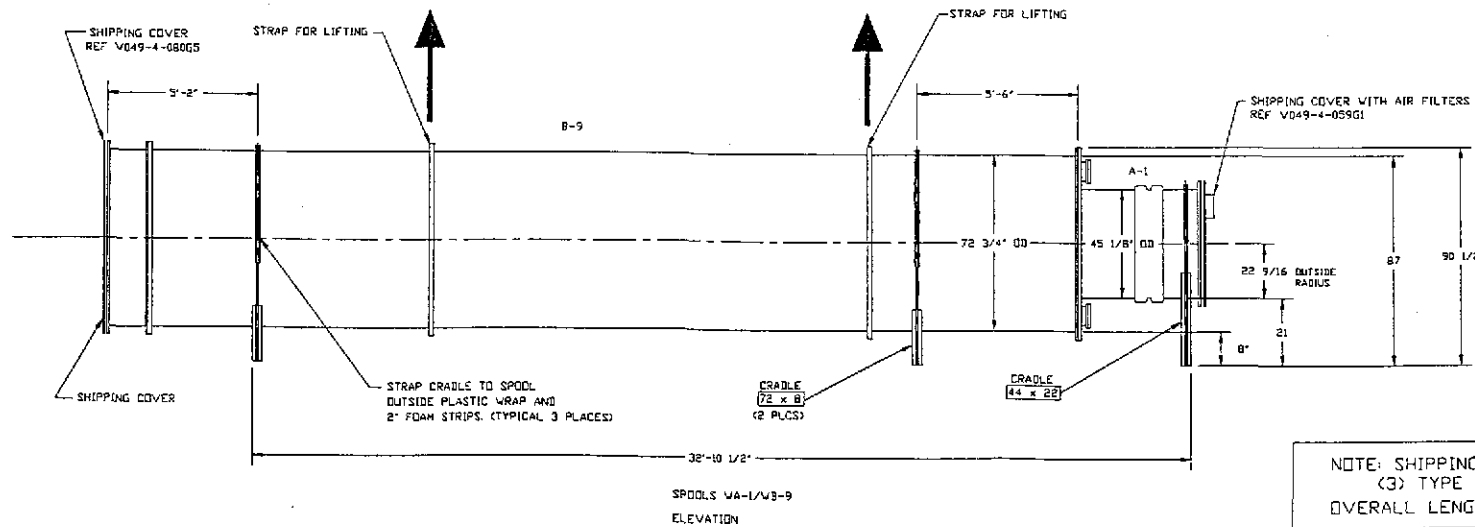
<p><b>PROPERTY OF THE ORIGINAL</b></p> <p>THIS DOCUMENT CONTAINS INFORMATION BELONGING TO PROCESS SYSTEMS INTERNATIONAL, INC. OR ITS AFFILIATED COMPANIES AND SHALL BE USED ONLY FOR THE PURPOSES FOR WHICH IT WAS PREPARED. IT SHALL NOT BE COPIED, REPRODUCED OR OTHERWISE USED FOR OTHER THAN THE PURPOSES FOR WHICH IT WAS PREPARED. ANY REPRODUCTION OR OTHER USE WITHOUT THE WRITTEN CONSENT OF PROCESS SYSTEMS INTERNATIONAL, INC. AND SHALL BE RETURNED UPON REQUEST.</p>				<p><b>UNLESS OTHERWISE SPECIFIED</b></p> <p>DIMENSIONS ARE IN INCHES</p> <p>FRACTIONS &amp; DECIMALS ARE TO BE USED AS SHOWN UNLESS OTHERWISE SPECIFIED</p> <p>FINISHES ARE TO BE AS SHOWN UNLESS OTHERWISE SPECIFIED</p> <p>DATE: 6/23/97</p>				<p><b>PROCESS SYSTEMS INTERNATIONAL, INC.</b></p> <p>12000 W. 10TH AVENUE, WESTMINSTER, CO 80057 USA</p> <p>SHIPPING SPOOL WB-6/WA-6B SHIPPING SPOOL WB-7/WA-6A SHIPPING SPOOL B-4/A-12 LIGCO VACUUM EQUIPMENT</p> <p>REV 0</p>			
<p>NO NOT SCALE THIS DRAWING</p> <p>ISSUED FOR SHIPPING</p>		<p>REV 1</p> <p>ISSUE DESCRIPTION</p>		<p>DATE: 6/23/97</p> <p>DESIGN: DA</p>		<p>DATE: 6/23/97</p> <p>DESIGN: DA</p>		<p>DATE: 6/23/97</p> <p>DESIGN: DA</p>			
<p>DATE: 6/23/97</p> <p>DESIGN: DA</p>		<p>DATE: 6/23/97</p> <p>DESIGN: DA</p>		<p>DATE: 6/23/97</p> <p>DESIGN: DA</p>		<p>DATE: 6/23/97</p> <p>DESIGN: DA</p>		<p>DATE: 6/23/97</p> <p>DESIGN: DA</p>			

**PACKAGING/LIFTING/SHIPPING INSTALLATION**

1. REFERENCE DOCUMENTS  
COMPONENT PACKAGING, HANDLING, SHIPPING  
PROCEDURE - V049-2-123  
CONTAMINATION CONTROL PLAN - V049-2-119
2. PROTECT BELLOWS BY WRAPPING WITH HEAVY PLASTIC STRIPS  
PRIOR TO BAGGING.
3. ENTIRE VESSEL TO BE SHRINK WRAPPED WITH 2 LAYERS  
OF 6 MIL POLYETHYLENE.
4. VESSEL TO BE MOUNTED ON TRAILER IN  
ORIENTATION SHOWN.
5. TIGHTEN BELLOWS TIE RODS TO LOCK IN  
NEUTRAL LENGTH POSITION.
6. REMOVE FROM TRAILER AT SITE BY LIFTING  
WITH STRAPS AT LOCATIONS SHOWN.
7. SECURELY ATTACH THESE LIFTING INSTRUCTIONS  
TO VESSEL IN A WATER PROOF  
POLYETHYLENE BAG.
8. VESSEL TO BE SHIPPED STRAPPED TO TRUCK AT  
CRADLE LOCATIONS SHOWN.
9. COVER WITH CLEAN TIGHT TARPS DURING SHIPPING.
10. VESSEL TO BE SHIPPED VIA AIR RIDE  
TRAILER ONLY.
11. CARE TO BE TAKEN WITH LIFTING STRAPS TO AVOID  
HITTING OR RUBBING AGAINST ANY NOZZLES.



**NOTE: THE TRUCK DRIVER IS TO  
ADD PROPER BRACING TO  
PREVENT FORWARD OR AFT  
MOVEMENT OF THE VESSEL  
DURING SHIPMENT.**



**NOTE: SHIPPING SPOOLS BE-5/BE-6 USE  
(3) TYPE 72X8 CRADLES EA.  
OVERALL LENGTH OF BE-5 & BE-6 = 34'-0"**

SHIPPING WEIGHT = 10,500 LBS.

**SHT 7 OF 14**

**NECESSARY AND CONFIDENTIAL**  
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REV	DATE	DESCRIPTION	BY	CHKD

REV	DATE	DESCRIPTION	BY	CHKD
0	6/19/97	ISSUED FOR SHIPPING		

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

**SHIPPING SPOOLS WA-1A/WB-9A  
SHIPPING SPOOLS BE-5 & BE-6  
SHIPPING CRITERIA  
LIGO VACCUUM EQUIPMENT**

REV: 0  
DATE: 6/19/97  
BY: [Signature]  
CHKD: [Signature]

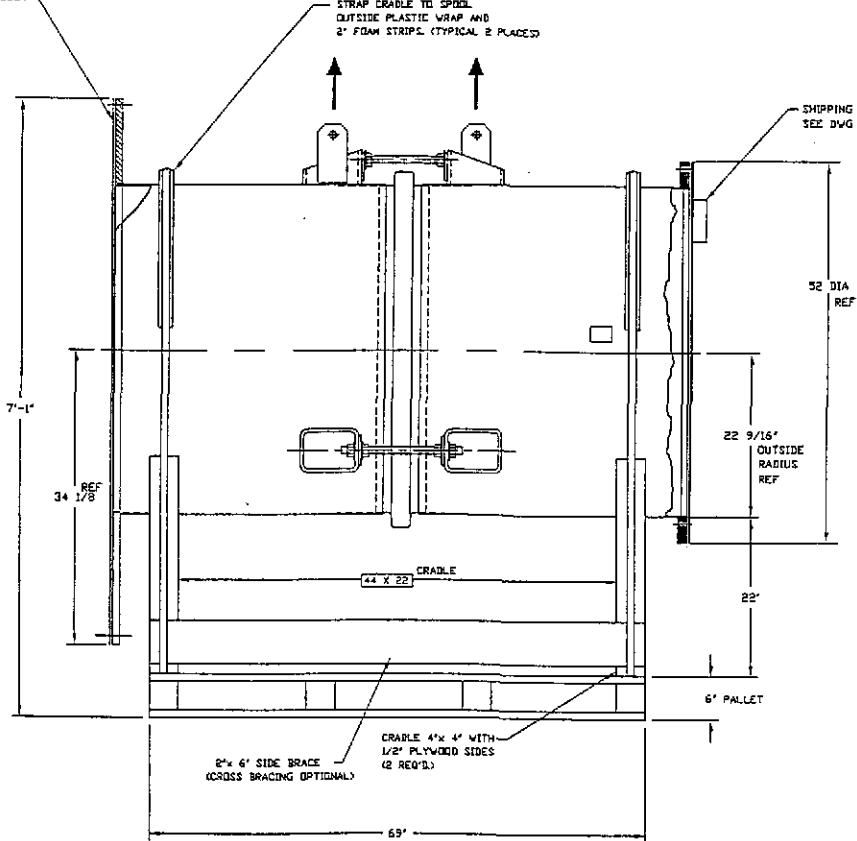
SCALE: 1/8"=1'-0" SHEET: SHT 7 OF 14



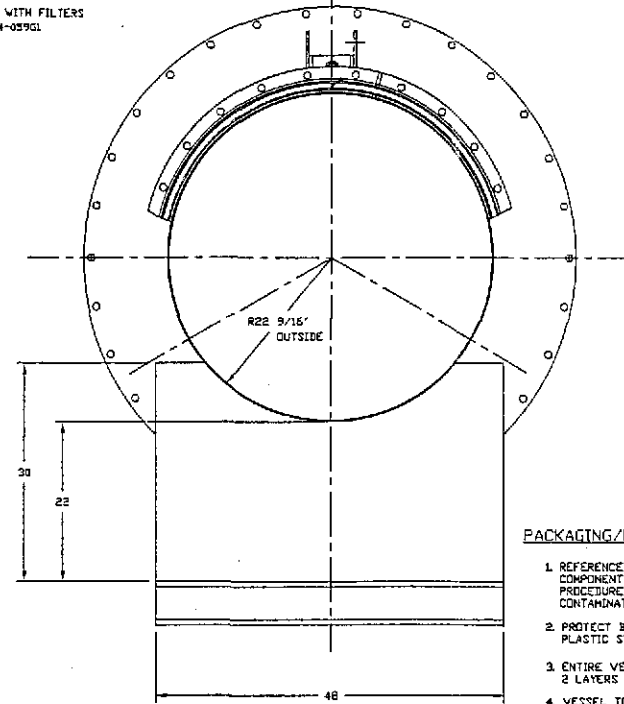
SHIPPING COVER  
SEE DWG V049-4-080G4

STRAP CRADLE TO SPOOL  
OUTSIDE PLASTIC WRAP AND  
2" FOAM STRIPS (TYPICAL 2 PLACED)

SHIPPING COVER WITH FILTERS  
SEE DWG V049-4-089G1



TOP & LIFTING LUGS



**PACKAGING/LIFTING/SHIPPING INSTALLATION**

1. REFERENCE DOCUMENTS  
COMPONENT PACKAGING, HANDLING, SHIPPING  
PROCEDURE - V049-2-123  
CONTAMINATION CONTROL PLAN - V049-2-119
2. PROTECT BELLOWS BY WRAPPING WITH HEAVY  
PLASTIC STRIPS PRIOR TO BAGGING.
3. ENTIRE VESSEL TO BE SHRINK WRAPPED WITH  
2 LAYERS OF 6 MIL POLYETHYLENE.
4. VESSEL TO BE MOUNTED ON TRAILER IN  
ORIENTATION SHOWN.
5. TIGHTEN BELLOWS TIE RODS TO LOCK IN  
NEUTRAL LENGTH POSITION.
6. REMOVE FROM TRAILER AT SITE BY LIFTING  
AT LOCATIONS SHOWN.
7. SECURELY ATTACH THESE LIFTING INSTRUCTIONS  
TO VESSEL IN A WATER PROOF  
POLYETHYLENE BAG.
8. VESSEL TO BE SHIPPED STRAPPED TO TRUCK AT  
CRADLE LOCATIONS SHOWN.
9. COVER WITH CLEAN TIGHT TARPS DURING SHIPPING.
10. VESSEL TO BE SHIPPED VIA AIR RIDE  
TRAILOR ONLY.
11. CARE TO BE TAKEN DURING LIFTING TO AVOID  
HITTING OR RUBBING AGAINST ANY VITAL COMPONENTS.

NOTE: THE TRUCK DRIVER IS TO  
ADD PROPER BRACING TO  
PREVENT FORWARD OR AFT  
MOVEMENT OF THE VESSELS.  
DURING SHIPMENT.

SHIT 8 of 14

APPROX. WEIGHT: 1600#

**DISCLAIMER AND LIABILITY**  
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OR BY ANY INFORMATION STORAGE  
RETRIEVAL SYSTEM, WITHOUT THE  
WRITTEN CONSENT OF PROCESS SYSTEMS  
INTERNATIONAL, INC. AND SHALL BE  
RETURNED UPON REQUEST.

REV. NO.	DESCRIPTION	DWG. NO.	DESCRIPTION

REV.	DESCRIPTION	DATE	BY	CHKD.	DRWN.	DATE	BY

DO NOT SCALE THIS DRAWING	ISSUED FOR SHIPPING	DATE	BY

**PROCESS SYSTEMS INTERNATIONAL, INC.**  
30 WINDUP DR., WESTBOROUGH, MASSACHUSETTS 01581 USA

**ADAPTER A-14  
SHIPPING ASSY.  
LIQD VACUUM EQUIPMENT**

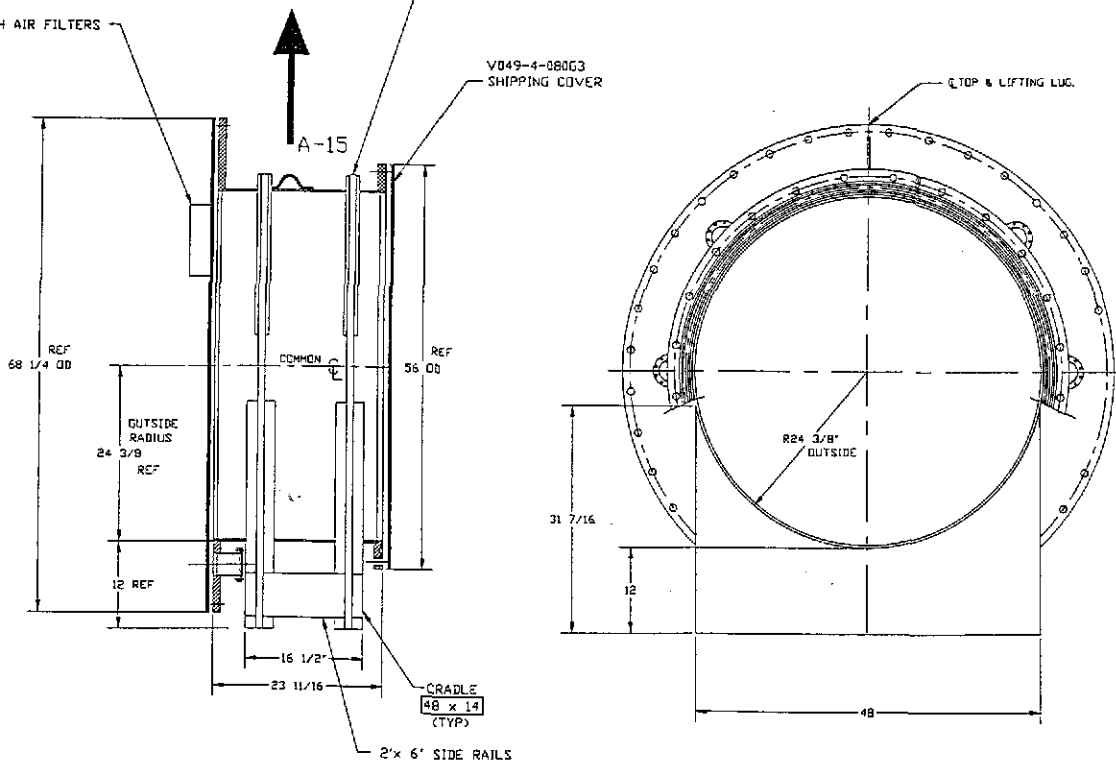
DWG. NO. V049-4-229  
REV. 0  
SCALE 1/16" = 1"  
SHEET 1 OF 1

V049-4-059G4  
SHIPPING COVER WITH AIR FILTERS

STRAP CRADLE TO SPOOL  
OUTSIDE PLASTIC WRAP AND  
2" FOAM STRIPS. (TYPICAL 3 PLACES)

V049-4-080G3  
SHIPPING COVER

Q TOP & LIFTING LUG.



PACKAGING/LIFTING/SHIPPING INSTALLATION

1. REFERENCE DOCUMENTS  
COMPONENT PACKAGING HANDLING SHIPPING  
PROCEDURE - V049-2-123  
CONTAMINATION CONTROL PLAN - V049-2-119
2. ENTIRE VESSEL TO BE SHRINK WRAPPED WITH 2 LAYERS  
OF 5 MIL POLYETHYLENE.
3. VESSEL TO BE MOUNTED ON TRAILER IN  
ORIENTATION SHOWN.
4. REMOVE FROM TRAILER AT SITE BY LIFTING  
AT LOCATIONS SHOWN.
5. SECURELY ATTACH THESE LIFTING INSTRUCTIONS  
TO VESSEL IN A WATER PROOF  
POLYETHYLENE BAG.
6. VESSEL TO BE SHIPPED STRAPPED TO TRUCK AT  
CRADLE LOCATIONS SHOWN.
7. COVER WITH CLEAN TIGHT TARPS DURING SHIPPING.
8. VESSEL TO BE SHIPPED VIA AIR RIDE  
TRAILER ONLY.
9. CARE TO BE TAKEN DURING LIFTING TO AVOID  
HITTING OR RUBBING AGAINST ANY NOZZLES.

NOTE! THE TRUCK DRIVER IS TO  
ADD PROPER BRACING TO  
PREVENT FORWARD OR AFT  
MOVEMENT OF THE VESSEL  
DURING SHIPMENT.

NOTE: ADAPTERS A-3 & A12 ALSO USE  
(2) TYPE 48X14 CRADLES EA.  
OVERALL LENGTH OF A-3 & A12 = 46" EA.

SHT 90P14 APPROX. WEIGHT: 1025# EA.

SYMBOL		CHARACTERISTIC	VALUES/STOLERANCE/NOTES
∠	FLATNESS	±0.005 IN IN DIAMETER	
○	CYLINDRICITY	±0.005 IN IN DIAMETER	
∥	PARALLELISM	±0.005 IN IN DIAMETER	
⊥	PERPENDICULARITY	±0.005 IN IN DIAMETER	
∠	ANGULARITY	±0.005 IN IN DIAMETER	
⊕	TRUE POSITION	±0.005 IN IN DIAMETER	
○	CONCENTRICITY	±0.005 IN IN DIAMETER	

REV	DESCRIPTION	DATE	BY	CHKD
0	ISSUED FOR SHIPPING	6/12/97	DA	DA

DWG. NO.	DESCRIPTION	DWG. NO.	DESCRIPTION

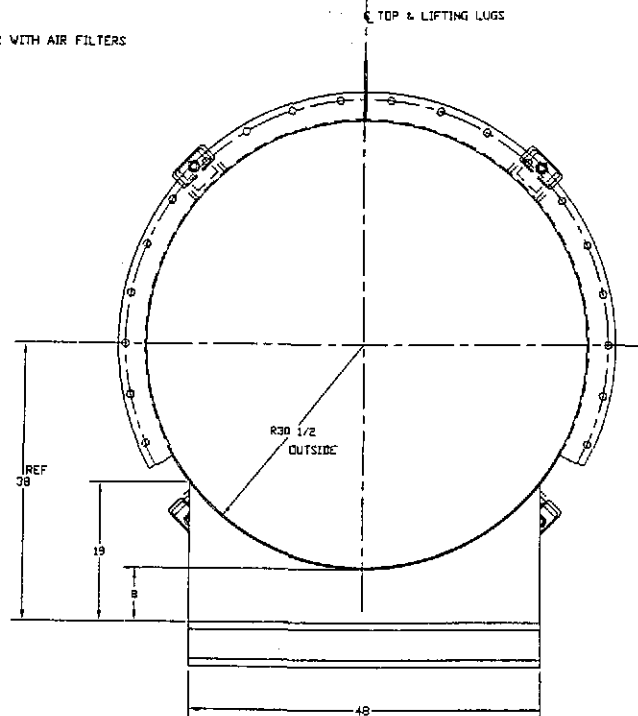
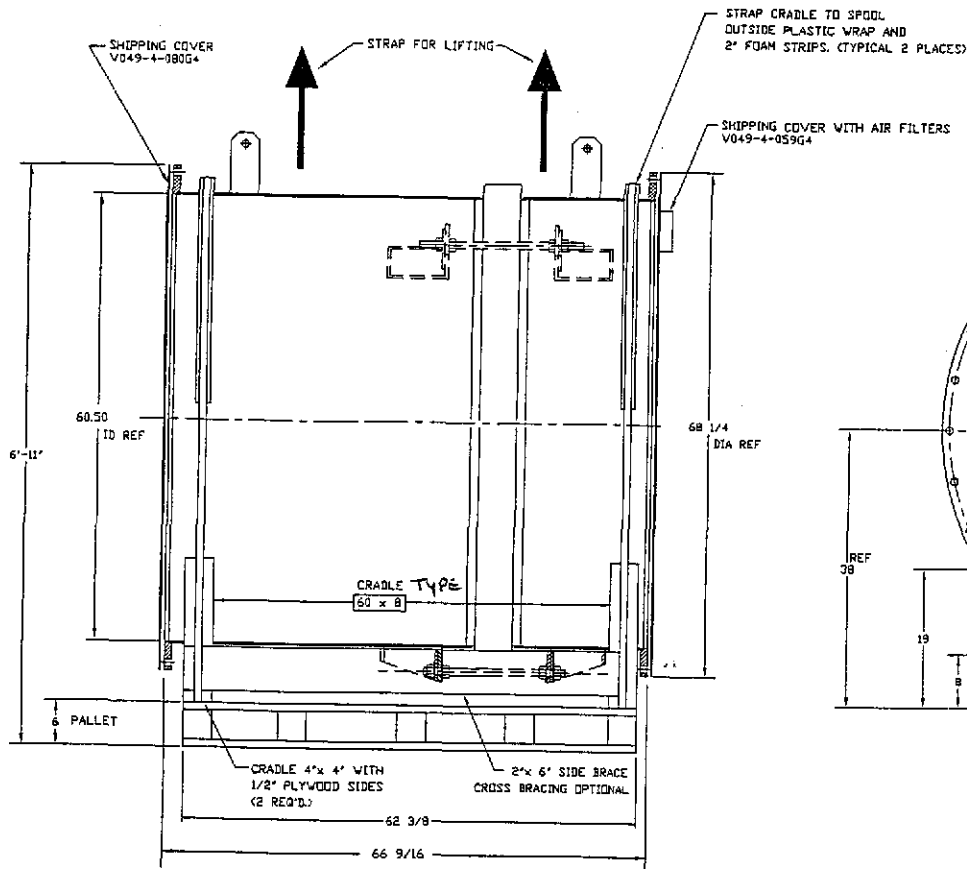
  

ISSUE	DATE	BY	CHKD
1	1-1/2" x 1"		

PROCESS SYSTEMS INTERNATIONAL INC.  
30 WALTON DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

ADAPTER A-15  
ADAPTER A-3  
ADAPTER A-12  
LIGD VACUUM EQUIPMENT

REV: 0  
V049-4-230



**PACKAGING/LIFTING/SHIPPING INSTALLATION**

1. REFERENCE DOCUMENTS  
COMPONENT PACKAGING, HANDLING, SHIPPING  
PROCEDURE - V049-2-123  
CONTAMINATION CONTROL PLAN - V049-2-119
2. PROTECT BELLOWS BY WRAPPING WITH HEAVY PLASTIC STRIPS  
PRIOR TO BAGGING.
3. ENTIRE VESSEL TO BE SHRINK WRAPPED WITH 2 LAYERS  
OF 6 MIL POLYETHYLENE.
4. VESSEL TO BE MOUNTED ON TRAILER IN  
ORIENTATION SHOWN.
5. TIGHTEN BELLOWS TIE RODS TO LOCK IN  
NEUTRAL LENGTH POSITION.
6. REMOVE FROM TRAILER AT SITE BY LIFTING  
WITH STRAPS AT LOCATIONS SHOWN.
7. SECURELY ATTACH THESE LIFTING INSTRUCTIONS  
TO VESSEL IN A WATER PROOF  
POLYETHYLENE BAG.
8. VESSEL TO BE SHIPPED STRAPPED TO TRUCK AT  
CRADLE LOCATIONS SHOWN.
9. COVER WITH CLEAN TIGHT TARPS DURING SHIPPING.
10. VESSEL TO BE SHIPPED VIA AIR RIDE  
TRAILER ONLY.
11. CARE TO BE TAKEN WITH LIFTING STRAPS TO AVOID  
HITTING OR RUBBING AGAINST VITAL EQUIPMENT.

NOTE: THE TRUCK DRIVERS IS TO  
ADD PROPER BRACING TO  
PREVENT FORWARD OR AFT  
MOVEMENT OF THE VESSEL  
DURING SHIPMENT.

SHT 100 of 14

APPROX. WEIGHT 13864

**REVISIONS AND COMMENTS**

ALL DIMENSIONS UNLESS OTHERWISE SPECIFIED ARE IN INCHES. DIMENSIONS IN PARENTHESES ARE IN MILLIMETERS. DIMENSIONS IN PARENTHESES ARE TO BE USED ONLY IF THE DIMENSION IS NOT SPECIFIED IN THE DRAWING. DIMENSIONS IN PARENTHESES ARE TO BE USED ONLY IF THE DIMENSION IS NOT SPECIFIED IN THE DRAWING. DIMENSIONS IN PARENTHESES ARE TO BE USED ONLY IF THE DIMENSION IS NOT SPECIFIED IN THE DRAWING.

REV	DESCRIPTION	DATE	BY	CHKD	APP'D
0	ISSUED FOR SHIPPING	6/28/97	BA		

SYMBOL	CHARACTERISTIC	UNLESS OTHERWISE SPECIFIED
□	FLATNESS	MAXIMUM IR 3.000
○	CYLINDRICITY	FRACTIONAL 0.1
∥	PARALLELISM	MAXIMUM IR 0.004
⊥	PERPENDICULARITY	MAXIMUM IR 0.004
∠	ANGULARITY	NO NET SCALE THIS DRAWING
⊕	TRUE POSITION	UNLESS INDICATED OTHERWISE
⊖	CONCENTRICITY	MAXIMUM IR 0.004

REV	DESCRIPTION	DATE	BY	CHKD	APP'D
0	ISSUED FOR SHIPPING	6/28/97	BA		

PROCESS SYSTEMS INTERNATIONAL INC.  
30 WALTON DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

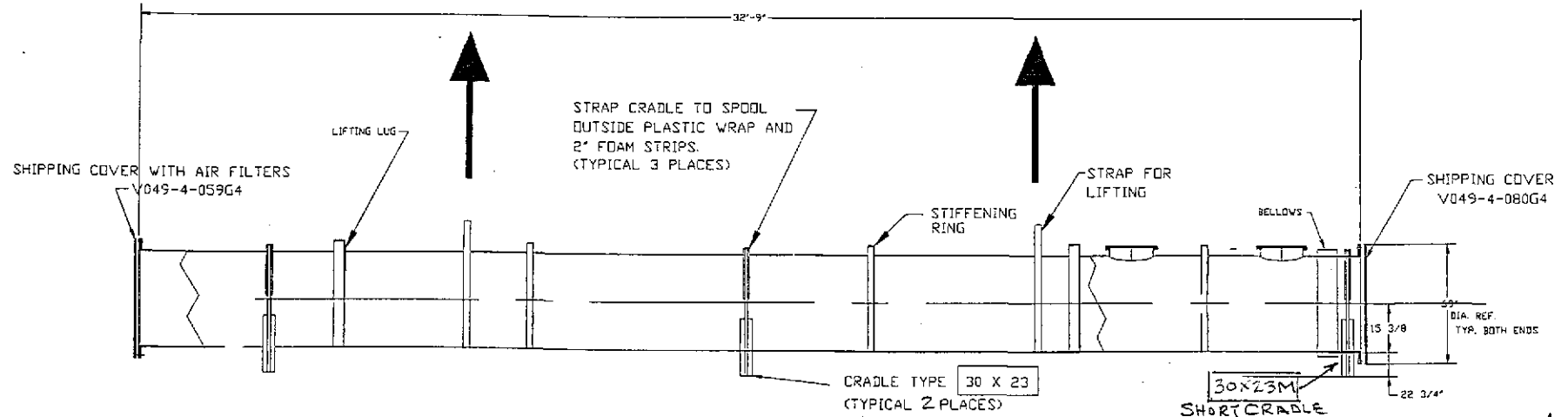
SPOOL BE-2  
SHIPPING ASSY.  
LIGO VACUUM EQUIPMENT

DATE FILED: 6/28/97  
REV: 0  
DWG NO: V049-4-231  
REV: 0

SCALE: 1-1/2" = 1"  
SHEET: 1 OF 1

**PACKAGING/LIFTING/SHIPPING INSTALLATION**

1. REFERENCE DOCUMENTS  
COMPONENT PACKAGING, HANDLING, SHIPPING  
PROCEDURE - V049-2-123  
CONTAMINATION CONTROL PLAN - V049-2-119
2. ENTIRE VESSEL TO BE SHRINK WRAPPED WITH 2 LAYERS  
OF 6 MIL POLYETHYLENE.
3. VESSEL TO BE MOUNTED ON TRAILER IN  
ORIENTATION SHOWN.
4. REMOVE FROM TRAILER AT SITE BY LIFTING  
WITH STRAPS AT LOCATIONS SHOWN.
5. SECURELY ATTACH THESE LIFTING INSTRUCTIONS  
TO VESSEL IN A WATER PROOF  
POLYETHYLENE BAG.
6. VESSEL TO BE SHIPPED STRAPPED TO TRUCK AT  
CRADLE LOCATIONS SHOWN.
7. COVER WITH CLEAN TIGHT TARPS DURING SHIPPING.
8. VESSEL TO BE SHIPPED VIA AIR RIDE  
TRAILOR ONLY.
9. CARE TO BE TAKEN WITH LIFTING STRAPS TO AVOID  
HITTING OR RUBBING AGAINST ANY EQUIPMENT.



**NOTE! THE TRUCK DRIVER IS TO ADD  
PROPER BRACING TO PREVENT  
FORWARD OR AFT MOVEMENT OF  
THE VESSEL DURING SHIPMENT.**

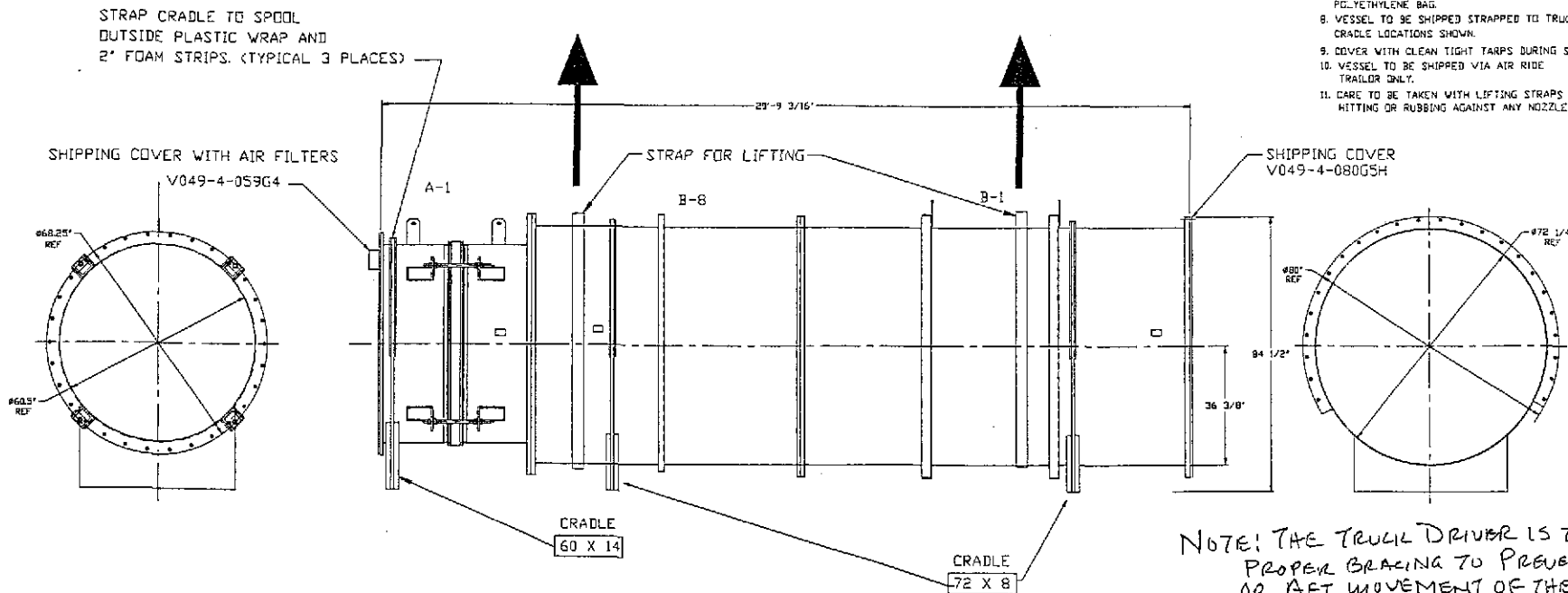
APPROX SHIPPING WEIGHT = 6800 LBS.

**SHI 11 OF 14**

<p><b>REVISIONS AND COMMENTS</b></p> <p>NO REVISIONS OR COMMENTS ARE TO BE MADE TO THIS DRAWING UNLESS SPECIFICALLY NOTED BY THE ISSUING OFFICE. ANY CHANGES TO THIS DRAWING SHALL BE MADE BY THE ISSUING OFFICE. THIS DRAWING IS THE PROPERTY OF PROCESS SYSTEMS INTERNATIONAL, INC. AND SHALL BE RETURNED UPON REQUEST.</p>		<p><b>UNLESS OTHERWISE SPECIFIED</b></p> <p>DIMENSIONS ARE IN INCHES</p> <p>FRACTIONS: 1/8" OR MORE TO THE NEAREST 1/16"</p> <p>DECIMALS: TO THE NEAREST 0.005"</p> <p>ANGLES: TO THE NEAREST 5 MINUTES</p> <p>UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE TO BE TAKEN TO THE CENTERLINE OF THE PART.</p>		<p><b>DO NOT SCALE THIS DRAWING</b></p> <p>USED IN: [ ]</p> <p>NEXT ASS'N: [ ]</p>		<p><b>ISSUED FOR SHIPPING</b></p> <p>DATE: 6/18/97</p> <p>BY: [Signature]</p>		<p><b>PROCESS SYSTEMS INTERNATIONAL, INC.</b></p> <p>28 WALTON DR. WESTBOROUGH, MASSACHUSETTS 01581 USA</p> <p>SPINDLES: 82A, 82B, 83A, 85A</p> <p>SHIPPING CRITERIA</p> <p>LIGO VACUUM EQUIPMENT</p>	
REV	DESCRIPTION	DATE	BY	CHKD	DATE	BY	CHKD		
0	ISSUED FOR SHIPPING	6/18/97	[Signature]						

**PACKAGING/LIFTING/SHIPPING INSTALLATION**

1. REFERENCE DOCUMENTS  
COMPONENT PACKAGING, HANDLING, SHIPPING  
PROCEDURE - V049-2-123  
CONTAMINATION CONTROL PLAN - V049-2-119
2. PROTECT BELLOW'S BY WRAPPING WITH HEAVY PLASTIC STRIPS  
PRIOR TO BAGGING.
3. ENTIRE VESSEL TO BE SHRINK WRAPPED WITH 2 LAYERS  
OF 6 MIL POLYETHYLENE.
4. VESSEL TO BE MOUNTED ON TRAILER IN  
ORIENTATION SHOWN.
5. TIGHTEN BELLOW'S TIE RODS TO LOCK IN  
NEUTRAL LENGTH POSITION.
6. REMOVE FROM TRAILER AT SITE BY LIFTING  
WITH STRAPS AT LOCATIONS SHOWN.
7. SECURELY ATTACH THESE LIFTING INSTRUCTIONS  
TO VESSEL IN A WATER PROOF  
POLYETHYLENE BAG.
8. VESSEL TO BE SHIPPED STRAPPED TO TRUCK AT  
CRADLE LOCATIONS SHOWN.
9. COVER WITH CLEAN TIGHT TARPS DURING SHIPPING.
10. VESSEL TO BE SHIPPED VIA AIR RIDE  
TRAILER ONLY.
11. CARE TO BE TAKEN WITH LIFTING STRAPS TO AVOID  
HITTING OR RUBBING AGAINST ANY NOZZLES.



NOTE: THE TRUCK DRIVER IS TO ADD  
PROPER BRACING TO PREVENT FORWARD  
OR AFT MOVEMENT OF THE VESSEL  
DURING SHIPMENT.

NOTE(2) SHIPPING SPOOLS LA-2/LB-1/LBE-1 USE  
3 TYPE 72X8 CRADLES EA, (LA ONLY).

APPROX. WEIGHT: 1450#

SHT. 12 OF 14

**REVISIONS AND COMMENTS**

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REV. NO.	DESCRIPTION	DATE	BY

**UNLESS OTHERWISE SPECIFIED**

ENGINEERING AND IN UNITS  
DIMENSIONS ARE IN INCHES  
FRACTIONS ARE 1/8  
DECIMALS ARE TO 3 DECIMALS  
TOLERANCES ARE AS SHOWN  
UNLESS OTHERWISE SPECIFIED  
FINISHES ARE AS SHOWN  
MATERIALS ARE AS SHOWN

DO NOT SCALE THIS DRAWING  
USED ON  
NEXT ASSY.

REV	DESCRIPTION	DATE	BY	CHKD	DRWN	DATE	SCALE
1	ISSUED FOR SHIPPING	6/26/97	SPR				

PROCESS SYSTEMS INTERNATIONAL, INC.  
30 WALDEN DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

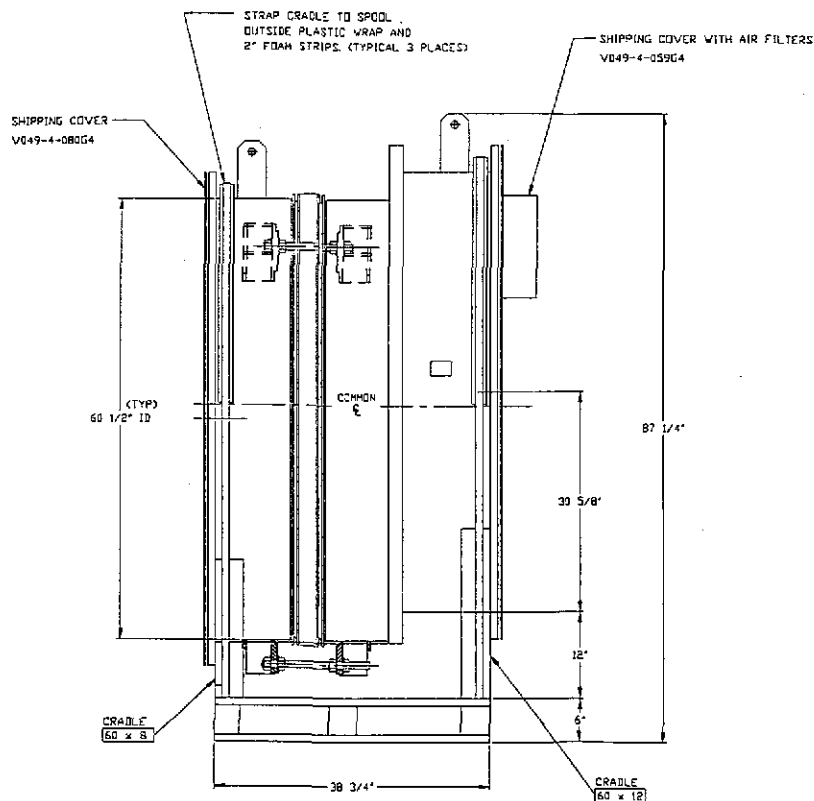
SHIPPING SPOOLS WA-13/WB-8/WB-1  
SHIPPING SPOOLS LA-2/LB-1/LBE-1  
SHIPPING CRITERIA  
LIGD VACUUM EQUIPMENT

DWG FILE	REV	DATE	BY
V049-4-233	1	6/26/97	SPR

SCALE: NONE SHEET: 1 OF 1

**PACKAGING/LIFTING/SHIPPING INSTALLATION**

1. REFERENCE DOCUMENTS  
COMPONENT PACKAGING, HANDLING, SHIPPING  
PROCEDURE - V049-2-123  
CONTAMINATION CONTROL PLAN - V049-2-115
2. PROTECT BELLOWS BY WRAPPING WITH HEAVY PLASTIC STRIPS  
PRIOR TO BAGGING.
3. ENTIRE VESSEL TO BE SHRINK WRAPPED WITH 2 LAYERS  
OF 6 MIL POLYETHYLENE.
4. VESSEL TO BE MOUNTED ON TRAILER IN  
ORIENTATION SHOWN.
5. TIGHTEN BELLOWS TIE RODS TO LOCK IN  
NEUTRAL LENGTH POSITION.
6. REMOVE FROM TRAILER AT SITE BY LIFTING  
WITH STRAPS AT LOCATIONS SHOWN.
7. SECURELY ATTACH THESE LIFTING INSTRUCTIONS  
TO VESSEL IN A WATER PROOF  
POLYETHYLENE BAG.
8. VESSEL TO BE SHIPPED STRAPPED TO TRUCK AT  
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9. COVER WITH CLEAN TIGHT TARPS DURING SHIPPING.
10. VESSEL TO BE SHIPPED VIA AIR RIDE  
TRAILOR ONLY.



NOTE: THE TRUCK DRIVER IS TO ADD  
PROPER BRACING TO PREVENT  
FORWARD OR AFT MOVEMENT  
OF THE LOAD DURING SHIPMENT.

SHEET 13 OF 14 APPROX. WEIGHT: 2275#

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PROCESS SYSTEMS INTERNATIONAL, INC. IS THE  
SOLE PROPRIETOR OF THE PROCESS SYSTEMS  
INTERNATIONAL, INC. DESIGN AND ALL RIGHTS  
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OR MECHANICAL, INCLUDING PHOTOCOPYING,  
RECORDING, OR BY ANY INFORMATION STORAGE  
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PROCESS SYSTEMS INTERNATIONAL, INC. AND  
SHALL BE RETURNED TO THE ISSUING OFFICE  
UPON COMPLETION OF THE PROJECT.

DWG. NO.	DESCRIPTION	DWG. NO.	DESCRIPTION
	REFERENCE DRAWINGS		

**UNLESS OTHERWISE SPECIFIED**

DIMENSIONS ARE IN INCHES  
FRACTIONS ARE IN 16ths  
DECIMALS ARE IN 10ths  
DIMENSIONS IN PARENTHESIS ARE  
FOR INFORMATION ONLY  
DIMENSIONS IN SQUARES ARE  
FOR INFORMATION ONLY  
DIMENSIONS IN CIRCLES ARE  
FOR INFORMATION ONLY

DO NOT SCALE THIS DRAWING  
USED ON: \_\_\_\_\_  
NEXT ASS'N: \_\_\_\_\_

ISSUED FOR	DATE	BY	REV	DESCRIPTION
FOR FABRICATION	6/30/97	SHS	1	ISSUED FOR FAB

PROCESS SYSTEMS INTERNATIONAL, INC.  
30 WILLOW DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

OFFSET SPOOL BE-3  
OFFSET SPOOL BE-3A  
LIGD VACUUM EQUIPMENT

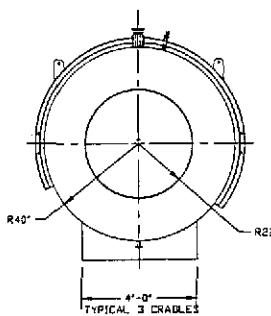
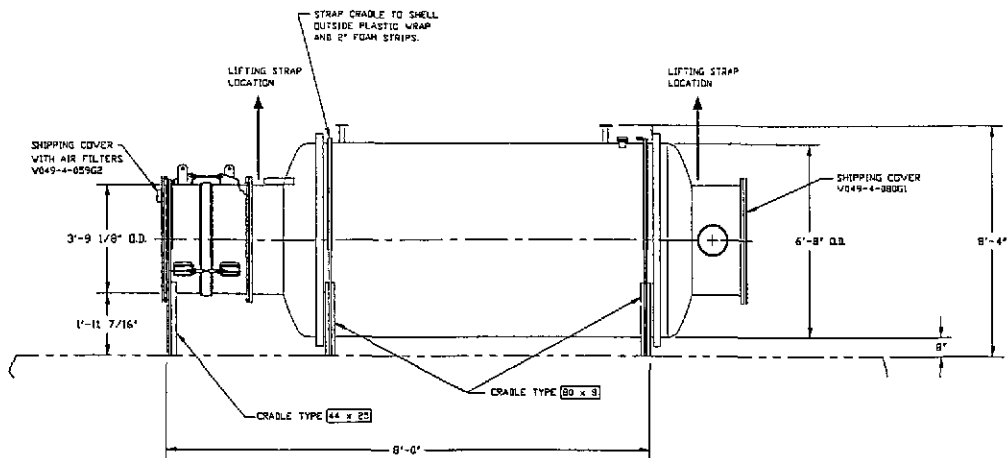
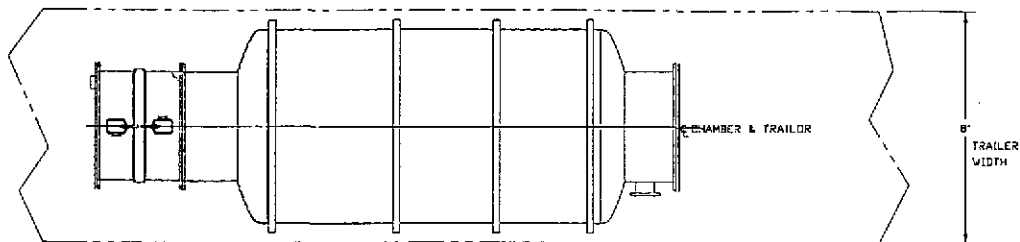
DWG. NO.	REV	DATE	BY	CHKD	DATE	BY
V049-4-234	0					

SCALE: NONE FEET 1 OF 1

**PACKAGING/LIFTING/SHIPPING INSTALLATION**

1. REFERENCE DOCUMENTS  
COMPONENT PACKAGING, HANDLING, SHIPPING  
PROCEDURE - V049-2-123  
CONTAMINATION CONTROL PLAN - V049-2-119
2. PROTECT BELLOW'S BY WRAPPING WITH HEAVY PLASTIC STRIPS  
PRIOR TO BAGGING.
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**NOTE: THE TRUCK DRIVER IS TO  
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FORWARD OR AFT MOVEMENT OF  
THE VESSEL DURING SHIPMENT.**



<p><b>PROPERTY AND CONFIDENTIALITY</b>                  SYSTEMS INTERNATIONAL, INC. OR ITS                  AFFILIATES, EMPHASES AND SHALL BE                  USED ONLY FOR THE PURPOSE FOR                  WHICH IT WAS SUPPLIED. IT SHALL NOT                  BE REPRODUCED OR TRANSMITTED IN                  ANY FORM OR BY ANY MEANS, ELECTRONIC                  OR MECHANICAL, INCLUDING PHOTOCOPYING,                  RECORDING, OR BY ANY INFORMATION                  STORAGE AND RETRIEVAL SYSTEM, WITHOUT                  THE WRITTEN PERMISSION OF SYSTEMS                  INTERNATIONAL, INC. AND SHALL BE                  RETURNED UPON REQUEST.</p>				<p><b>UNLESS OTHERWISE SPECIFIED                  DIMENSIONS ARE IN INCHES                  TOLERANCES:                  FRACTIONS:                  FIVE PLACES DECIMALS: ± 0.0001                  FIVE PLACES DECIMALS: ± 0.0002                  DECIMALS: ± 0.0005                  DECIMALS: ± 0.0010</b></p>				<p><b>ISSUE FOR SHIPPING</b>                  01/22/97 16495                  01/22/97 16495                  01/22/97 16495</p>			
<p>DO NOT SCALE THIS DRAWING</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>
<p>ISSUE NO.</p>	<p>DESCRIPTION</p>	<p>ISSUE NO.</p>	<p>DESCRIPTION</p>	<p>ISSUE NO.</p>	<p>DESCRIPTION</p>	<p>ISSUE NO.</p>	<p>DESCRIPTION</p>	<p>ISSUE NO.</p>	<p>DESCRIPTION</p>	<p>ISSUE NO.</p>	<p>DESCRIPTION</p>
<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>	<p>01/22/97 16495</p>

Sheet 14 of 14 SHIPPING WEIGHT=9000#

**PROCESS SYSTEMS INTERNATIONAL, INC.**  
 30 VALLEY DR. WILMINGTON, MASSACHUSETTS 01897 USA

**80K LING/BE-4  
 SHIPPING CRITERIA  
 LIQD VACUUM EQUIPMENT**

01/22/97 16495  
 01/22/97 16495  
 01/22/97 16495

SCALE: 1/2"=1'-0" SHEET 1 OF 1

**ATTACHMENT "O"**  
**TO**  
**V049-2-021**  
**WASHINGTON INSTALLATION DOCUMENT REVISION LIST**  
**V049-0-000**

**ATTACHMENT**

Number:

**A V049-2-021**

Rev.

**3**



## INSTALLATION DRAWING LIST

REV.	DWG. NUMBER	TITLE	REV.	DWG. NUMBER	TITLE	REV.	DWG. NUMBER	TITLE	REV.	DWG. NUMBER	TITLE
2	V049-0-001	LEGEND/STATION DIAGRAMS (3 SHTS.)	1	V049-2-110	PORTABLE SOFT WALL CLEANROOMS	0	V049-4-091	80K PUMP RESERVOIR-SHORT LEFT (3 SHTS.)	4	V049-5-012	PIPING ARR'T. PLAN CORNER STA. VA (4 SHTS.)
2	V049-0-002	BEAM SPLITTER CHAMBER ALL BUT CORNER VERTEX ARMS	1	V049-2-111	SMALL VALVES	1	V049-4-092	80K PUMP RESERVOIR-LONG LEFT (3 SHTS.)	3	V049-5-013	PIPING ARR'T. ELEVATION, CORNER STA. VA
3	V049-0-003	BEAM SPLITTER CHAMBER CORNER VERTEX ARMS	6	V049-2-112	BAKEOUT SYSTEM BLANKETS AND CARTS	0	V049-4-093	80K PUMP RESERVOIR-LONG RIGHT (3 SHTS.)	4	V049-5-014	PIPING ARR'T. SECTIONS, CORNER STA. VA
3	V049-0-004	HORIZONTAL ACCESS MODULE				2	V049-4-094	80K PUMP RESERVOIR SUPPLY, ASSY. SHORT (2 SHTS.)	3	V049-5-017	PIPING ARR'T. PLAN, RIGHT MID STA. VA (4 SHTS.)
2	V049-0-005	18cm & 12cm GATE VALVES				2	V049-4-095	80K PUMP RESERVOIR SUPPLY, ASSY. LONG (2 SHTS.)	3	V049-5-018	PIPING ARR'T. ELEVATION, RIGHT MID STA. VA (2 SHTS.)
6	V049-0-006	80K CRYOPUMP	2	V049-2-113	CORNER STATIONS	1	V049-4-096	72 1/4" ID FLANGE DETAIL (GROOVED)	3	V049-5-019	PIPING ARR'T. SECTIONS, RIGHT MID STA. VA
1	V049-0-007	CHAMBER PRESSURIZATION SYSTEM	2	V049-2-114	MID STATIONS	1	V049-4-097	60 1/2" ID FLANGE DETAIL (FLAT FACED)	3	V049-5-020	PIPING ARR'T. ELEVATION, RIGHT END STA. VA
5	V049-0-010	VA LEFT END STATION	2	V049-2-115	END STATIONS	2	V049-4-098	60 1/2" ID FLANGE DETAIL (FLAT/SLOTTED)	3	V049-5-023	PIPING ARR'T. SECTIONS, RIGHT END STA. VA
5	V049-0-011	VA LEFT MID STATION				0	V049-4-099	72 1/4" ID FLANGE DETAIL (FLAT/SLOTTED)	3	V049-5-028	PIPING ARR'T. PLAN, LEFT MID STA. VA (2 SHTS.)
5	V049-0-012	VA LEFT BEAM MANIFOLD				1	V049-4-101	BSC OVERALL ASSY.	3	V049-5-025	PIPING ARR'T. ELEVATION, LEFT MID STA. VA (2 SHTS.)
5	V049-0-013	VA VERTEX SECTION	4	V049-3-001	ELECTRICAL DRAWING LIST (2 SHTS.)	1	V049-4-106	25 L/S ANNULUS TUBING-44" G.V. TYPE III	3	V049-5-027	PIPING ARR'T. SECTIONS, LEFT MID STA. VA
5	V049-0-014	VA DIAGONAL SECTION				2	V049-4-107	25 L/S ION PUMP VALVE SUPPORT (2 SHTS.)	3	V049-5-028	PIPING ARR'T. SECTIONS, LEFT MID STA. VA
5	V049-0-015	VA RIGHT BEAM MANIFOLD	4	V049-4-002	HORIZONTAL ACCESS MODULE (HAM)	1	V049-4-108	25 L/S ANNULUS TUBING 48" G.V. TYPE I	3	V049-5-030	PIPING ARR'T. PLAN, LEFT END STA. VA (2 SHTS.)
5	V049-0-016	VA RIGHT MID STATION	3	V049-4-003	BSC SHELL WELDMENT/MACHINING (4 SHEETS)	3	V049-4-109	ANNULUS TUBING & ION PUMP ASSY. 44" G.V.	3	V049-5-031	PIPING ARR'T. ELEVATION, LEFT END STA. VA
5	V049-0-017	VA RIGHT END STATION	3	V049-4-004	80K CRYOPUMP, LONG LEFT HAND (2 SHEETS)	3	V049-4-110	25 L/S ANNULUS TUBING 48" G.V. TYPE II	3	V049-5-032	PIPING ARR'T. SECTIONS, LEFT END STA. VA
3	V049-0-018	VA CORNER STATION MECHANICAL ROOM	3	V049-4-005	80K CRYOPUMP, SHORT RIGHT (2 SHEETS)	3	V049-4-111	80K SHORT-SHIELD ASSY. RW/LH (3 SHTS.)	0	V049-5-033	OVERALL FLANGE ARR'T. CORNER STA. VA
			2	V049-4-006	80K CRYOPUMP, LONG RIGHT HAND (2 SHEETS)	3	V049-4-112	80K LONG-VERTICAL WELDMENT LH (2 SHTS.)	0	V049-5-035	OVERALL FLANGE ARR'T. MID STA. VA
			2	V049-4-007	80K CRYOPUMP, SHORT LEFT HAND (2 SHEETS)	2	V049-4-119	80K LONG-VESSEL WELDMENT LH (2 SHTS.)	0	V049-5-036	OVERALL FLANGE ARR'T. TIP END STA. VA & LA
			3	V049-4-010	ROUGHING PUMP CART ARRANGEMENTS	2	V049-4-120	80K SHORT-VESSEL WELDMENT RH (2 SHTS.)	0	V049-5-037	CLEAN ROOM WITH BSC ASSY.
			3	V049-4-011	TURBO PUMP CART ARRANGEMENTS	3	V049-4-121	80K SHORT VESSEL WELDMENT RH (2 SHTS.)	0	V049-5-050	SURVEY-BENCHMARKS-MID STA. VA & LA
			1	V049-4-012	BASE EXTENSION-TURBO PUMP CART	1	V049-4-122	75L ION PUMP SUPPORT	0	V049-5-051	SURVEY-BENCHMARKS-END STA. VA & LA
			4	V049-4-014	COVER, BSC TYPE I	1	V049-4-123	HAM 75L ION PUMP SUPPORT			
			2	V049-4-017	44 1/4" ID FLANGE DETAIL (GROOVED)	0	V049-4-124	BELLOWS 1" DIA. TIE-ROD ASSY.			
			2	V049-4-018	48 1/4" ID FLANGE DETAIL (GROOVED)	4	V049-4-127	84 1/2" ID ACCESS COVER-HAM			
			4	V049-4-019	60 1/2" ID BSC FLANGE DETAIL (GROOVED)	3	V049-4-128	HAM SHIELD WELDMENT ASSY. "B" (3 SHTS.)			
			2	V049-4-020	72 1/4" ID FLANGE DETAIL (GROOVED)	0	V049-4-129	HAM ANNULUS FLEX HOSE			
			3	V049-4-021	84 1/4" ID FLANGE DETAIL (GROOVED)	1	V049-4-132	44 5/8" ID FLANGE DETAIL (GROOVED)			
			5	V049-4-022	104 1/2" ID FLANGE DETAIL (GROOVED)	2	V049-4-135	BSC CLEAN ROOM ASSY-STYLE 1 & 3			
			4	V049-4-023	BSC SUPPORT ASSY.	3	V049-4-134	BSC CLEAN ROOM WELDMENT STYLE 1 & 3			
			4	V049-4-025	BSC ANNULUS PIPING	2	V049-4-135	BSC CLEAN ROOM ASSY.			
			1	V049-4-028	72 1/4" ID FLANGE DETAIL (FLAT FACED)	1	V049-4-136	CLEAN ROOM ASSY - HAM			
			1	V049-4-029	48 1/4" ID FLANGE DETAIL (FLAT FACED)	1	V049-4-137	CLEAN ROOM STRUCTURE WELDMENT - HAM			
			5	V049-4-031	60 1/2" ID HAM FLANGE DETAIL (GROOVED/SLOTTED)	2	V049-4-138	BSC CLEAN ROOM WELDMENT			
			3	V049-4-032	60 1/2" ID HAM FLANGE DETAIL (FLAT FACED)	0	V049-4-140	80K LONG-LEG ASSY.			
			1	V049-4-033	44" GATE VALVE SUPPORT FRAME	0	V049-4-141	80K SHORT-LEG ASSY.			
			1	V049-4-034	48" GATE VALVE SUPPORT FRAME	2	V049-4-142	16 1/2" OD CONFLAT REDUCING FLANGES			
			1	V049-4-036	BSC INTERNAL PLATFORM DETAILS	0	V049-4-144	60 1/2" ID FLANGE DETAIL BE-3A (FLAT FACED)			
			3	V049-4-040	HAM TIE ROD ASSY.	0	V049-4-145	LN2 TANK BASE TEMPLATE			
			2	V049-4-041	104 1/2" ID FLANGE DETAIL (FLAT FACED)	1	V049-4-146	80K HEAD/NOZZLE ASSY.			
			1	V049-4-042	44 5/8" ID FLANGE DETAIL (FLAT FACED)	1	V049-4-147	80K HEAD/NOZZLE ASSY.			
			1	V049-4-043	PIPE BRIDGE-CORNER STATION	1	V049-4-148	80K SHIELD SUPPORT LUG			
			1	V049-4-045	BSC RGA/AUX TURBO CONN. ASSY.	0	V049-4-158	BELLOWS 1 1/4" DIA. TIE-ROD ASSY.			
			1	V049-4-047	BSC RGA/AUX TURBO/GAUGE PAIR ASSY.	0	V049-4-159	FASTENING LUG			
			1	V049-4-048	44 5/8" ID x 80" OD FLANGE DETAIL (FLAT FACED)	0	V049-4-157	80K PUMP RT JACKETED LINE			
			3	V049-4-052	VESSEL SUPPORT (HAM)	0	V049-4-163	GATE VALVE FIN CLAMP			
			1	V049-4-053	EXPANSION JOINT (HAM)	1	V049-4-164	25 L/S ANNULUS TUBING-44" G.V. TYPE I			
			5	V049-4-054	HAM ANNULUS PIPING	1	V049-4-165	ANNULUS TUBING & ION PUMP ASSY. 48" G.V.			
			2	V049-4-055	60 1/2" ID RING DETAIL REDUCING UNION	1	V049-4-166	25 L/S ANNULUS TUBING-44" G.V. TYPE II			
			1	V049-4-056	30 1/2" ID x 68 1/4" OD FLANGE DETAIL (FLAT FACED)	0	V049-4-168	ASSEMBLY BACK TO AIR CART, 50 CFM			
			3	V049-4-057	30 1/2" ID x 68 1/4" OD FLANGE DETAIL (GROOVED)	0	V049-4-175	ASSEMBLY BACK TO AIR CART, 100 CFM			
			1	V049-4-058	44 5/8" ID x 60 1/2" ID FLANGE DETAIL	1	V049-4-176	1KW REGEN HEATER ASSY.			
			1	V049-4-059	SHIPPING COVER WITH FILTER UNITS	0	V049-4-177	EBV3 REGEN HEATER ASSY.			
			4	V049-4-060	44 1/4" ID FLANGE DETAIL (GROOVED/SLOTTED)	0	V049-4-194	12" OD CONFLAT BLANK x 2 3/4" OD CONFLAT			
			0	V049-4-061	3/4" OD ELBOW x 2 3/4" CF. FLG. ANNULUS CONN.	0	V049-4-195	12" OD CONFLAT BLANK x 25 KF			
			1	V049-4-064	60 1/2" ID x 68 1/2" OD BE-3A FLANGE (FLAT)	0	V049-4-196	8" OD CONFLAT BLANK x 25 KF			
			2	V049-4-066	60 1/2" ID x 72 1/4" OD OFFSET FLANGE (BE3A)	0	V049-4-197	10" OD TUBE BELLOWS-TURBO PUMP			
			3	V049-4-067	61.31" ID x 72 1/4" OD BE-3A FLANGE (GROOVED)	2	V049-4-199	BSC SHIPPING SKID			
			2	V049-4-068	48 1/4" ID x 60 1/2" ID OFFSET FLANGE	0	V049-4-203	BSC ANNULUS TUBE SUPPORT			
			1	V049-4-070	48.81 ID x 68 1/4" OD FLANGE DETAIL (FLAT FACED)	0	V049-4-204	BSC AIR FILTER ASSY.			
			0	V049-4-071	48.81 ID x 80 OD FLANGE DETAIL (FLAT FACED)	0	V049-4-206	HAM ANNULUS TUBING SHIPPING SUPPORT			
			0	V049-4-072	PS-1 PIPE SUPPORT TEE POST (LNB PIPING)	0	V049-4-302	BSC TEST/SHIP ASSY (TWO DOORS)			
			1	V049-4-073	PS-2 PIPE SUPPORT	0	V049-4-303	BSC TEST/SHIP ASSY (THREE DOORS)			
			1	V049-4-074	PS-3 PIPE SUPPORT TEE POST	0	V049-4-304	BSC TEST/SHIP ASSY (ONE DOOR)			
			2	V049-4-075	PS-4 PIPE/ELECTRICAL SUPPORT	0	V049-4-305	BSC TEST/SHIP ASSY (ONE DOOR)			
			0	V049-4-076	PS-5 PIPE SUPPORT @ 80K LONG PUMP	4	V049-5-001	EQUIPMENT ARR'T. PLAN, CORNER STA. VA (SHT 1 OF 2)			
			2	V049-4-077	75 L/S ION PUMP/MANIFOLDS	4	V049-5-001	EQUIPMENT ARR'T. ELEVATION, (SHT. 2 OF 2)			
			1	V049-4-078	25 L/S ION PUMP/MANIFOLDS	1	V049-5-002	EQUIPMENT ARR'T. ISO, CORNER STA. VA			
			4	V049-4-079	48 1/4" ID x 68 1/4" OD FLANGE DETAIL	4	V049-5-004	EQUIPMENT ARR'T. RIGHT MID STA. VA			
			1	V049-4-080	SHIPPING COVER ASSY. WITHOUT FILTER ASSY.	4	V049-5-005	EQUIPMENT ARR'T. RIGHT END STA. VA			
			1	V049-4-081	48 1/4" ID FLANGE DETAIL (GROOVED/SLOTTED)	4	V049-5-006	EQUIPMENT ARR'T. LEFT MID STA. VA			
			0	V049-4-082	PS-6 PIPE SUPPORTS @ BACKING PUMPS	4	V049-5-007	EQUIPMENT ARR'T. LEFT END STA. VA			
			0	V049-4-087	60 1/2" ID x 60" OD FLANGE DETAIL (FLAT FACED)	1	V049-5-010	EQUIPMENT ARR'T. ISO, RIGHT MID STA. VA			
			2	V049-4-090	80K PUMP RESERVOIR-SHORT RIGHT (3 SHTS.)	1	V049-5-011	EQUIPMENT ARR'T. ISO, RIGHT END STA. VA			

\* = DRAWINGS ADDED/REVISED SINCE MARCH 1997

<p><b>PROCESSES AND CONFIDENTIAL</b></p> <p>AS DOCUMENTED HEREIN, INFORMATION IS UNCLASSIFIED EXCEPT WHERE SHOWN OTHERWISE. THIS INFORMATION IS UNCLASSIFIED EXCEPT WHERE SHOWN OTHERWISE.</p> <p>DO NOT SCALE THIS DRAWING</p> <p>USED ON: _____</p> <p>NEXT ASSY: _____</p>	<p><b>UNLESS OTHERWISE SPECIFIED</b></p> <p>DRAWINGS ARE IN INCHES UNLESS OTHERWISE SPECIFIED</p> <p>FRACTIONS ARE TO BE SHOWN AS DECIMALS UNLESS OTHERWISE SPECIFIED</p> <p>ALL DIMENSIONS ARE TO BE SHOWN UNLESS OTHERWISE SPECIFIED</p> <p>ALL DIMENSIONS ARE TO BE SHOWN UNLESS OTHERWISE SPECIFIED</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 20%;">REV.</td> <td style="width: 20%;">DWN</td> <td style="width: 20%;">REC</td> <td style="width: 20%;">DATE</td> <td style="width: 20%;">BY</td> </tr> <tr> <td>2</td> <td>REC</td> <td>REC</td> <td>07/17/97</td> <td>0521</td> </tr> <tr> <td>1</td> <td>REC</td> <td>REC</td> <td>07/17/97</td> <td>0512</td> </tr> <tr> <td>0</td> <td>REC</td> <td>DA</td> <td>6/8/97</td> <td>0345</td> </tr> </table> <p>ISSUE DESCRIPTION</p> <p>ISSUE DESCRIPTION</p> <p>ISSUE DESCRIPTION</p>	REV.	DWN	REC	DATE	BY	2	REC	REC	07/17/97	0521	1	REC	REC	07/17/97	0512	0	REC	DA	6/8/97	0345
REV.	DWN	REC	DATE	BY																		
2	REC	REC	07/17/97	0521																		
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0	REC	DA	6/8/97	0345																		

**PROCESS SYSTEMS INTERNATIONAL INC.**  
30 WALTON DRIVE, WESTBOROUGH, MASSACHUSETTS 01581 USA

**INSTALLATION DOCUMENT LIST**  
WASHINGTON SITE  
LIGA VACUUM EQUIPMENT

GAZ FILE: V0490000

REV. NO: 0

REV. NO: V049-0-000

SHEET: 2

TOTAL SHEETS: 2