

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

WASHINGTON SITE

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

4	REC. 5 SEP 1997	R/S 9/16/97	RE-RELEASED FOR CONSTRUCTION PER AEO #0548
3	M/S 2 JUL 97	REB 2 JUL 97	RELEASED FOR CONSTRUCTION PER AEO #538
2	M/S 8 JUL 97	REB 8 JUL 97	RELEASED FOR CONSTRUCTION PER AEO #0511
1	M/S 6 MAY 96	REB 5 DEC 96	RELEASED PER AEO #0377
0	M/S 6 MAY 96	REB 6 MAY 96	RELEASED PER AEO #0177

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION

INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number	Rev.
	<i>M/S</i>	8 JUL 97	<i>REB</i>	8 JUL 97	V048-2-021* LIGO-E970140-04-V	4

CONTENTS

ATTACHMENT LISTING3

1 INTRODUCTION4

2 DEFINITIONS.....4

3 SITE VISIT5

4 CONTRACTOR CONTACTS.....5

5 PERMITS AND CODES5

6 SAFETY REGULATIONS.....7

7 GENERAL REQUIREMENTS7

8 SCOPE OF WORK.....13

9 TESTING21

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

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

12 PROJECT DOCUMENTS LIST24

13 SCHEDULE OF THE WORK.....25

14 BASIS OF BID.....25

15 SELECTION OF THE CONTRACTOR.....26

SPECIFICATION

Number:

A V049-2-021

Rev.

4

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 KFabricated Class 100 Vacuum and Air Piping V049-2-178
- Attachment LConcrete 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
- Attachment P.....Vacuum Equipment Grout Testing Plan

SPECIFICATION	
Number: A V049-2-021	Rev. 4

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.

4

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.

4

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.

SPECIFICATION

Number:

A V049-2-021

Rev.

4

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 LN₂ 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 LN₂ 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:	Rev.
A V049-2-021	4

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.

4

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:	Rev.
A V049-2-021	4

- 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.

4

- 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.

4

Title: LIGO VACUUM EQUIPMENT INSTALLATION AND COMMISSIONING – WASHINGTON SITE

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.

4

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.

SPECIFICATION

Number:

A V049-2-021

Rev.

4

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:	Rev.
A V049-2-021	4

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 ± 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.

4

- 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”

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.

SPECIFICATION	
Number:	Rev.
A V049-2-021	4

- 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.

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 C109 specifications shall be performed, including strength tests, at the discretion of the PSI site manager on a T&M basis. The grout testing is shown in Attachment P.

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, roughened and dampened prior to placing grout.

At base plate locations that are required to be scarified, indentations in the concrete shall be a minimum of 1/8 inch. (See Attachment M.)

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 per the manufacturer's specifications.

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

SPECIFICATION	
Number:	Rev.
A V049-2-021	4

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 guage aluminum tube and adequately supported by the field contractor.

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), LN₂ 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.

LN₂ 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 LN₂ 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 LN₂ tank area foundation and LN₂ tank anchor bolts are provided by the Buyer. The Contractor is responsible for installing the LN₂ tank and all associated equipment.

SPECIFICATION	
Number:	Rev.
A V049-2-021	4

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, LN₂)

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.

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).

SPECIFICATION

Number:

A V049-2-021

Rev.

4

- 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.

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.

SPECIFICATION	
Number: A V049-2-021	Rev. 4

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. LN₂ (V.J./LN₂ 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

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.

SPECIFICATION

Number:

A V049-2-021

Rev.

4

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 2×10^{-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.

4

- 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 LN₂ 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.

4

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: A V049-2-021	Rev. 4

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.

4

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.

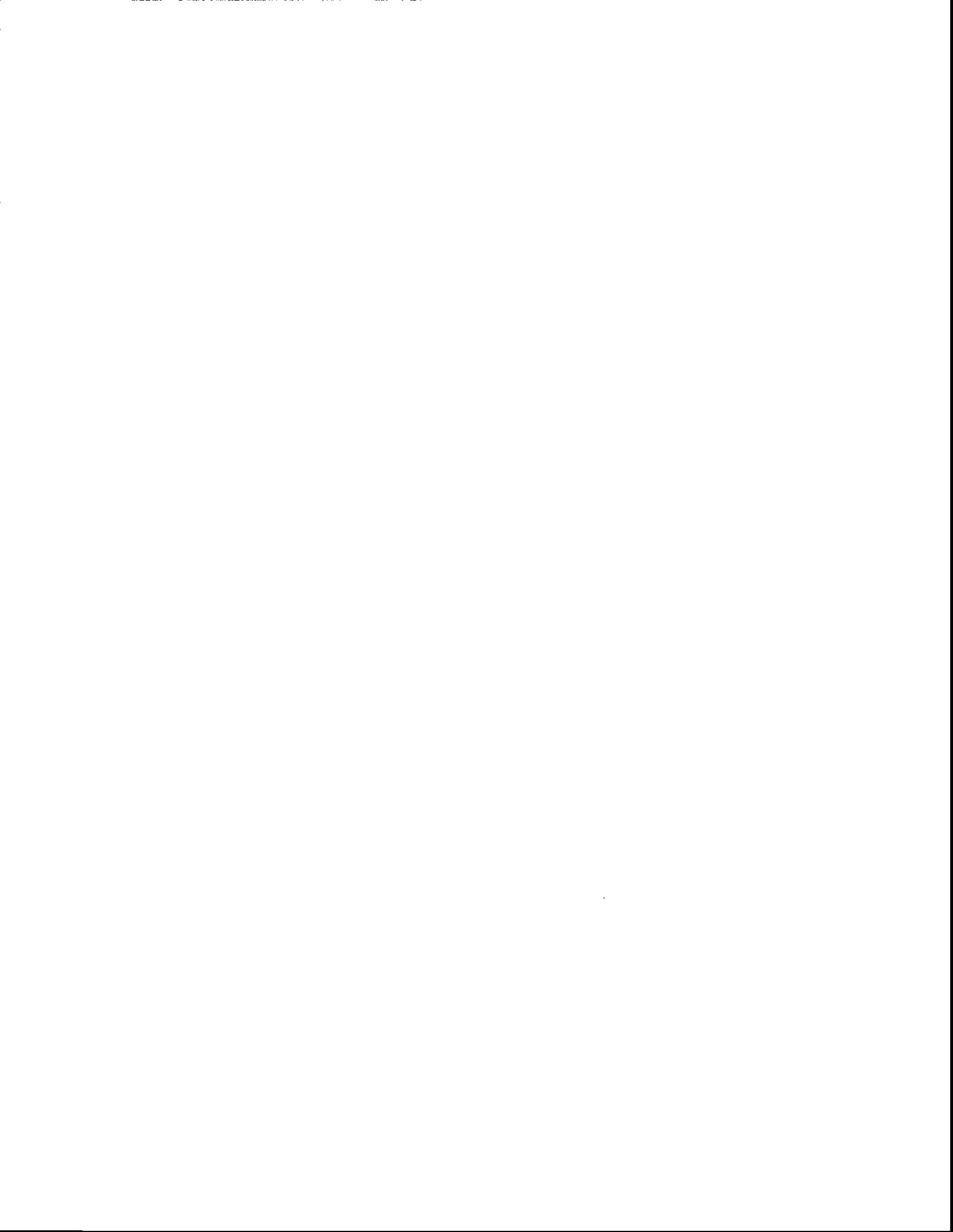
SPECIFICATION

Number:

A V049-2-021

Rev.

4



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

WASHINGTON SITE	DRAWING SIZE	DOCUMENT NUMBER
------------------------	-------------------------	----------------------------

NOTE: FOR CURRENT REV. LEVEL OF DOCUMENT, SEE INSTALLATION DOCUMENT

LIST ON DWG.V049-0-000

P&ID's

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

DRAWING/ BOM STRUCTURE

General Project (Sht. 1 of 3)	D	V049-0-100
Washington Site (Sht. 2 of 3)	D	V049-0-100

ATTACHMENT

Number: A V049-2-021	Rev. 4
-----------------------------	---------------

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

DOCUMENT NO.

Anchor Bolt Installation Procedure	V049-1-101
Leak Check Procedure	V049-2-014
Installation/Commissioning Spec.	V049-2-021
Electrical and Instrument Construction Spec.	V049-2-022
Project Safety Plan	V049-2-023
Project Q.A. Plan	V049-2-029
Piping Design and Material Specification	V049-2-037
Welding Procedures	V049-2-070
	V049-2-071
	V049-2-072
	V049-2-073
Material/Welding Repair Procedure	V049-2-074
Isolatable Section Bakeout Procedure	V049-2-116
Clean Room Activities	V049-2-118
Contamination Control Plan	V049-2-119
Raw Material Handling Procedure	V049-2-120
Component Packaging, Handling and Shipping	V049-2-123
Control of Non-Conformance	V049-2-124
Visual Inspection Procedure	V049-2-128
Black Light Test Procedure	V049-2-130
Site Piping Cleaning Procedure	V049-2-131
Site Vacuum Surface Re-Cleaning Procedure	V049-2-132
RGA Calibration	V049-2-137
Structural Carbon Steel Fabrication and Painting	V049-2-139
Thermal Insulation – Piping	V049-2-163
80K Pump Relief Valve Spec.	V049-2-164
Conflat Flange Assembly Procedure	V049-2-168
O-Ring Installation and Flange Assembly Procedure	V049-2-169
Component Alignment Procedure	V049-2-174
Vacuum Pump Field Installation Procedure	V049-2-175
Prefabricated Vacuum & Class 100 Air piping	V049-2-178

ATTACHMENT

Number:	A V049-2-021	Rev.	4
---------	---------------------	------	----------

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
Mid Stations	V049-2-114
End Stations	V049-2-115

ATTACHMENT

Number:	A V049-2-021	Rev.	4
---------	--------------	------	---

WASHINGTON SITE

MECHANICAL DRAWINGS

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

	DRAWING SIZE	DOCUMENT NUMBER
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:

A V049-2-021

Rev.

4

WASHINGTON SITE

MECHANICAL DRAWINGS

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

	DRAWING SIZE	DOCUMENT NUMBER
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 ₂ 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 1	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:	A V049-2-021	Rev.	4
---------	---------------------	------	----------

WASHINGTON SITE

MECHANICAL DRAWINGS

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

Clean Room Assembly - HAM
 Clean Room Structure Weldment-HAM
 BSC Clean Room Weldment
 16 1/2" OD Conflat Reducing Flanges
 LN2 Tank Base Template
 Lifting Lug
 80K Pump 2" Jacketed Line
 Gate Value Fin Clamp
 25 L/S Annulus Tubing - 44" G.V. Type I
 Annulus Tubing & Ion Pump Assy 48" G.V.
 25 L/S Annulus Tubing - 44" G.V. Type II
 Assembly Back To Air Cart 50 cfm
 Assembly Back To Air Cart 100 cfm
 Regen. Electric Heater Assembly 4 in. dia.
 Regen. Electric Heater Assembly 6 in. dia.
 12" O.D. CF Blank x 2.75 O.D. CF
 12" O.D. CF Blank x 25 KF
 8" O.D. CF Blank x 25 KF
 10" O.D. Tube Bellows-Turbo Pump
 BSC Shipping skid Assembly
 BSC Annulus Tube Support
 BSC Air Filter Assembly
 HAM Annulus Tube Shipping Support
 BSC Test/Ship Assembly-Two Door
 BSC Test/Ship Assembly-Three Door
 BSC Test/Ship Assembly-No Doors
 BSC Test/Ship Assembly-One Door
 Adapter A-1, 44.62" ID x 72.25 ID, 3 Sheets
 Adapter A-3, 48.25" ID x 60.5 ID, 2 Sheets
 60" HAM Cover, Grooved Type A4, 2 Sheets
 Adapter A-6, 48.25" ID x 60.5 ID, 2 Sheets
 Adapter A-7A, 60.5" ID x 72.25 ID, 5 Sheets
 Adapter A-7B, 60.5" ID x 72.25 ID, 5 Sheets
 BSC End Cover 60.5" Type All
 Adapter A-12, 48.25" ID x 60.5 ID, 2 Sheets
 Adapter A-13, 60.5" ID x 72.25 ID, 2 Sheets
 Adapter A-14, 44.62" ID x 60.5 ID, 2 Sheets

DRAWING SIZE	DOCUMENT NUMBER
D	V049-4-136
D	V049-4-137
D	V049-4-138
B	V049-4-142
D	V049-4-145
D	V049-4-159
D	V049-4-161
B	V049-4-163
C	V049-4-164
D	V049-4-165
C	V049-4-166
D	V049-4-168
D	V049-4-175
D	V049-4-176
D	V049-4-177
B	V049-4-194
B	V049-4-195
B	V049-4-196
B	V049-4-197
D	V049-4-199
B	V049-4-203
D	V049-4-204
B	V049-4-206
D	V049-4-302
D	V049-4-303
D	V049-4-304
D	V049-4-305
D	V049-4-A1
D	V049-4-A3
D	V049-4-A4
D	V049-4-A6
D	V049-4-A7A
D	V049-4-A7B
D	V049-4-A11
D	V049-4-A12
D	V049-4-A13

ATTACHMENT	
Number:	Rev.
A V049-2-021	4

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 1 of 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.

4

WASHINGTON SITE

MECHANICAL DRAWINGS

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

	DRAWING SIZE	DOCUMENT NUMBER
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:

A V049-2-021

Rev.

4

ATTACHMENT "B"
TO
V049-2-021
BUILDING CRANE COVERAGE

ATTACHMENT

Number:

A V049-2-021

Rev.

4

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:
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)

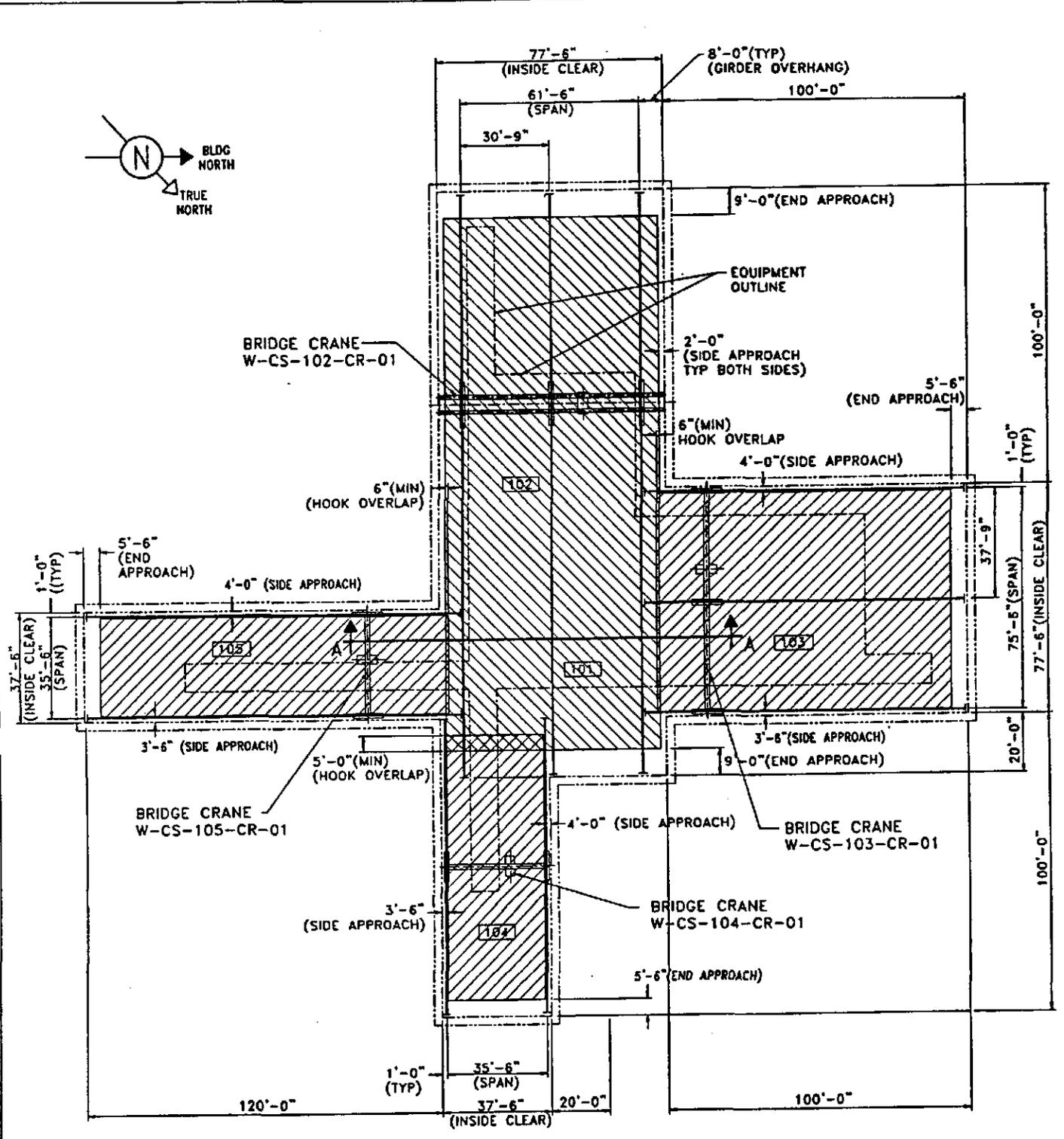
- | | |
|------------------------------|--|
| 1. Location: | LVEA Corner Station |
| 2. Number Required: | One (1) |
| 3. Tag No.: | W-CS-105-CR-01 |
| 4. Arrangement: | Refer to Figures 3 |
| 5. Type: | Electric, Single-Girder Under-Running |
| 6. Number of Hoists: | One(1) |
| 7. Class: | CMAA, Class 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

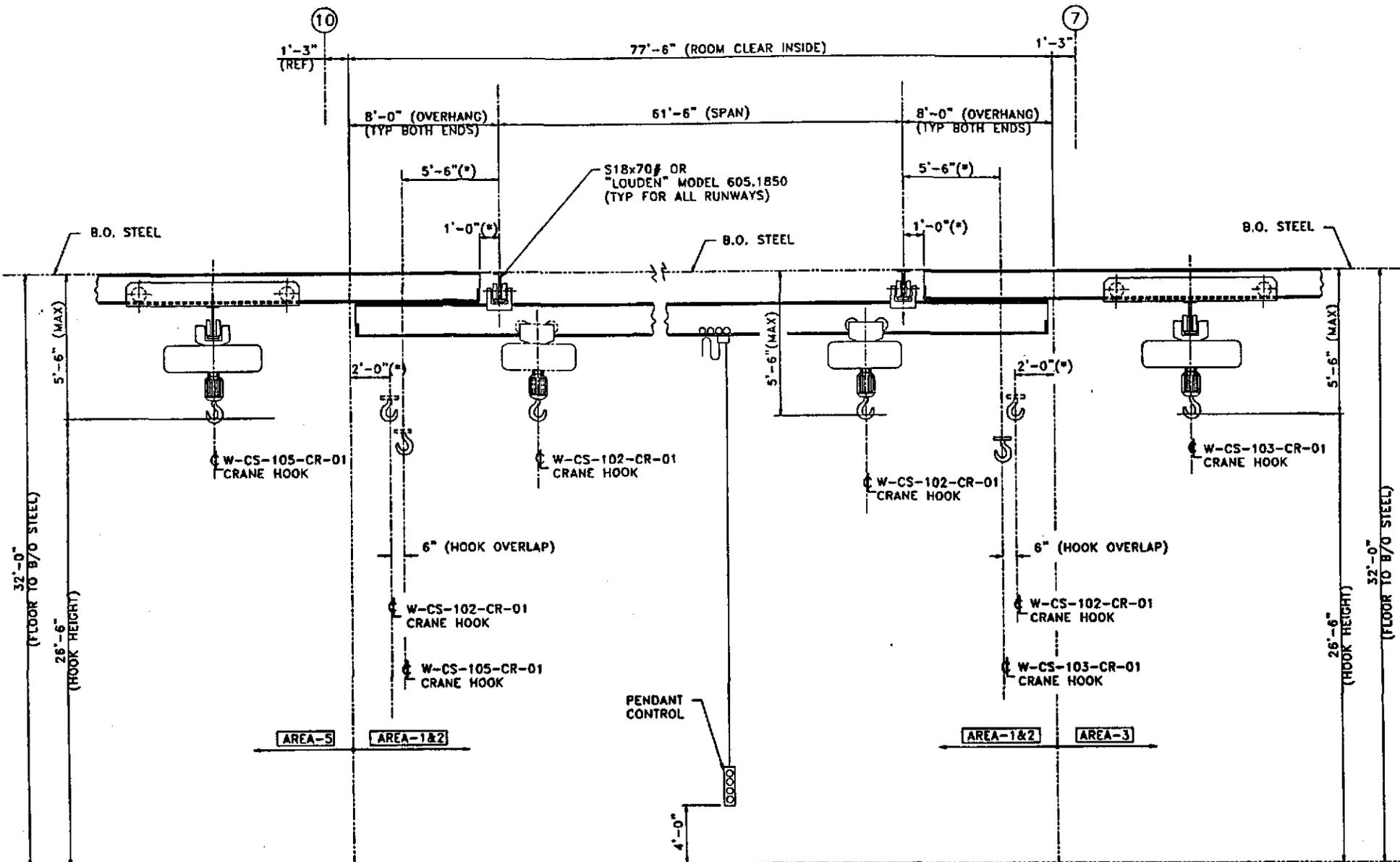
NOTE: "LOUDEN" Rail No. 605.1850 may be used instead the specified.



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]



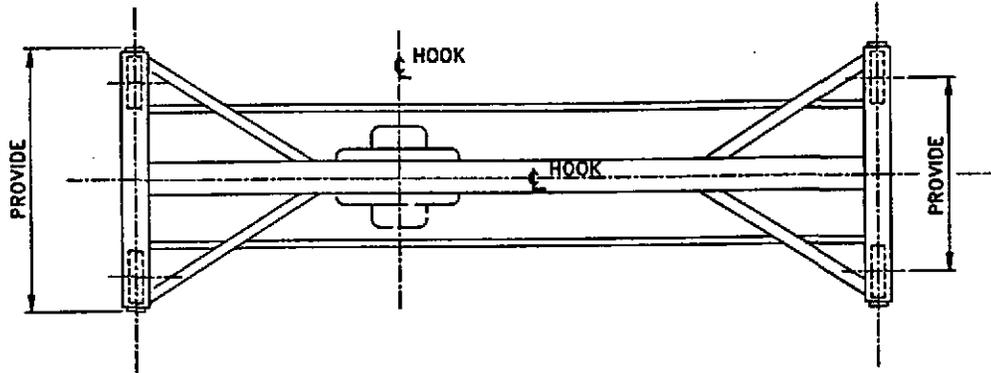
NOTES:

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.

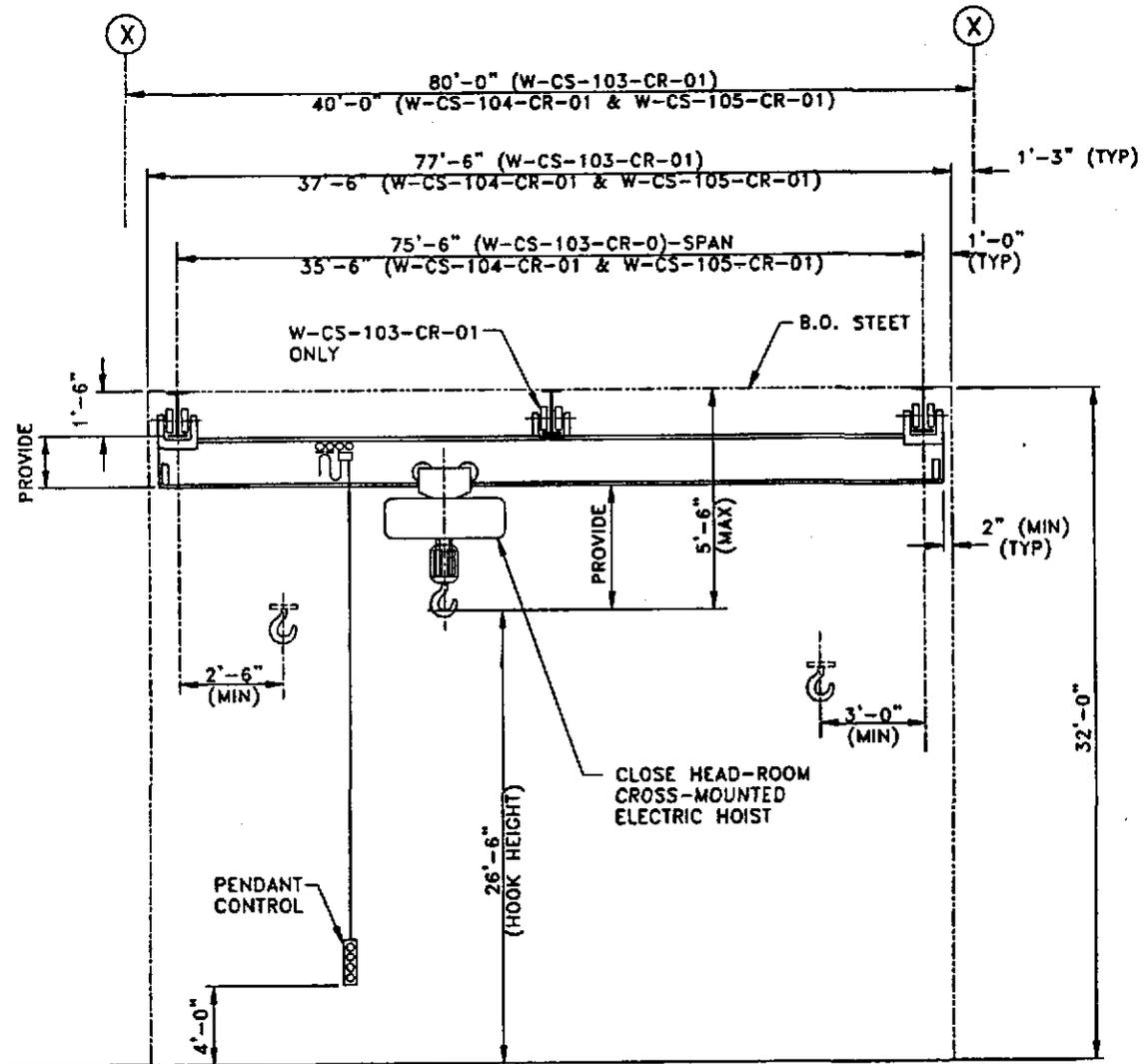
SECTION A-A
(LOOKING WEST)

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

PG 7 of 8



PLAN

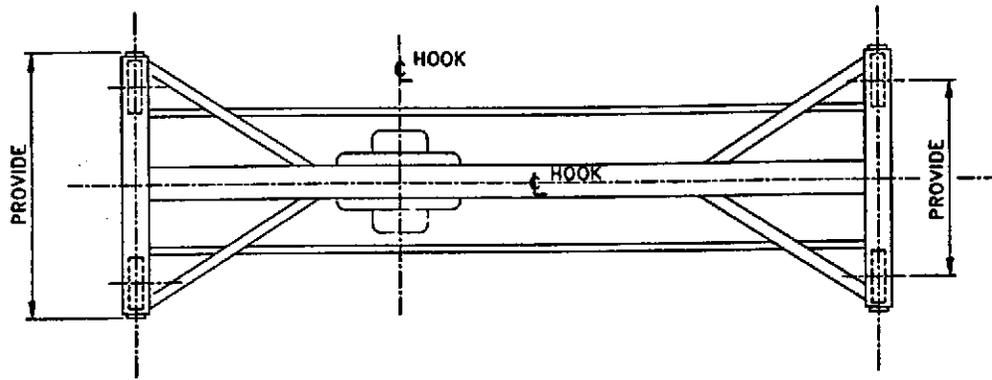


ELEVATION

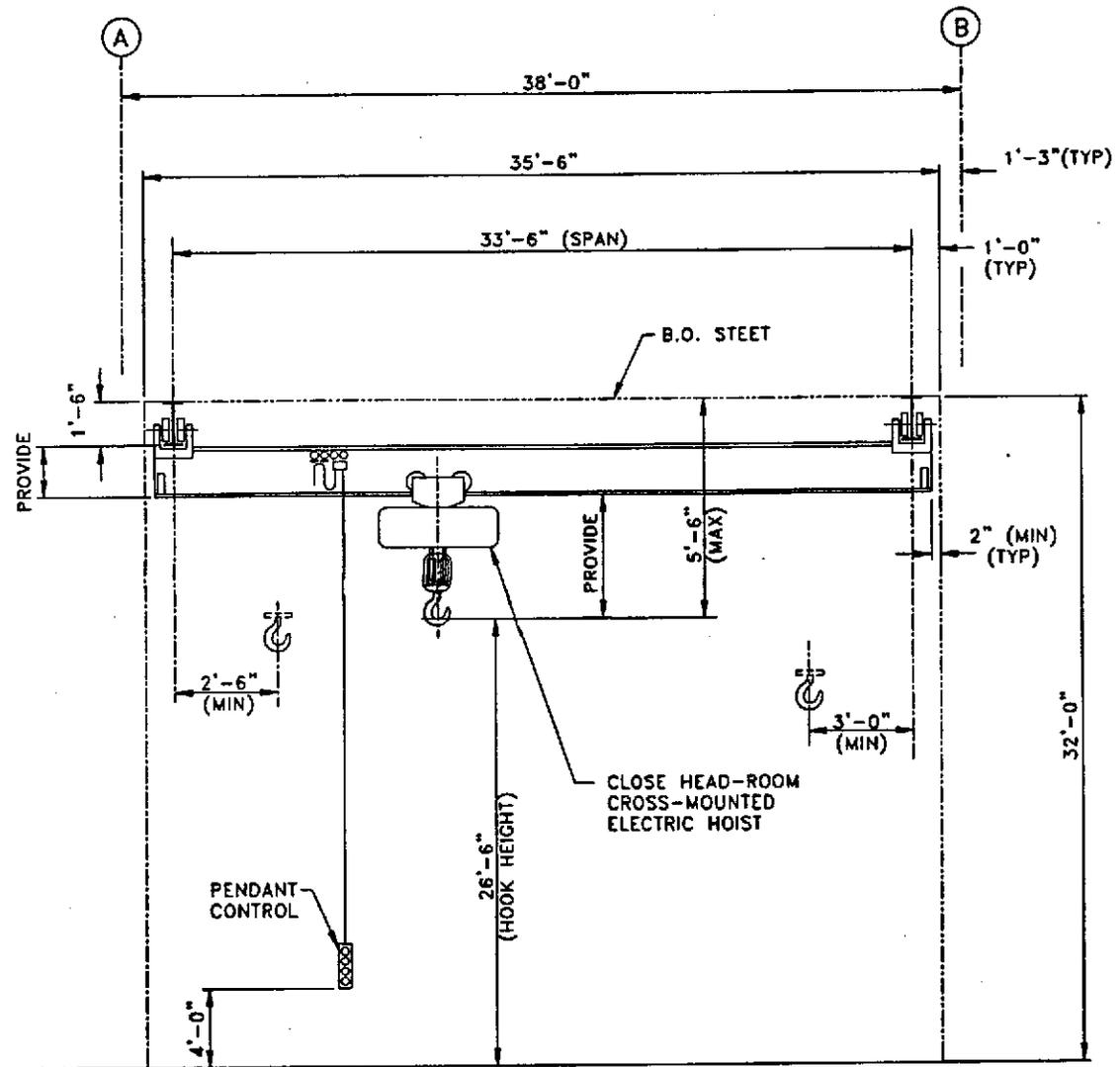
NOTES:

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

P6 90F9

**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:	Rev.
A V049-2-021	4

Title: LIGO VACUUM EQUIPMENT INSTALLATION AND COMMISSIONING – WASHINGTON SITE

Item	Description	Qty.	Estimated Shipping Weight(lbs.)
LWDX	LN ₂ Tanks-14,000 Gal.	6	41,000
LWDX	LN ₂ 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 ₂ Piping Run (One per LN ₂ 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"

ATTACHMENT	
Number:	Rev.
A V049-2-021	4

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

ATTACHMENT "D"

TO

V049-2-021

ELECTRICAL AND INSTRUMENT CONSTRUCTION WORK V049-2-022

(LIGO-E970138-02-V)

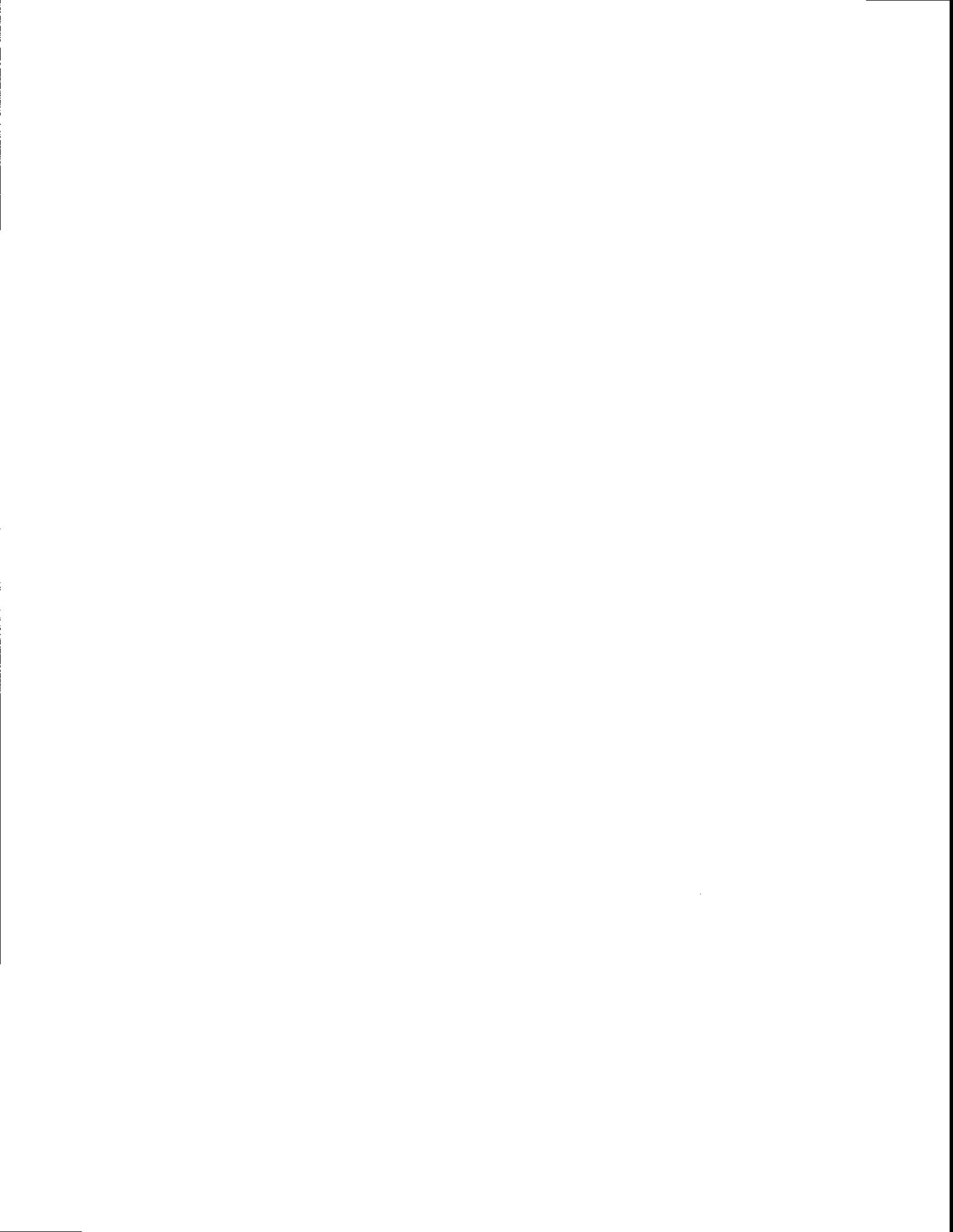
ATTACHMENT

Number:

A V049-2-021

Rev.

4



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>APW/30/97</i>	<i>REB 7-1-97</i>	<i>RELEASED FOR CONSTRUCTION DEO # 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

PROCESS SYSTEMS INTERNATIONAL, INC				SPECIFICATION		
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
A 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.

SPECIFICATION	
Number	Rev
A V049-2-022	2

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)

By Others Work not under this Contract.

Contractor Company doing electrical and instrumentation work as defined in the Contract Documents.

PSI Process Systems International, Inc.

Indicated Shown or noted.

Install Place, secure, and connect.

Labeled Equipment marked with an identifying symbol authorized by a nationally recognized testing company such as UL, FM, ETL indicating sample of product has been tested and determined it complies with their safety standards.

Owner California Institute of Technology and The US Government

Owner's Representative Persons designated by Owner

Permitted As by code, Contract Documents, or PSI.

Provide Furnish and install.

Required As by code, Contract Documents, or prevailing conditions.

Submittal Information required to show that the proposed equipment complies with project requirements.

Use Provide material or equipment referenced.

Work Material and equipment and their installation and other requirements as established in the Contract Documents.

Wire (Verb) Connect to equipment indicated and provide wiring required for connection.

Wiring Conductors, raceways, and accessories as required for a complete installation.

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

SPECIFICATION

Number	Rev
A V049-2-022	2

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	Rev
A V049-2-022	2

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

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

A V049-2-022

Rev

2

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

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

- 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

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

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:

<u>Line</u>	<u>208/120V</u>	<u>480/277V</u>
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	Rev
A V049-2-022	2

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

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 indicated 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	Rev
A V049-2-022	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.

— E N D —

SPECIFICATION

Number

A V049-2-022

Rev

2

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

DRAWING	DESCRIPTION
V049-3-002	OVERALL SITE PLAN
V049-3-101	INSTRUMENT PLAN—VERTEX SECTION
V049-3-102	INSTRUMENT PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-103	INSTRUMENT PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-104	INSTRUMENT PLAN—DIAGONAL SECTION
V049-3-106	CABLE TRAY PLAN—VERTEX SECTION
V049-3-107	CABLE TRAY PLAN—LEFT BEAM MANIFOLD SECTION
V049-3-108	CABLE TRAY PLAN—RIGHT BEAM MANIFOLD SECTION
V049-3-109	CABLE TRAY PLAN—DIAGONAL SECTION
V049-3-110	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
A V049-2-022	2

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
A V049-2-022	2

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

<u>DRAWING</u>	<u>DESCRIPTION</u>
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
A V049-2-022	2

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
A V049-2-022	2

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
A V049-2-022	2

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

ITEM	INSTRUMENT TAG/EQUIPMENT DESIGNATION	
		V INDICATES VACUUM ENVIRONMENT LOCATION
		DESCRIPTION (INDICATED ON DRAWING/SHEET)
23	LT-500	— CRYOPUMP WCP8 LEVEL TRANSMITTER* (V049-3-501)
24	LT-505	— CRYOPUMP WCP8 DEWAR LEVEL TRANSMITTER* (V049-3-501)
25	PNL-100A	— CORNER STATION ION CONTROLLER PANEL (V049-3-116)
26	PNL-100B	— CORNER STATION ION CONTROLLER PANEL (V049-3-116)
27	PNL-200	— LEFT MID STATION ION CONTROLLER PANEL (V049-3-204)
28	PNL-300	— RIGHT MID STATION ION CONTROLLER PANEL (V049-3-304)
29	PNL-400	— LEFT END STATION ION CONTROLLER PANEL (V049-3-404)
30	PNL-500	— RIGHT END STATION ION CONTROLLER PANEL (V049-3-504)
31	PT-101	— CRYOPUMP WCP1 PRESSURE TRANSMITTER* (V049-3-102)
32	PT-151	— CRYOPUMP WCP2 PRESSURE TRANSMITTER* (V049-3-103)
33	PT-201	— CRYOPUMP WCP3 PRESSURE TRANSMITTER* (V049-3-201)
34	PT-251	— CRYOPUMP WCP4 PRESSURE TRANSMITTER* (V049-3-201)
35	PT-301	— CRYOPUMP WCP5 PRESSURE TRANSMITTER* (V049-3-301)
36	PT-351	— CRYOPUMP WCP6 PRESSURE TRANSMITTER* (V049-3-301)
37	PT-401	— CRYOPUMP WCP7 PRESSURE TRANSMITTER* (V049-3-401)
38	PT-501	— CRYOPUMP WCP8 PRESSURE TRANSMITTER* (V049-3-501)
39	TE-103A, 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
A V049-2-022	2

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

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	Rev
A V049-2-022	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



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

ATTACHMENT "E"

TO

V049-2-021

FINAL DESIGN REPORT VOLUME IV INSTALLATION/COMMISSIONING

V049-1-100

(LIGO-C960967-01-V)

"SHIPPED LOOSE"

ATTACHMENT

Number:

A V049-2-021

Rev.

4

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
(LIGO-D970330-00 v)

ATTACHMENT	
Number:	Rev.
A V049-2-021	4

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

"DRAWINGS SHIPPED LOOSE"

(31 Sheets Total)

ATTACHMENT

Number:

A V049-2-021

Rev.

4

ATTACHMENT "H"
TO
V049-2-021
VENDOR EQUIPMENT DRAWINGS
(List Attached)

SPECIFICATION

Number:	A V049-2-021	Rev.	4
---------	--------------	------	---

(DRAWINGS SHIPPED)
LOOSE

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

SPECIFICATION

Number:	Rev.
A V049-2-021	4

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 ₂ Tanks – Outline	CS-12004, 2 Sheets	4	C	Process Engineering
15A.	LN ₂ 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 ₂ 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:

A V049-2-021

Rev.

4

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.

4

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.

4

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

ATTACHMENT	
Number: A V049-2-021	Rev. 4

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

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

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

4

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

LIGO Equipment Installation and Shipping Data

Washington Corner Station: Area 100

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- 48"	8500 lbs.	6ft. W x 2ft. H x 17ft. L	Shipped to site by vendor
WGV 2- 48"	8500 lbs.	6ft. W x 2ft. H x 17ft. L	Shipped to site by vendor
WGV 3- 48"	8500 lbs.	6ft. W x 2ft. H x 17ft. L	Shipped to site by vendor
WGV 4- 48"	8500 lbs.	6ft. W x 2ft. H x 17ft. L	Shipped to site by vendor
WGV 5- 44"	7200 lbs.	5ft. W x 2ft. H x 16ft. L	Shipped to site by vendor
WGV 6- 44"	7200 lbs.	5ft. W x 2ft. H x 16ft. L	Shipped to site by vendor

ATTACHMENT	
Number: A V049-2-021	Rev. 4

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

Washington Corner Station: Area 100

Tag No.	Shp.Wt.	Shp.Dim.	Onsite Date
WGV 7- 44"	7200 lbs.	5ft.W x 2ft.H x 16ft.L	Shipped to site by vendor Shipped to site by vendor
WGV 8- 44"	7200 lbs.	5ft.W x 2ft.H x 16ft.L	
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		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	
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.

4

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

Washington Corner Station: Area 100

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	
1ea. HAM Clean Rms.	4100 lbs.	13 ft.4in.W x 16 ft.9in.L x 11 ft.H	
2ea BSC Clean Rms	5800 lbs	17 ft.6in.W x 18 ft.8in.L x 18 ft.6in.H	
4ea. 6 in. gate valves	50 lbs.		
6ea. 10 in. gate valves	100 lbs.		
8ea. 14 in. gate valves	350 lbs.		
2ea.12 in. O.D. Conflat Special Flange shipped loose for B5A & B7 (V049M195)			
2ea. 8 in. O.D. Conflat Special Flange shipped loose for B5A & B6 (V049M196)			

Washington Left Mid Station: Area 200

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- 44"	7200lbs.	5ft.W x 2ft.H x 16ft.L	Shipped to site by vendor
WGV 11- 44"	7200lbs.	5ft.W x 2ft.H x 16ft.L	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	
1ea BSC Clean Rm.	5800 lbs	17 ft.6in.W x 18 ft.8in.L x 18 ft.6in.H	
3 ea. 10 in. gate valves	100 lbs.		
1ea. 14 in. gate valve	350 lbs.		

ATTACHMENT

Number:	Rev.
A V049-2-021	4

12 in. O.D. Conflat Special Flange shipped loose for WA7B-1

(V049M195)

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

Washington Left End Station: Area 400

Tag No.	Shipping Weight	Shipping Dimensions	Onsite Date
WBSC 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- 44"	7200 lbs.	5ft.W x 2ft.H x 16ft.L	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	
1ea BSC Clean Rm.	5800 lbs	17 ft.6in.W x 18 ft.8in.L x 18 ft.6in.H	
2 ea. 10 in. gate valves			
1ea. 14 in. gate valve	350 lbs.		
12 in. O.D. Conflat Special Flange shipped loose for WA7B-2 (V049M195)			

Washington Right Mid Station: Area 300

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- 44"	7200 lbs.	5ft.W x 2ft.H x 16ft.L	Shipped to site by vendor
WGV 15- 44"	7200 lbs.	5ft.W x 2ft.H x 16ft.L	Shipped to site by vendor
WIP 10	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	
1ea BSC Clean Rm.	5800 lbs	17 ft.6in.W x 18 ft.8in.L x 18 ft.6in.H	
3 ea. 10 in. gate valves			

ATTACHMENT

Number:	Rev.
A V049-2-021	4

1ea. 14 in. gate valve 350 lbs.

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

Washington Right End Station: Area 500

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	
WA-7B2/WA-1F	6500 lbs.	80 in. OD x 19 ft.L	
WDW 8	40400 lbs.	10 ft. dia. X 40 ft.L	
WGV 20- 44"	7200 lbs.	5ft.W x 2ft.H x 16ft.L	Shipped to site by vendor
WIP 12	1400 lbs.	4 ft. L x 4 ft. L x 4 ft. W	
1ea BSC Clean Rm.	5800 lbs	17 ft.6in.W x 18 ft.8in.L x 18 ft.6in.H	
2 ea. 10 in. gate valves	100 lbs.		
1ea.14 in. gate valve	350 lbs.		

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.
A V049-2-021	4

ATTACHMENT "K"

TO

V049-2-021

FABRICATED CLASS 100 VACUUM AND AIR PIPING

V049-2-178

(LIGO-E970134-01-V)

ATTACHMENT

Number:

A V049-2-021

Rev.

4

Title: SPECIFICATION FOR PREFABRICATED VACUUM AND CLASS 100 AIR PIPING

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. Williams

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.

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
1	REC 9/5/97	R 2/3 9/5/97	REISSUED FOR CONSTRUCTION DEO# 6548 ADDED SECTION 3.2
Ø	MSE 10/15/97	REC 7/2/97	RELEASED FOR CONSTRUCTION PER DEO# 0535
P1	REC 12/20/96	12/20/96	ISSUED FOR QUOTES DEO 0393

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number
	REC	12/20/96	<i>[Signature]</i>	12/20/96	V049-2-178
					Rev. 1

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

SPECIFICATION

Number:	A V049-2-178	Rev.	1
---------	---------------------	------	---

1.0 PURPOSE

This specification defines the scope of work to be provided by the contractor for the supply of the 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, clean 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

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

3.2 All flex sections are to meet the following requirements:

Note: Flex sections are intended to act as vibration/sound isolators.

3.2.1 Vacuum and Class 100 Air Headers

Flex sections are to be vacuum compatible stainless steel, with full penetration welds, low stiffness bellows without metal braids.

All flex sections are to be cleaned, tested and packaged for UHV service, as manufactured by A&N Corp., Varian Vacuum Products or approved equal.

3.2.2 Cooling Water Supply / Return and Instrument Air Headers

Flex sections are to be Safeflex SFU-CT as manufactured by Mason Industries or approved equal.

SPECIFICATION

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

Rev. **1**

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 shown on the piping drawings. Branches shall terminate in fittings as designated on the P&I Diagrams. Blind flanges shall be provided as indicated including gaskets and hardware. Where ISO Quick flanges are designated on piping drawings, use 304 stainless steel centering rings with Viton o-rings. 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 leaks with a helium mass spectrometer at a sensitivity of 1×10^{-9} torr l/s. Spools shall be given unique serial numbers (1 to xx) to control testing documentation.
- 4.4 Each spool section shall be pressure washed with hot water using approved detergent (Oakite Inpro-Clean 1300)* and then rinsed with de-ionized 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 or visible particles 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 1300 in solution.

NOTE: This cleaning requirement also applies to contractor provided spools of piping, materials used between Class 100 Air Compressors and stainless steel O.D. tubing air headers.
- 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

SPECIFICATION	
Number: A V049-2-178	Rev. 1

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

Washington

For Drawing Revision level see Gen. Doc. List

Dwg. V049-0-000

DRAWING SIZE DOCUMENT NUMBER

	DRAWING SIZE	DOCUMENT NUMBER
P&ID's	D	
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

SPECIFICATION

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

Rev.
1

Title: FABRICATED CLASS 100 VACUUM AND AIR PIPING-LIGO WASHINGTON SITE

QTY Washington

For Drawing Revision level see Gen. Doc. List **DRAWING SIZE DOCUMENT NUMBER**
 Dwg. V049-0-000

MECHANICAL DRAWINGS

6	25 L/S Annulus Tubing-44" G.V. Type III	C	V049-4-106
2	25 L/S Annulus Tubing 48" G.V. Type I	C	V049-4-108
8	Annulus Tubing & Ion Pump Assembly. 44" G.V.	D	V049-4-109
2	25 L/S Annulus Tubing 48"G.V. Type II	C	V049-4-110
2	25 L/S Annulus Tubing - 44" G.V. Type I	C	V049-4-164
4	Annulus Tubing & Ion Pump Assy 48" G.V.	D	V049-4-165
8	25 L/S Annulus Tubing - 44" G.V. Type II	C	V049-4-166
-	Left & Right Beam Manifold Annulus Headers	D	V049-5-012
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		

SPECIFICATION

Number: A V049-2-178	Rev. 1
-----------------------------	---------------

Title: FABRICATED CLASS 100 VACUUM AND AIR PIPING-LIGO WASHINGTON SITE

Washington

For Drawing Revision level see Gen. Doc. List

DRAWING SIZE DOCUMENT NUMBER

Dwg. V049-0-000

MECHANICAL DRAWINGS

Equipment Arr't. Plan, Corner Station WA Sht 1 of 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 (2 Shts)	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
Piping Arr't Elevation Left Mid Station/WA (2 Sheets)	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

SPECIFICATION

Number: A V049-2-178	Rev. 1
-----------------------------	-----------

ATTACHMENT "B"

TO

V049-2-178

SPECIFICATION FOR PIPING AND MATERIAL FOR LIGO VACUUM EQUIPMENT

V049-2-037

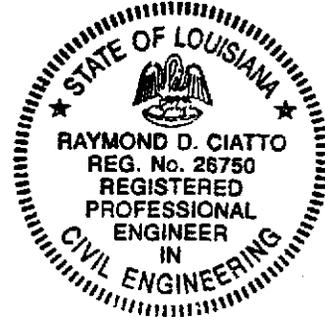
ATTACHMENT	
Number: A V049-2-178	Rev. <i>Ø</i>

Title:

SPECIFICATION FOR PIPING DESIGN AND MATERIAL

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

Hanford, Washington
And
Livingston, Louisiana



EX-105 8/5/99

7/21/97

PROCESS ENGINEER: Robert Than
 PROJECT ENGINEER: S. Moten
 CIVIL/STRUC. ENGINEER: R. D. Ciatto
 MANUFACTURING ENGINEER: Phillip Falco
 QUALITY ASSURANCE ENGINEER: Alan S. Bucklow
 PROJECT MANAGER: Tom Byg

REV LTR	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
5	DM 1/14/97	D.M.W 1-18-97	Clarified 1B1 flange/gasket requirements DEO # 0411
4	REL 11/27/96	D.M.W 11-28	Revised T3 CLASS, MAT'L TO BE 304S/S, IT WAS 304L. DEO 0369
3	DM 10/16/96	D.M.W 10-17-96	Added "C2", Spec. shrt for cryogenic copper lines. Revised 1B1-FLANGES DEO # 0317
2	REL 8/24/96	PH/PEB 8/28/96	Revised "T4" SPEC. SH7.17, 17BMS. DEO 249 RELEASED FOR PURCHASE
1	REL 7/25/96	RES 8/13/96	Revised "T4" SPEC. SH7.17 RELEASED FOR PURCHASE DEO # 0236
0	REL 1-19-96	D.M.W	RELEASED FOR DESIGN & QUOTES DEO # 0044

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

Title:

SPECIFICATION FOR PIPING DESIGN AND MATERIAL

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

SPECIFICATION

Number **A** V049-2-037

Rev. **5**

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

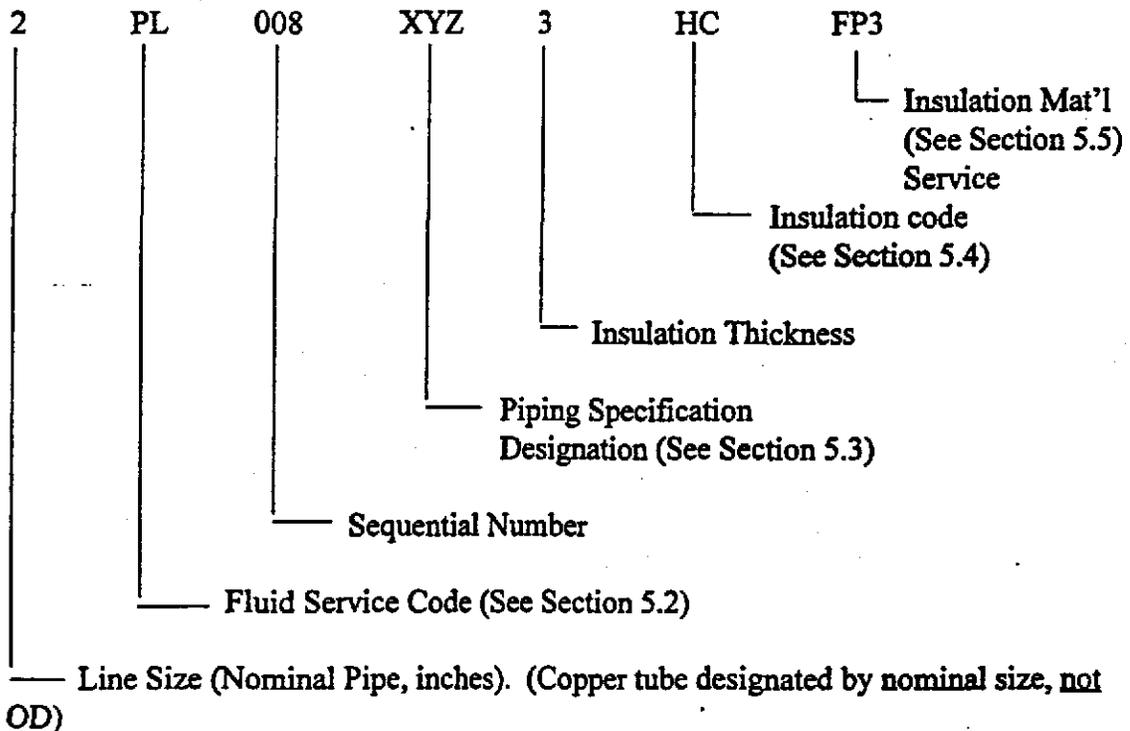
3.1 All materials used to manufacture the piping, tubing, flanges or fittings, as designated per this specification, are to be of U.S.A. origin and manufacture.

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:



SPECIFICATION

Number **A** V049-2-037

Rev. **5**

Number

Rev.

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

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

Number

Rev.

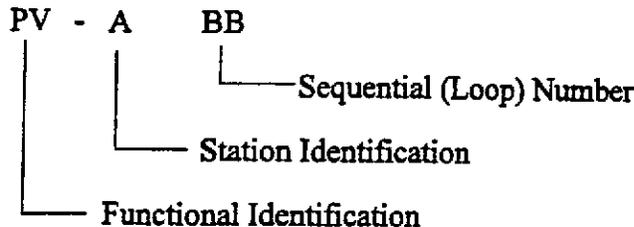
5.5 Insulation Material Codes

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

SPECIFICATIONNumber **A** V049-2-037Rev. **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 SSTL
Design Conditions:
Pressure 0 to 192 psig
Temperature -320°F to 350°F
Corrosion Allowance Zero

Pipe:
12" and smaller ASTM A312 TP304

Pipe Schedule:
1 1/2" and smaller Schedule 10S SMLS
8" and smaller Schedule 10S SMLS or EFW
10" thru 12" Schedule 10S EFW

Note: Vacuum jacketed piping will be designed and fabricated in accordance with the manufacturer's standard, and PSI spec. V049-2-016.

Fittings:
1 1/2" and smaller Socket Welded 3000#
2" and larger Butt Weld
ASTM A403 WP304 WPS, WPW
O'Let's ASTM A182-F304

Flanges: Not allowed, except on atmospheric vent lines as indicated on P&ID's. 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:

<u>Run Size "</u>												
½	04											
¾	06	04										
1	12	06	04									
1½	05	05	06	04								
2	05	05	06	06	04							
3	05	05	05	05	06	04						
4	05	05	05	05	12	06	04					
6	05	05	05	05	12	12	06	04				
8	05	05	05	05	12	12	12	06	04			
10	05	05	05	05	12	12	12	12	06	04		
12	05	05	05	05	12	12	12	12	12	06	04	
Branch Size	½	¾	1	1½	2	3	4	6	8	10	12	

04 - Tee
 05 - Sockolet
 06 - Tee Then Reducer or Reducing Tee
 12 - BW O'let

SPECIFICATION

Number **A** V049-2-037

Rev. **5**

Number

Rev.

Title

SPECIFICATION FOR PIPING DESIGN AND MATERIAL

1B2

PIPING DESIGN AND MATERIAL SPECIFICATION

Service: Non-Cryogenic - Clean

Primary Rating: 150# ANSI 304 SSSL

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.

SPECIFICATION

Number **A** V049-2-037

Rev. **5**

Number

Rev.

Title

SPECIFICATION FOR PIPING DESIGN AND MATERIAL

1B2

Branch Connections:

Run Size "												
½	04											04 - Tee
¾	06	04										05 - Sockolet
1	12	06	04									06 - Tee Then
1½	05	05	06	04								Reducer or
2	05	05	06	06	04							Reducing Tee
3	05	05	05	05	06	04						12 - BW O'let
4	05	05	05	05	12	06	04					
6	05	05	05	05	12	12	06	04				
8	05	05	05	05	12	12	12	06	04			
10	05	05	05	05	12	12	12	12	06	04		
12	05	05	05	05	12	12	12	12	12	06	04	
Branch Size	½	¾	1	1½	2	3	4	6	8	10	12	

Note:

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

Tube Size (OD):	Minimum Wall Thickness (Inches)
------------------------	--

1/4"	0.035"
3/8"	0.035"
1/2"	0.049"
3/4"	0.049"
1"	0.065"

Fittings: All Fittings to be Parker Weld tube fittings SA479 or ASTM A276 GR TP316 and ASTM A182 GR TP316, or equal.

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

Note:

1. Tubing to be internally cleaned, 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.

SPECIFICATION

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

Number

Rev.

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

Tube Size (OD):	Minimum Wall Thickness (Inches)
------------------------	--

1/4"	0.035"
3/8"	0.035"
1/2"	0.049"
3/4"	0.049"
1"	0.065"

Fittings: All Fittings to be Parker A-LOK tube fittings SA479 or ASTM A276 GR TP316 and ASTM A182 GR TP316 or equal.

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

Note:

1. Tubing to be internally cleaned, 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.

SPECIFICATION

Number	A	V049-2-037
--------	---	------------

Rev.	5
------	---

Number

Rev.

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**

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
--------	----------	------------	------	----------

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**

Number
Rev.

Title

SPECIFICATION FOR PIPING DESIGN AND MATERIAL

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

V049-2-037

Rev.

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.

SPECIFICATION

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

Number
Rev.

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:					SPECNO: V049-2-037
TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:
						Inspector:
VENDOR Q.A. PLAN			X	2	X	
CLEANING PROCEDURE			X	2	X	
PREP FOR SHIPMENT PROCEDURE			X	2	X	
CERTIFICATE OF COMPLIANCE				2	X	

V049-2-002
 Rev. 15
 Pg. 20
 SPEC V049-2-037

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. Stan
 PROCESS ENGINEER: Robert Thum
 QUALITY ASSURANCE: Alan L. Bradburn
 TECHNICAL DIRECTOR: D. C. McWilliam
 PROJECT MANAGER: Paul 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
2	DEC 07/10/97	D. McW 7-10-97	REVISED FOR PURCHASE TO ADD QTY. 12 - 1/2" VALVES DEO 0520
1	TMS 9-25-96	D. McW 9-26-96	REVISED FOR PURCHASE PER DEO 0274
0	TMS 3-1-96	D. McW 2-5-96	RELEASED FOR QUOTE PER DEO 077

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

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.

SPECIFICATION		
Number		Rev.
A	V049-2-060	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*

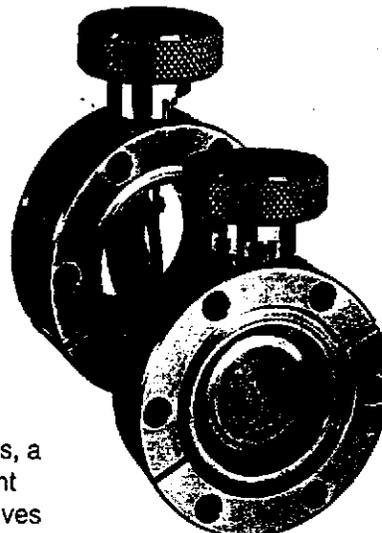
DESCRIPTION

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.

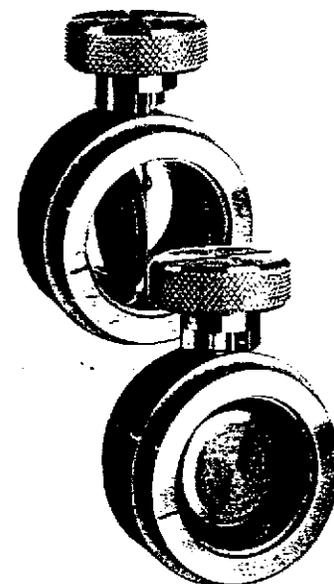
These quick-acting Butterfly Valves feature an improved sealing action. The opening in the body of the valve has been machined at a slight angle to the plane of the flapper. The flapper is set to rotate slightly off-center. On closure, this causes the sealing pressure to be applied more uniformly all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



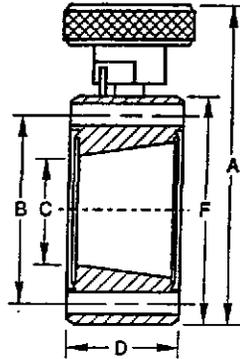
Del-Seal Flange
BFV-150



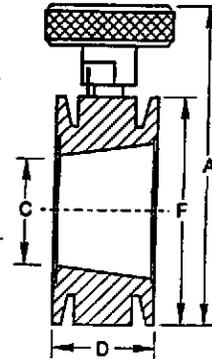
Kwik-Flange Flange
KBFV-150

Butterfly Valves

Toll Free Outside CA 1-800-443-8817



Del-Seal Flange



Kwik-Flange Flange

ORDERING INFORMATION

Please order by Part Number

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

Dimensions are in inches



ATTACHMENT "D"

TO

V049-2-178

SPECIFICATION FOR SMALL VACUUM VALVES

V049-2-059

ATTACHMENT

Number:

A V049-2-178

Rev.

Title: SPECIFICATION FOR SMALL VACUUM VALVES

SPECIFICATION FOR
SMALL VACUUM VALVES
FOR
LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Thomas M. Stern

PROCESS ENGINEER: Roberto Thom.

QUALITY ASSURANCE: Alenwood Bealbrook

TECHNICAL DIRECTOR: D. O. W. W. Alessis

PROJECT MANAGER: Burke 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.

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

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

Title

SPECIFICATION FOR SMALL VACUUM VALVES

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 1×10^{-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

V049-2-059

Rev.

1

Number

Rev.

Title

SPECIFICATION FOR SMALL VACUUM VALVES

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.

SPECIFICATION

Number

A

Rev.

1

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.

4

Page ___ of ___

ATTACHMENT "M"

**TO
V049-2-021**

CONCRETE ANCHOR INSTALLATION PROCEDURE

V049-1-101
(LIGO-E970139-02-V)

ATTACHMENT

Number:

A V049-2-021

Rev.

4

Page | of |



Title: PROCEDURE FOR INSTALLATION OF CONCRETE ANCHORS



PROCEDURE FOR
 INSTALLATION OF CONCRETE ANCHORS
 FOR
 LIGO VACUUM EQUIPMENT

Hanford, Washington

PREPARED BY:

R. D. Ciatto

INSTALLATION MANAGER:

David M. [Signature]

QUALITY ASSURANCE:

Allen T. 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.

2	REV. 55001.97	RES 9/5/97	RE-RELEASED FOR CONSTRUCTION DEO# 0548
1	REV. 55001.97	RES 7/13/97	RELEASED FOR CONSTRUCTION PER DEO# 0537
0	-	-	ISSUED PER DEO 138 FOR 2012

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE		
PROCESS SYSTEMS INTERNATIONAL, INC.			PROCEDURE		
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number V049-1-101
	DOC	4/26/96	RES	4/26/96	Rev. 2

Title: CONCRETE ANCHOR INSTALLATION PROCEDURE

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:	Rev.
A V049-1-101	2

Title: CONCRETE ANCHOR INSTALLATION PROCEDURE

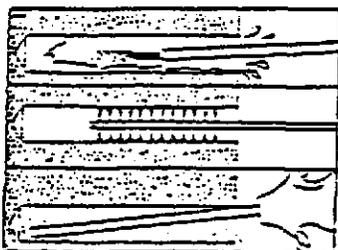
- 4.2 Critical equipment shall be aligned per procedures V049-2-021 section 8.3 and V049-2-174 prior to drilling the anchor bolt hole. Critical equipment anchor bolt requirements are detailed in attachment A of this specification.
- 4.3 Locate and install anchor bolts in accordance with the this specification and the equipment 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 Dwg. V049-4-423 shows the threaded rod installation
- 4.5 Adhere to curing time required by Hilti before loading or disturbing anchors.
- 4.6 Prior to placing grout, tighten nuts the following torque:

3/4" rod - 175 ft.lbs.

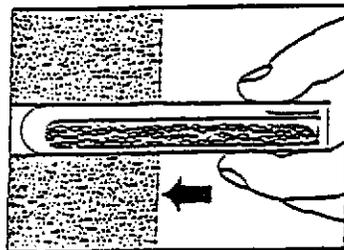
1" rod - 375 ft.lbs.

- 4.7 Step by step instructions:

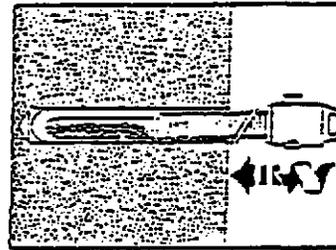
Installation Instructions (HAS Threaded Rod — Option #1)



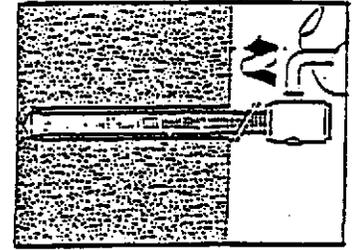
1. Set the drill depth gauge and drill the hole to the required hole depth. **IMPORTANT:** Clear out dust and fragments preferably using a jet of water or compressed air and a wire brush. The hole may be camo, but the water should be blown out.



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.

SPECIFICATION	
Number:	Rev.
A V049-1-101	2

**ATTACHMENT "A" TO V049-1-101
REQUIRED CONCRETE ANCHORS FOR VACUUM EQUIPMENT**

Component Tag No.	Anchor Diameter	Rod Length	Minimum Embedment Depth	Notes
WBSC1	1"	14 1/8"	8 1/4"	12
WBSC2	1"	14 1/8"	8 1/4"	12
WBSC3	1"	14 1/8"	8 1/4"	12
WBSC4	1"	14 1/8"	8 1/4"	12
WBSC5	1"	14 1/8"	8 1/4"	
WBSC6	1"	14 1/8"	8 1/4"	
WBSC7	1"	18 1/4"	12 3/8"	2,8
WBSC8	1"	18 1/4"	12 3/8"	2,8
WBSC9	1"	14 1/8"	8 1/4"	3,8
WBSC10	1"	14 1/8"	8 1/4"	3,8
WHAM1	1"	15"	8 1/4"	4
WHAM2	1"	14 1/8"	8 1/4"	
WHAM3	1"	14 1/8"	8 1/4"	
WHAM4	1"	14 1/8"	8 1/4"	
WHAM5	1"	14 1/8"	8 1/4"	
WHAM6	1"	14 1/8"	8 1/4"	4
WHAM7	1"	14 1/8"	8 1/4"	4
WHAM8	1"	14 1/8"	8 1/4"	
WHAM9	1"	14 1/8"	8 1/4"	
WHAM10	1"	14 1/8"	8 1/4"	
WHAM11	1"	14 1/8"	8 1/4"	
WHAM12	1"	14 1/8"	8 1/4"	4
WHAM13	Spare			
WCP1	1"	18 1/4"	12 3/8"	9
WCP2	1"	18 1/4"	12 3/8"	9
WCP3	1"	18 1/4"	12 3/8"	9
WCP4	1"	18 1/4"	12 3/8"	9
WCP5	1"	18 1/4"	12 3/8"	9
WCP6	1"	18 1/4"	12 3/8"	9
WCP7	1"	18 1/4"	12 3/8"	9
WCP8	1"	18 1/4"	12 3/8"	9
WGV1	3/4"	12 1/2"	6 5/8"	6
WGV2	3/4"	12 1/2"	6 5/8"	6
WGV3	3/4"	12 1/2"	6 5/8"	6
WGV4	3/4"	12 1/2"	6 5/8"	6

ATTACHMENT	
Number: A V049-1-101	Rev. 2

Title: INSTALLATION OF CONCRETE ANCHORS

Component Tag No.	Anchor Diameter	Rod Lenth	Minimum Embedment Depth	Notes
WGV5	3/4"	12 1/2"	6 5/8"	7
WGV6				5
WGV7	3/4"	12 1/2"	6 5/8"	7
WGV8				5
WGV9				5
WGV10	3/4"	12 1/2"	6 5/8"	7
WGV11	3/4"	12 1/2"	6 5/8"	7
WGV12				5
WGV13				5
WGV14	3/4"	12 1/2"	6 5/8"	7
WGV15	3/4"	12 1/2"	6 5/8"	7
WGV16				5
WGV17	3/4"	12 1/2"	6 5/8"	7
WGV18	3/4"	12 1/2"	6 5/8"	7
WGV19				5
WGV20	3/4"	12 1/2"	6 5/8"	7
WA-7A	1"	14 1/8"	8 1/4"	
WB-1A	1"	14 1/8"	8 1/4"	11
WB-1B	1"	14 1/8"	8 1/4"	11
WB-2A	1"	14 1/8"	8 1/4"	11
WB-2B	1"	14 1/8"	8 1/4"	11
WB-3A	1"	14 1/8"	8 1/4"	11
WB-5A	1"	14 1/8"	8 1/4"	11
WB-6	1"	18 1/4"	12 3/8"	8
WB-7	1"	18 1/4"	12 3/8"	8
WB-9A	1"	14 1/8"	8 1/4"	13
WB-9B	1"	14 1/8"	8 1/4"	13
WBE-5	1"	14 1/8"	8 1/4"	
WBE-6	1"	14 1/8"	8 1/4"	
Pipe Bridge	3/4"	9 3/4"	6 5/8"	10

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. Adjust rod lenth accordingly.
4. Use 12 3/8" minimum embedment for the four anchors at the end of the arm. Adjust rod lenth accordingly.
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. Scarify floor.
9. Use Hilti HAS Super Threaded Rod with 12 3/8" embedment for all baseplates. Scarify floor.
10. No grout pad. Shim if necessary.
11. Scarify floor at baseplates connected to diagonal members.
12. Scarify floor.
13. Use Hilti HAS Super Threaded Rod for baseplates connected to diagonal members. Scarify floor for these baseplates.

ATTACHMENT	
Number:	Rev.
A V049-1-101	2

ATTACHMENT "N"
TO
V049-2-021
EQUIPMENT SHIPPING, HANDLING AND RIGGING PROCEDURES
VO49-2-123
(LIGO-C971838-01-V)

ATTACHMENT

Number:

A V049-2-021

Rev.

4



Title: COMPONENT PACKAGING, HANDLING AND SHIPPING

COMPONENT PACKAGING, HANDLING AND SHIPPING

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington

PREPARED BY: DAVID EVANS / REB
MANUFACTURING ENGR: N/A
QUALITY ASSURANCE: ALAN BRADBROOK / REB
TECHNICAL DIRECTOR: D. A. McWilliams
PROJECT MANAGER: Richard 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 / BTK / REB	7/18/97	RELEASED FOR CONSTRUCTION PER REQ # 0526
0		D.E. 5/6/96	REB 5/6/96	RELEASE PER DRG 176

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION		
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number	Rev.
	D.E.	5/6/96	REB	5/6/96	A V049-2-123	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

Title: COMPONENT PACKAGING, HANDLING AND SHIPPING

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 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**

Title: COMPONENT PACKAGING, HANDLING AND SHIPPING

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.

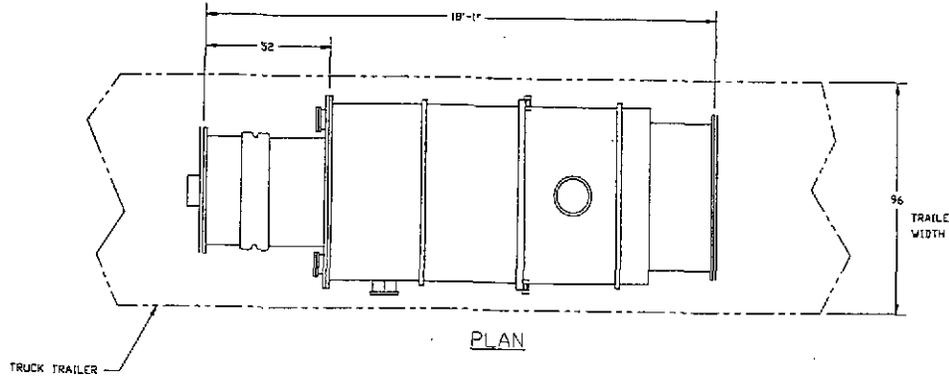
Special shipping instructions such as "USE SPREADER BAR WHEN LIFTING" or shipping weight should be painted in the proper places and detailed instructions attached to the vessel if applicable. (See Attachments).

SPECIFICATION

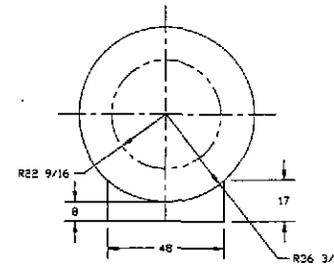
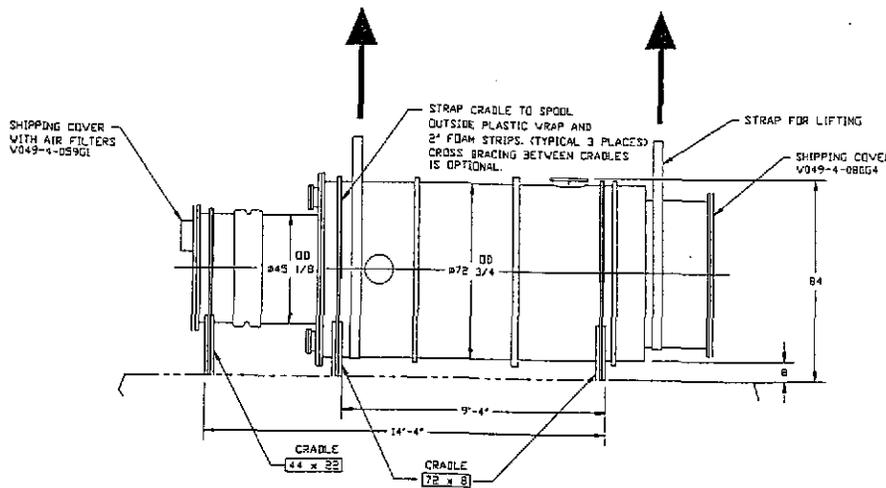
Number:	A V049-2-123	Rev.	1
---------	--------------	------	---

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 SHRINK WRAPPED WITH 2 LAYERS
OF 6 MIL POLYETHYLENE.
4. VESSEL TO BE MOUNTED ON TRAILER IN
ORIENTATION SHOWN.
5. TIGHTEN BELLOWES THE 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.



SHG 5 OF 14
SHIPPING WEIGHT 6600# EA

QTY	DESCRIPTION	REV	DATE	ISSUE DESCRIPTION
1	SHIPPING CRITERIA	1	6/20/97	ISSUED FOR SHIPPING
1	LIGO VACUUM EQUIPMENT	1	6/20/97	ISSUED FOR SHIPPING
1	SHIPPING SPOOL A-1/A-7A	1	6/20/97	ISSUED FOR SHIPPING
1	SHIPPING SPOOL A-1/A-7B	1	6/20/97	ISSUED FOR SHIPPING

QTY	DESCRIPTION	REV	DATE	ISSUE DESCRIPTION
1	SHIPPING CRITERIA	1	6/20/97	ISSUED FOR SHIPPING
1	LIGO VACUUM EQUIPMENT	1	6/20/97	ISSUED FOR SHIPPING
1	SHIPPING SPOOL A-1/A-7A	1	6/20/97	ISSUED FOR SHIPPING
1	SHIPPING SPOOL A-1/A-7B	1	6/20/97	ISSUED FOR SHIPPING

QTY	DESCRIPTION	REV	DATE	ISSUE DESCRIPTION
1	SHIPPING CRITERIA	1	6/20/97	ISSUED FOR SHIPPING
1	LIGO VACUUM EQUIPMENT	1	6/20/97	ISSUED FOR SHIPPING
1	SHIPPING SPOOL A-1/A-7A	1	6/20/97	ISSUED FOR SHIPPING
1	SHIPPING SPOOL A-1/A-7B	1	6/20/97	ISSUED FOR SHIPPING

PROCESS SYSTEMS INTERNATIONAL INC.
25 WALTON DR. WILMINGTON, MASSACHUSETTS 01897 USA

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

QTY: 1
REV: 1
DATE: 6/20/97
ISSUE DESCRIPTION: ISSUED FOR SHIPPING

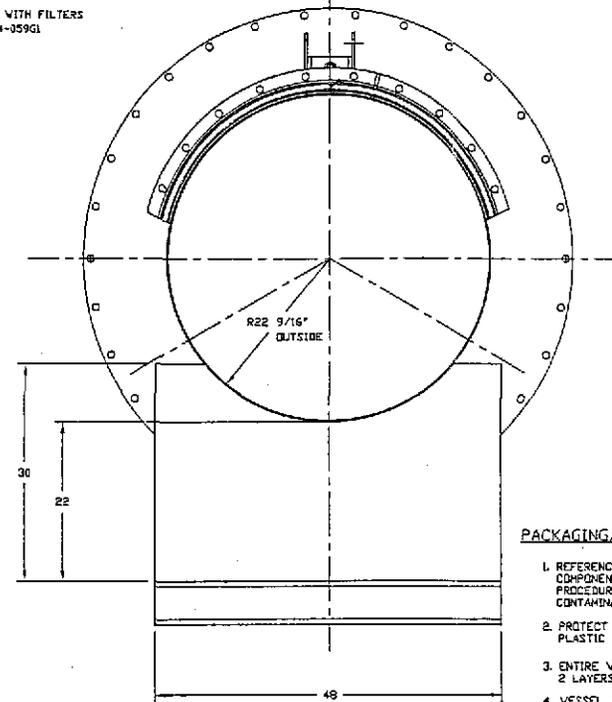
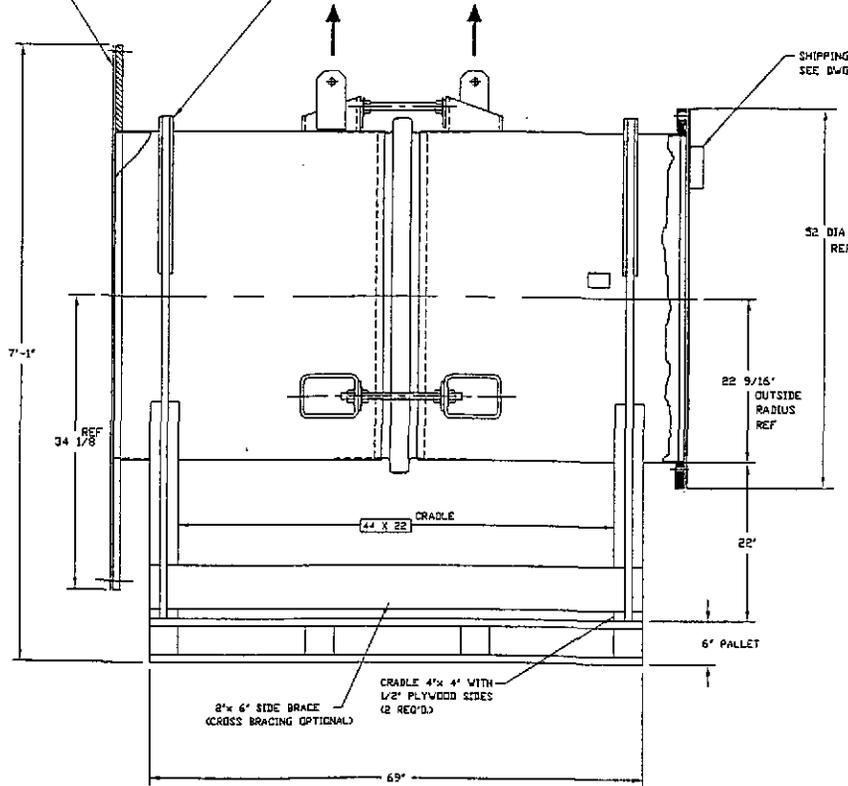
SCALE: 1/2"=1'-0"

SHIPPING COVER
SEE DWG V049-4-080G4

STRAP CRABLE TO SPOOL
OUTSIDE PLASTIC WRAP AND
2" FOAM STRIPS (TYPICAL 2 PLACES)

SHIPPING COVER WITH FILTERS
SEE DWG V049-4-059G1

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
TRAILER 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.

SHT 8 OF 14

APPROX. WEIGHT: 1688#

PROPRIETARY AND CONFIDENTIAL

THIS DOCUMENT CONTAINS PROPRIETARY
INFORMATION BELONGING TO PROCESS
SYSTEMS INTERNATIONAL, INC. NO PART
HEREOF IS TO BE DISCLOSED OR
REPRODUCED IN ANY MANNER WITHOUT
THE WRITTEN PERMISSION OF PROCESS
SYSTEMS INTERNATIONAL, INC. THIS
DOCUMENT IS THE PROPERTY OF PROCESS
SYSTEMS INTERNATIONAL, INC. AND SHALL
REMAINE UNCLASSIFIED.

ISSUE CHANGES

REVISIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED
DRAWING IS TO BE MADE UP
ON 11" X 17" SHEET. ALL DIMENSIONS
ARE TO BE MADE UP ON 11" X 17"
SHEET UNLESS OTHERWISE SPECIFIED.
ALL DIMENSIONS ARE TO BE MADE
UP ON 11" X 17" SHEET UNLESS
OTHERWISE SPECIFIED.

DO NOT SCALE THIS DRAWING

USED ON

NEXT ASS'Y

REV 6 ISSUED FOR SHIPPING

DATE 6/20/97

BY [Signature]



PROCESS SYSTEMS INTERNATIONAL, INC.
30 WILSON ST., WESTPORT, MASSACHUSETTS 01886 USA

ADAPTER A-14
SHIPPING ASSY.
LIGGO VACUUM EQUIPMENT

Q&P FILE V0494229

REV 0

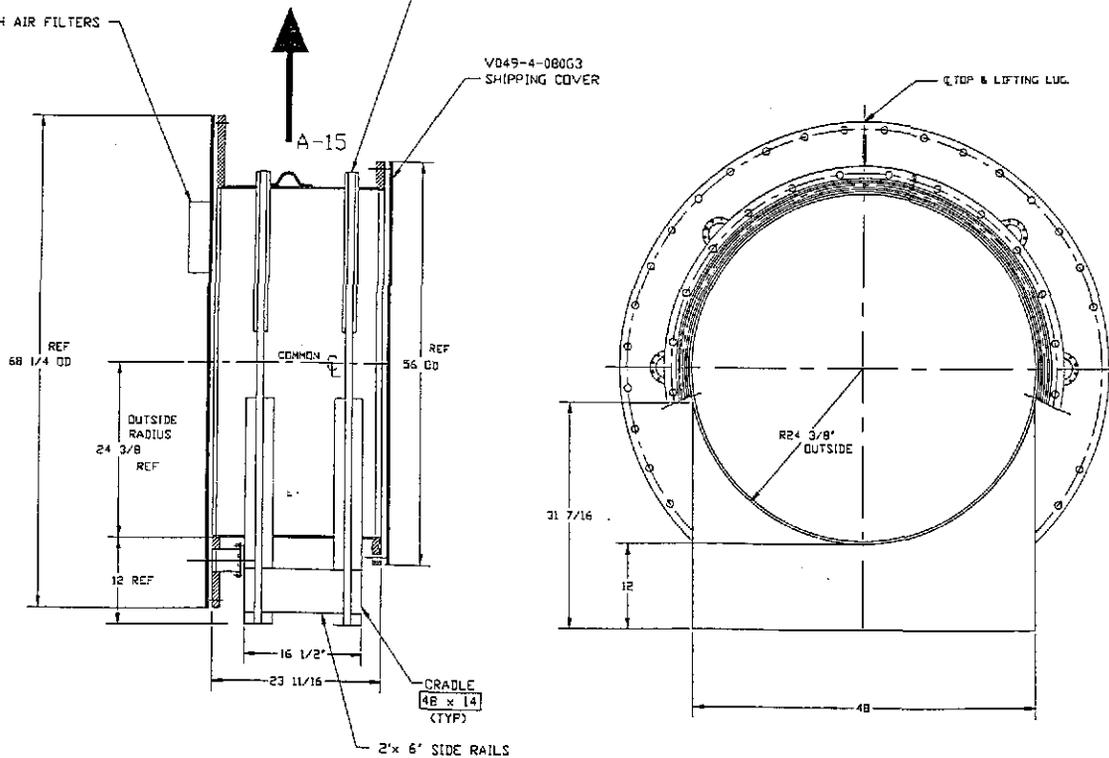
DATE 1-1/2" x 1"

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



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
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	WARRANTY RESERVE SPECIES	REV	DESCRIPTION	DATE	BY	CHKD	DATE	BY	CHKD	DATE	BY
□		FLATNESS	THRESHOLD: .002 IN DEPTH TOLERANCE: FRACTIONAL: .002										
○		CYLINDRICITY	MAXIMUM: .002 IN DIA THREE PLACE DECIMAL: .002										
//		PARALLELISM	THREE PLACE DECIMAL: .002										
⊥		PERPENDICULARITY	THREE PLACE DECIMAL: .002										
∠		ANGULARITY	DO NOT SCALE THIS DRAWING										
⊕		TRUE POSITION	USED ON:	0	ISSUED FOR SHIPPING								
○		CONDUCTIVITY	NEXT ASS'Y:										

SYMBOL	DESCRIPTION	REV	DATE	BY	CHKD	DATE	BY

SYMBOL	DESCRIPTION	REV	DATE	BY	CHKD	DATE	BY

SYMBOL	DESCRIPTION	REV	DATE	BY	CHKD	DATE	BY

SYMBOL	DESCRIPTION	REV	DATE	BY	CHKD	DATE	BY

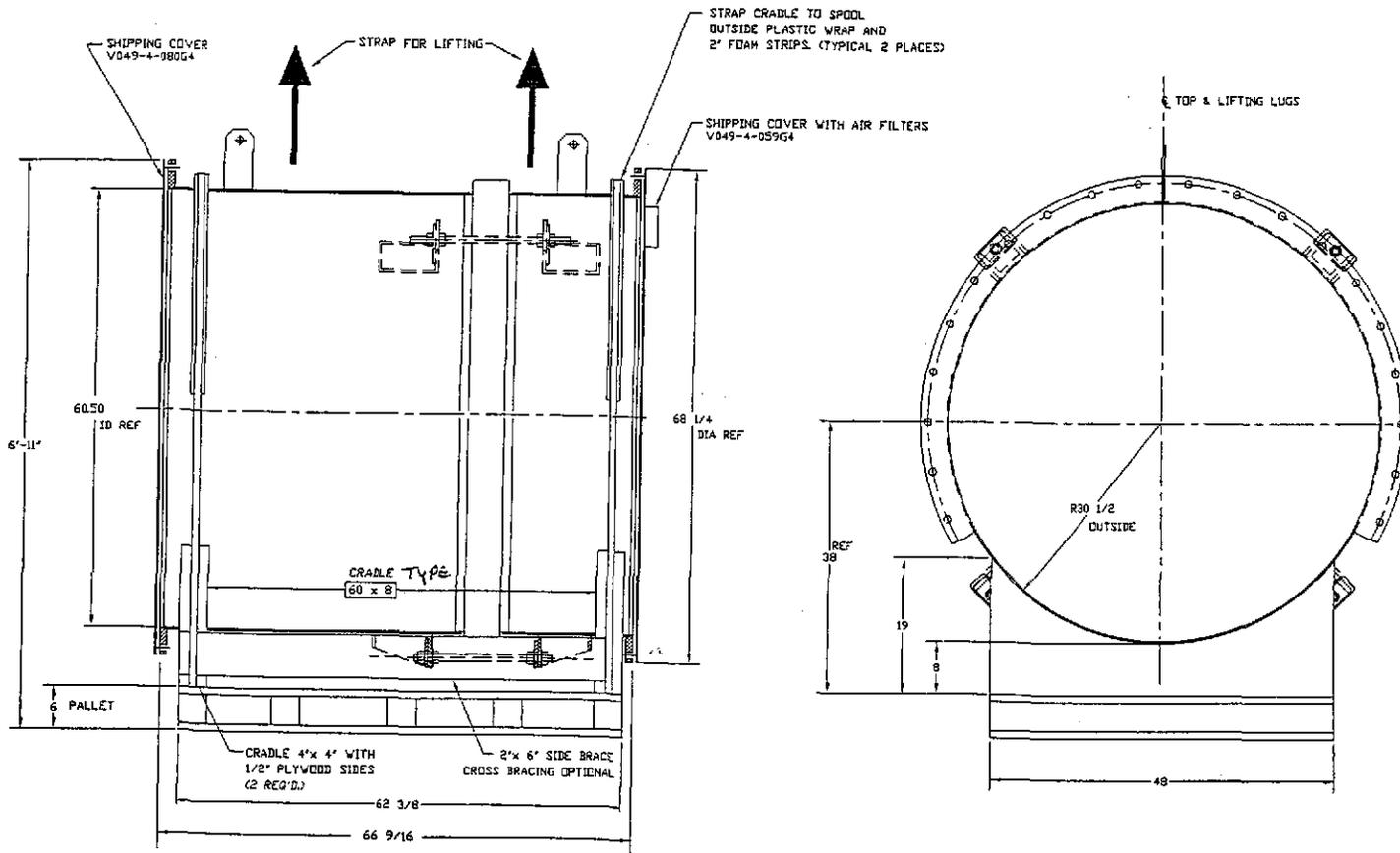
SYMBOL	DESCRIPTION	REV	DATE	BY	CHKD	DATE	BY

PROCESS SYSTEMS INTERNATIONAL, INC.
20 KENNEDY DRIVE, WESTBOROUGH, MASSACHUSETTS 01581 USA

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

DATE FILED: V049-230
REV: 0
PAC NO: V049-4-230
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. 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 VITAL EQUIPMENT.

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

SHT100=14

APPROX. WEIGHT: 1386#

UNCLASSIFIED AND CONFIDENTIAL
NO PERSON OR ENTITY REPRESENTING
INFORMATION RELAYING TO PROCESS
SYSTEMS INTERNATIONAL, INC. OR ITS
AFFILIATED COMPANIES AND SHALL BE
USED ONLY FOR THE PURPOSES FOR
WHICH IT WAS SUPPLIED. IT SHALL NOT
BE COPIED, REPRODUCED OR OTHERWISE
TRANSMITTED IN ANY MANNER, ELECTRONIC
OR MECHANICAL, INCLUDING PHOTOCOPYING,
RECORDING OR BY ANY INFORMATION
SYSTEMS WITHOUT THE WRITTEN
CONSENT OF PROCESS SYSTEMS
INTERNATIONAL, INC. AND SHALL BE
RETURNED UPON REQUEST.

SYMBOL	CHARACTERISTIC	UNLESS OTHERWISE SPECIFIED	ISSUED FOR SHIPPING
∠	FLATNESS	INDICATED ARE IN INCHES	
⊙	CIRCULARITY	INDICATED ARE IN INCHES	
∥	PARALLELISM	INDICATED ARE IN INCHES	
⊥	PERPENDICULARITY	INDICATED ARE IN INCHES	
∠	ANGULARITY	DO NOT SCALE THIS DRAWING	
⊕	TRUE POSITION	USED ON	
⊖	CONCENTRICITY	NEXT ASSY.	

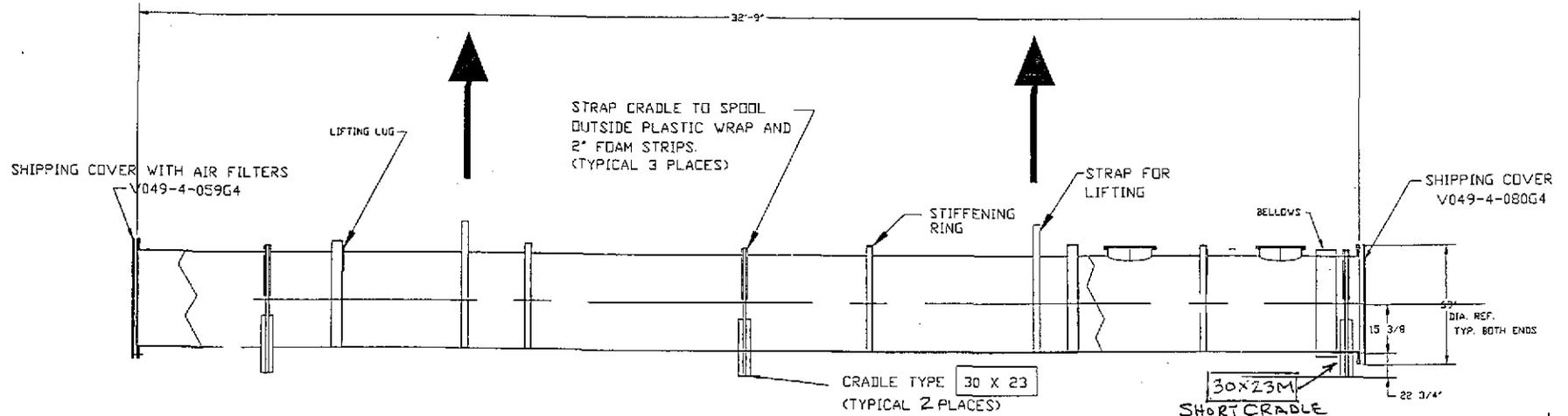
PROCESS SYSTEMS INTERNATIONAL, INC.
30 WILLOW DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

SPOOL BE-2
SHIPPING ASSY.
LTGO VACUUM EQUIPMENT

DATE FILED: 6/20/97 10:43
ISSUE NO: B
DRAWING NO: V049-4-231
REV: 0

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
TRAILER 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.**

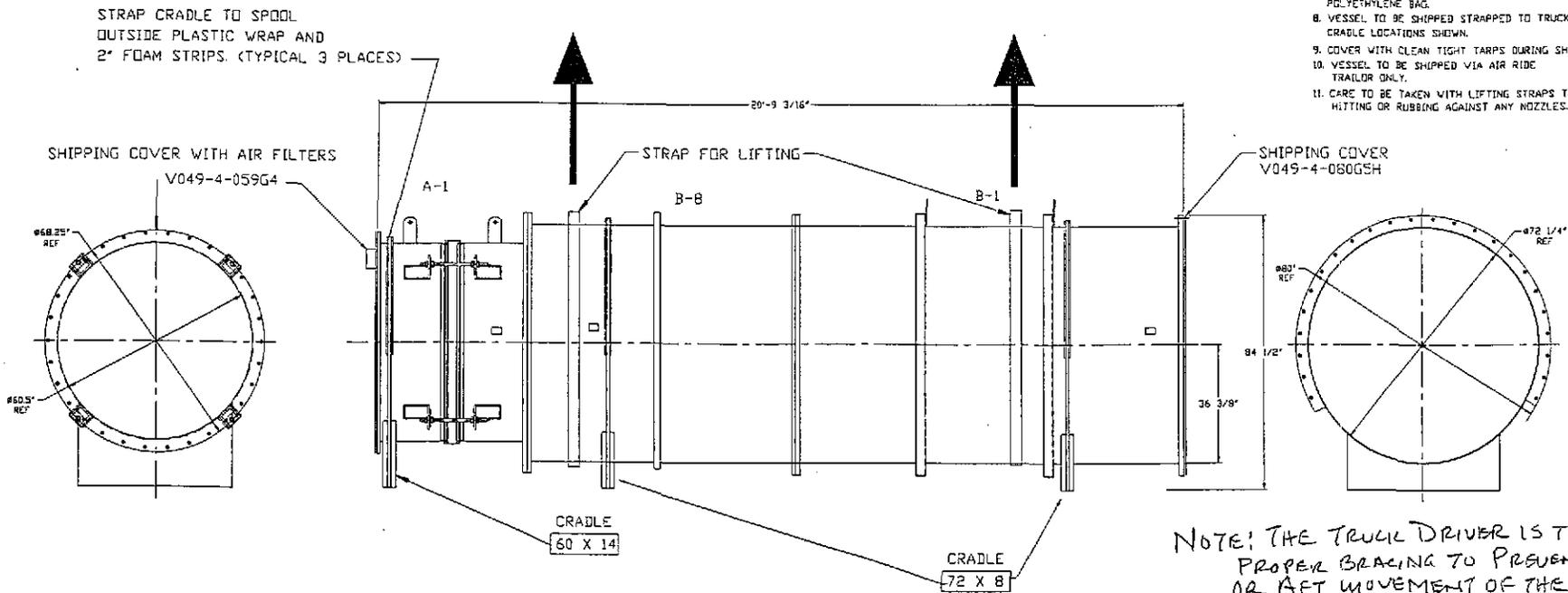
APPROX SHIPPING WEIGHT = 6800 LBS.

SHT 11 OF 14

<p><small>PROPERTY - NO CIRCULATION</small></p> <p><small>THIS DOCUMENT CONTAINS PROPRIETARY INFORMATION BELONGING TO PROCESS SYSTEMS INTERNATIONAL, INC. OR ITS AFFILIATED COMPANIES AND SHALL BE KEPT STRICTLY CONFIDENTIAL FOR THE USE OF THE USER ONLY. IF THIS DOCUMENT IS TO BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, PERMISSION MUST BE OBTAINED FROM PROCESS SYSTEMS INTERNATIONAL, INC. AND SHALL BE RETURNED WITH ORIGINAL.</small></p>		<p><small>UNLESS OTHERWISE SPECIFIED</small></p> <p><small>DIMENSIONS ARE IN INCHES</small></p> <p><small>TOLERANCES</small></p> <p><small>FRACTIONS: ± 0.005 UNLESS OTHERWISE SPECIFIED</small></p> <p><small>DECIMALS: ± 0.005 UNLESS OTHERWISE SPECIFIED</small></p> <p><small>ANGLES: ± 0.005 UNLESS OTHERWISE SPECIFIED</small></p> <p><small>FINISHES: AS SHOWN</small></p> <p><small>UNLESS OTHERWISE SPECIFIED</small></p>		<p><small>DO NOT SCALE THIS DRAWING</small></p> <p><small>USED ON:</small></p> <p><small>NEXT ASSY:</small></p>		<p><small>ISSUED FOR SHIPPING</small></p> <p><small>DATE: 6/18/97</small></p> <p><small>BY: [Signature]</small></p> <p><small>CHKD: [Signature]</small></p> <p><small>DATE: [Signature]</small></p>		<p>PROCESS SYSTEMS INTERNATIONAL, INC. 100 WILSON AVENUE, WILSON, MA 01974</p> <p>SP00LS BEA, B2B, B3A, B5A SHIPPING CRITERIA LIGO VACUUM EQUIPMENT</p> <p>DWG NO: V049-4-232 REV: 0</p>	
DWG. NO.	DESCRIPTION	DWG. NO.	DESCRIPTION	DWG. NO.	DESCRIPTION	DWG. NO.	DESCRIPTION	DWG. NO.	DESCRIPTION
V049-4-001	BEAM SPLITTER CHAMBER ASSEMBLY								
REFERENCE DRAWINGS									

PACKAGING/LIFTING/SHIPPING INSTALLATION

1. REFERENCE DOCUMENTS
COMPONENT PACKAGING, HANDLING, SHIPPING
PROCEDURE - V049-2-123
CONTAMINATION CONTROL PLAN - V049-2-119
2. PROTECT BELLWIS 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 BELLWIS 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: 1463M

SHT. 12 OF 14

PROPERTY AND CONFIDENTIAL

THIS DRAWING IS THE PROPERTY OF
PROCESS SYSTEMS INTERNATIONAL, INC. AND IS
NOT TO 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
CONSENT OF PROCESS SYSTEMS INTERNATIONAL,
INC. AND SHALL BE RETURNED UPON REQUEST.

DWG. NO.	DESCRIPTION	DWG. NO.	DESCRIPTION

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS
DECIMALS
HOLE DRILLING
FINISHES
SURFACE FINISHES
WELDING SYMBOLS
WELDING METHODS
WELDING PROCEDURES
WELDING QUALITY CONTROL
WELDING INSPECTION
WELDING RECORDS
WELDING TRAINING
WELDING CERTIFICATION
WELDING EQUIPMENT
WELDING MATERIALS
WELDING TOOLS
WELDING SAFETY
WELDING ENVIRONMENT
WELDING HEALTH AND SAFETY
WELDING LEGISLATION
WELDING STANDARDS
WELDING CODES
WELDING SPECIFICATIONS
WELDING CONTRACTS
WELDING AGREEMENTS
WELDING PERMITS
WELDING LICENSES
WELDING CERTIFICATES
WELDING RECORDS
WELDING INSPECTION
WELDING QUALITY CONTROL
WELDING TRAINING
WELDING CERTIFICATION
WELDING EQUIPMENT
WELDING MATERIALS
WELDING TOOLS
WELDING SAFETY
WELDING ENVIRONMENT
WELDING HEALTH AND SAFETY
WELDING LEGISLATION
WELDING STANDARDS
WELDING CODES
WELDING SPECIFICATIONS
WELDING CONTRACTS
WELDING AGREEMENTS
WELDING PERMITS
WELDING LICENSES
WELDING CERTIFICATES

DO NOT SCALE THIS DRAWING
USED ON: 3 ISSUES FOR SHIPPING
NEXT ASS'Y:

ISSUE NO.	DATE	DESCRIPTION	ISSUE DESCRIPTION	SCALE	NAME	SHEET	1 OF 1
1	6/26/97	ISSUES FOR SHIPPING					

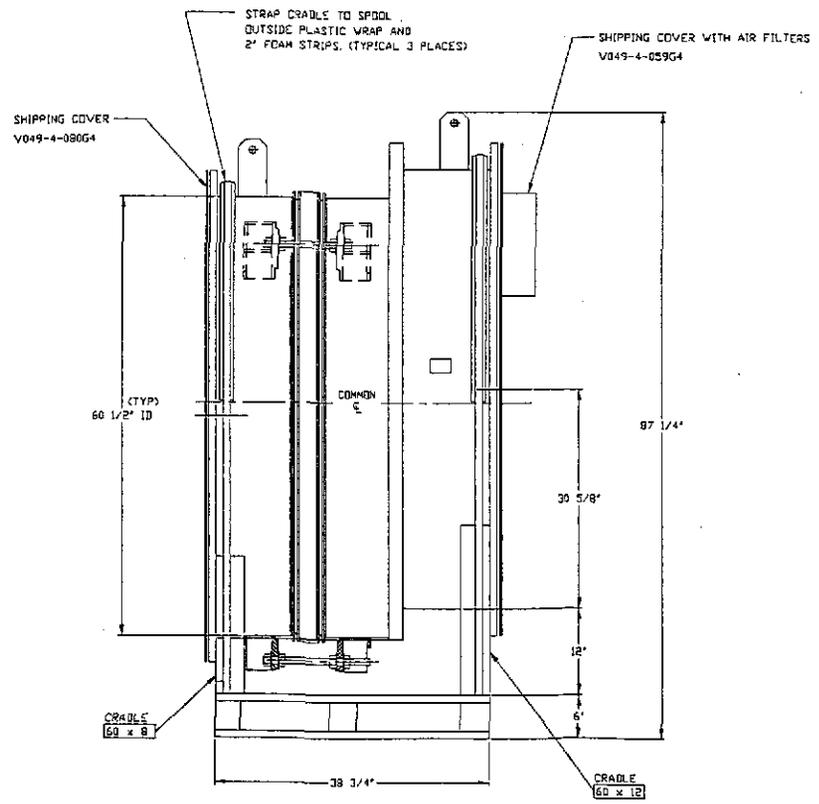
PROCESS SYSTEMS INTERNATIONAL, INC.
20 WALTON DR. WESTBOROUGH, MASSACHUSETTS 01581 USA

SHIPPING SPOOLS VA-13/VB-8/VB-1
SHIPPING SPOOLS LA-2/LB-1/LBE-1
SHIPPING CRITERIA
LIGO VACUUM EQUIPMENT

DWG. FILE: V049-4-233
SIZE: B
REV: 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.



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

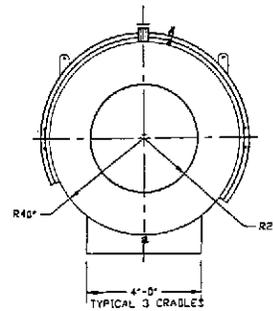
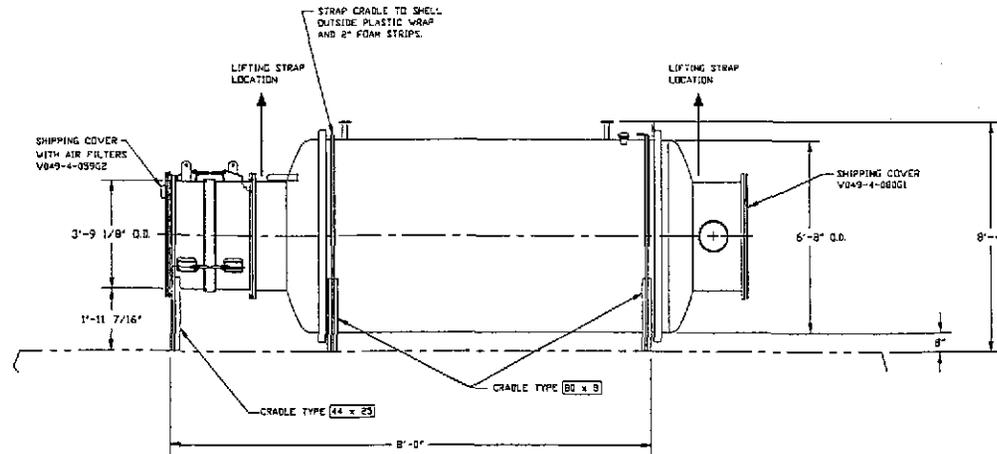
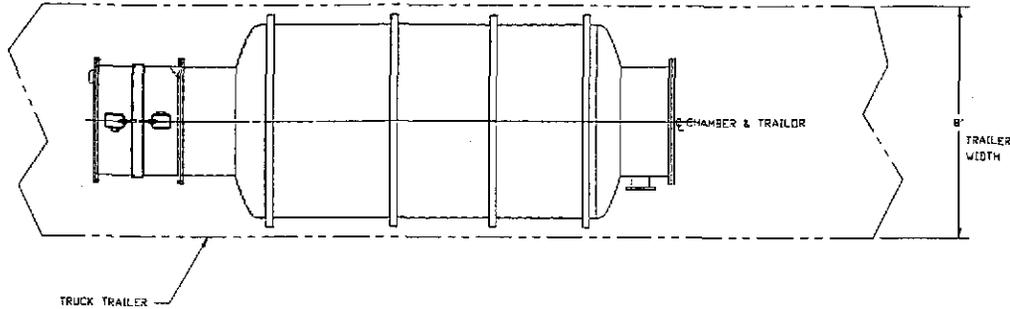
SHEET 13 OF 14 APPROX. WEIGHT: 2275#

<p>PROPERTY AND CONFIDENTIALITY</p> <p>REPRODUCING OR TRANSMITTING IN ANY FORM OR BY ANY MEANS, WITHOUT THE WRITTEN PERMISSION OF PROCESS SYSTEMS INTERNATIONAL, INC. IS PROHIBITED. THIS DRAWING IS THE PROPERTY OF PROCESS SYSTEMS INTERNATIONAL, INC. AND IS TO BE USED ONLY FOR THE PURPOSES AND LIMITS SPECIFIED HEREIN. IT SHALL NOT BE REPRODUCED, COPIED, OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, WITHOUT THE WRITTEN PERMISSION OF PROCESS SYSTEMS INTERNATIONAL, INC. AND SHALL BE RETURNED UPON REQUEST.</p>				<p>UNLESS OTHERWISE SPECIFIED</p> <p>DIMENSIONS ARE IN INCHES</p> <p>FRACTIONS: 1/8, 1/4, 3/8, 1/2, 5/8, 3/4, 7/8</p> <p>DECIMALS: .0005, .001, .002, .005, .01, .02, .05, .1, .2, .5, 1, 2, 5, 10, 20, 50, 100</p> <p>ANGLE DIMENSIONS: DEGREES, MINUTES, SECONDS</p> <p>UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE TO BE TAKEN TO THE CENTERLINE OF THE PART UNLESS OTHERWISE SPECIFIED.</p>				<p>PROCESS SYSTEMS INTERNATIONAL, INC. 25 HAZARD DR. WESTBOROUGH, MASSACHUSETTS 01581 USA</p> <p>OFFSET SPOOL BE-3 OFFSET SPOOL BE-3A LIGD VACUUM EQUIPMENT</p>			
<p>DO NOT SCALE THIS DRAWING</p>				<p>ISSUED FOR PDR</p>				<p>DATE: 6/26/97</p>			
<p>USED ON:</p>				<p>REV:</p>				<p>DATE: 6/26/97</p>			
<p>NEXT ASSY:</p>				<p>DESCRIPTION:</p>				<p>ISSUE DESCRIPTION:</p>			
<p>DWG. NO. DESCRIPTION</p>				<p>DWG. NO. DESCRIPTION</p>				<p>DWG. NO. DESCRIPTION</p>			
<p>REFERENCE DRAWINGS</p>				<p>REFERENCE DRAWINGS</p>				<p>REFERENCE DRAWINGS</p>			
<p>SCALE: NONE</p>				<p>SCALE: NONE</p>				<p>SCALE: NONE</p>			
<p>1 OF 1</p>				<p>1 OF 1</p>				<p>1 OF 1</p>			

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
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
THE VESSEL DURING SHIPMENT.**



NOTES AND COMMENTS

DOCUMENT CONTAINS PROPRIETARY INFORMATION RELATIVE TO PROCESS SYSTEMS INTERNATIONAL, INC. OR ITS ASSOCIATED COMPANIES AND SHALL BE USED ONLY FOR THE PURPOSES FOR WHICH IT WAS SUPPLIED. IT SHALL NOT BE COPIED, REPRODUCED OR OTHERWISE USED FOR OTHER PURPOSES WITHOUT THE WRITTEN PERMISSION OF PROCESS SYSTEMS INTERNATIONAL, INC. OR ITS ASSOCIATED COMPANIES. IF THIS DRAWING IS USED IN CONNECTION WITH THE DESIGN OR CONSTRUCTION OF ANY EQUIPMENT, THE USER SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY PERMITS AND APPROVALS FROM THE APPROPRIATE AUTHORITIES.

UNLESS OTHERWISE SPECIFIED

FINISHES ARE IN DIMS
FRACTIONS > 1/8\"/>

DO NOT SCALE THIS DRAWING
USED ON

REV	DESCRIPTION	ISSUE DESCRIPTION
0	ISSUED FOR SHIPPING	

Sht. 14 of 14

SHIPPING WEIGHT=9000#

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

**80K LONG/BE-4
SHIPPING CRITERIA
LIGG VACUUM EQUIPMENT**

DATE FILE: V049-235
SITE: 0
DWG NO: V049-4-235
REV: 0
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	V049-2-100	PORTABLE SOFT WALL CLEANROOMS	0	V049-4-091	BOK PUMP RESERVOIR-SHORT LEFT (3 SHTS.)	4	V049-5-012	PIPING ARR'T. PLAN CORNER STA. WA (4 SHTS.)
2	V049-0-002	BEAM SPLITTER CHAMBER ALL BUT CORNER VERTEX ARMS	0	V049-2-111	SMALL VALVES	1	V049-4-092	BOK PUMP RESERVOIR-LONG LEFT (3 SHTS.)	3	V049-5-013	PIPING ARR'T. ELEVATION, CORNER STA. WA
3	V049-0-003	BEAM SPLITTER CHAMBER CORNER VERTEX ARMS	0	V049-2-112	BAKEOUT SYSTEM BLANKETS AND CARTS	0	V049-4-093	BOK PUMP RESERVOIR-LONG RIGHT (3 SHTS.)	4	V049-5-014	PIPING ARR'T. SECTIONS, CORNER STA. WA
3	V049-0-004	HORIZONTAL ACCESS MODULE				2	V049-4-094	BOK PUMP RESERVOIR SUPPLY ASSY. LONG (2 SHTS.)	3	V049-5-017	PIPING ARR'T. PLAN, RIGHT MID STA. WA (4 SHTS.)
2	V049-0-005	112cm & 122cm GATE VALVES				1	V049-4-096	72 1/4" ID FLANGE DETAIL (GROOVED)	3	V049-5-018	PIPING ARR'T. ELEVATION, RIGHT MID STA. WA (2 SHTS.)
6	V049-0-006	BOK CRYOPUMP	2	V049-2-113	CORNER STATIONS	2	V049-4-097	60 1/2" ID FLANGE DETAIL (FLAT FACED)	3	V049-5-019	PIPING ARR'T. SECTIONS, RIGHT MID STA. WA
1	V049-0-007	CHAMBER PRESSURIZATION SYSTEM	2	V049-2-114	MID STATIONS	2	V049-4-098	60 1/2" ID FLANGE DETAIL (FLAT/SLOTTED)	3	V049-5-021	PIPING ARR'T. ELEVATION, RIGHT END STA. WA
5	V049-0-010	VA LEFT END STATION	2	V049-2-115	END STATIONS	0	V049-4-099	72 1/4" ID FLANGE DETAIL (FLAT/SLOTTED)	3	V049-5-023	PIPING ARR'T. SECTIONS, RIGHT END STA. WA
5	V049-0-011	VA LEFT MID STATION				1	V049-4-101	BSC OVERALL ASSY.	3	V049-5-026	PIPING ARR'T. PLAN, LEFT MID STA. WA (2 SHTS.)
5	V049-0-012	VA LEFT BEAM MANIFOLD				1	V049-4-102	25 L/S ANNUBUS TUBING-44" G.V. TYPE III	3	V049-5-027	PIPING ARR'T. ELEVATION, LEFT MID STA. WA (2 SHTS.)
5	V049-0-013	VA VERTIC. SECTION				2	V049-4-103	25 L/S ION PUMP VALE SUPPORT (2 SHTS.)	3	V049-5-028	PIPING ARR'T. SECTIONS, LEFT MID STA. WA
5	V049-0-014	VA DIAGONAL SECTION				1	V049-4-107	25 L/S ANNUBUS TUBING 48" G.V. TYPE I	3	V049-5-030	PIPING ARR'T. PLAN, LEFT END STA. WA (2 SHTS.)
5	V049-0-015	VA RIGHT BEAM MANIFOLD	4	V049-3-001	ELECTRICAL DRAWING LIST (2 SHTS.)	1	V049-4-108	ANNUBUS TUBING & ION PUMP ASSY. 44" G.V.	3	V049-5-031	PIPING ARR'T. ELEVATION, LEFT END STA. WA
5	V049-0-016	VA RIGHT MID STATION				1	V049-4-109	25 L/S ANNUBUS TUBING 48" G.V. TYPE II	3	V049-5-032	PIPING ARR'T. SECTIONS, LEFT END STA. WA
5	V049-0-017	VA RIGHT END STATION	4	V049-4-002	HORIZONTAL ACCESS MODULE (HAM)	1	V049-4-110	80K LONG-SHIELD ASSY. R/H/LH (3 SHTS.)	3	V049-5-033	OVERALL FLANGE ARR'T. CORNER STA. WA
3	V049-0-018	VA CORNER STATION MECHANICAL ROOM	3	V049-4-003	BSC SHELL WELDMENT/MACHINING (4 SHEETS)	3	V049-4-111	80K LONG-SHIELD ASSY. R/H/LH (3 SHTS.)	0	V049-5-035	OVERALL FLANGE ARR'T. MID STA. WA
			2	V049-4-005	80K CRYOPUMP, SHORT RIGHT (2 SHEETS)	3	V049-4-112	80K SHORT-SHIELD ASSY. R/H/LH (3 SHTS.)	0	V049-5-036	OVERALL FLANGE ARR'T. TYPICAL END STA. WA & LA
			2	V049-4-006	80K CRYOPUMP, LONG LEFT HAND (2 SHEETS)	3	V049-4-117	80K LONG-VERTICAL WELDMENT LH (2 SHTS.)	0	V049-5-037	CLEAN ROOM WITH BSC ASSY.
			2	V049-4-007	80K CRYOPUMP, SHORT LEFT HAND (2 SHEETS)	2	V049-4-118	80K LONG-VESSEL WELDMENT LH (2 SHTS.)	0	V049-5-050	SURVEY-BENCHMARKS-CORNER STA. WA
			2	V049-4-010	ROUGHING PUMP CART ARRANGEMENTS	2	V049-4-119	80K LONG-VESSEL WELDMENT RH (2 SHTS.)	0	V049-5-051	SURVEY-BENCHMARKS-MID STA. WA & LA
			3	V049-4-011	TURBO PUMP CART ARRANGEMENTS	3	V049-4-120	80K SHORT-VESSEL WELDMENT RH (2 SHTS.)	0	V049-5-052	SURVEY-BENCHMARKS-END STA. WA & LA
			1	V049-4-012	BASE EXTENSION-TURBO PUMP CART	1	V049-4-122	75L ION PUMP SUPPORT			
			4	V049-4-014	COVER, BSC TYPE I	1	V049-4-123	HAN 75L ION PUMP SUPPORT			
			3	V049-4-017	44 1/4" I.D. FLANGE DETAIL (GROOVED)	0	V049-4-124	BELLOWS' 1" DIA. TIE-ROD ASSY.			
			2	V049-4-018	49 1/4" I.D. FLANGE DETAIL (GROOVED)	4	V049-4-125	HAN SHIELD SUPPORT ASSY. '0" (3 SHTS.)			
			4	V049-4-019	62 1/2" I.D. BSC FLANGE DETAIL (GROOVED)	3	V049-4-126	HAN SHIELD SUPPORT ASSY. '0" (3 SHTS.)			
			2	V049-4-020	72 1/4" I.D. FLANGE DETAIL (GROOVED)	0	V049-4-128	HAN ANNUBUS FLEX HOSE			
			3	V049-4-021	84 1/4" I.D. FLANGE DETAIL (GROOVED)	1	V049-4-132	44 5/8" ID FLANGE DETAIL (GROOVED)			
			5	V049-4-022	104 1/2" I.D. FLANGE DETAIL (GROOVED)	0	V049-4-133	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			
			1	V049-4-025	BSC ANNUBUS PIPING	2	V049-4-137	CLEAN ROOM STRUCTURE WELDMENT - HAM			
			1	V049-4-026	72 1/4" I.D. FLANGE DETAIL (FLAT FACED)	1	V049-4-138	BSC CLEAN ROOM WELDMENT			
			5	V049-4-029	48 1/4" I.D. FLANGE DETAIL (FLAT FACED)	1	V049-4-140	80K LONG-LEG ASSY.			
			1	V049-4-031	60 1/2" I.D. HAM FLANGE DETAIL (GROOVED/SLOTTED)	0	V049-4-141	80K SHORT-LEG ASSY.			
			3	V049-4-032	60 1/2" I.D. HAM FLANGE DETAIL (FLAT FACED)	0	V049-4-142	16 1/2" OD CONFLAT REDUCING FLANGES			
			1	V049-4-033	44" GATE VALVE SUPPORT FRAME	2	V049-4-144	60 1/2" ID FLANGE DETAIL (FLAT FACED)			
			1	V049-4-034	48" GATE VALVE SUPPORT FRAME	0	V049-4-145	LNB TANK BASE TEMPLATE			
			1	V049-4-036	BSC INTERNAL PLATFORM DETAILS	0	V049-4-146	80K HEAD/NOZZLE ASSY.			
			3	V049-4-040	HAN TIE ROD ASSY.	1	V049-4-147	80K HEAD/NOZZLE ASSY.			
			2	V049-4-041	104 1/2" I.D. FLANGE DETAIL (FLAT FACED)	0	V049-4-148	80K SHIELD SUPPORT LUG			
			1	V049-4-042	44 5/8" I.D. FLANGE DETAIL (FLAT FACED)	0	V049-4-152	BELLOWS' 1 1/4" DIA. TIE-ROD ASSY.			
			1	V049-4-043	PIRE BRIDGE-CORNER STATION	0	V049-4-153	GETTING LUG			
			1	V049-4-045	BSC RGA/AUX TURBO CONN. ASSY.	0	V049-4-161	BOK PUMP 2" JACKETED LINE			
			1	V049-4-046	BSC RGA/AUX TURBO/GAUGE PAIR ASSY.	0	V049-4-163	GATE VALVE PIN CLAMP			
			1	V049-4-047	44 5/8" ID x 80" OD FLANGE DETAIL (FLAT FACED)	1	V049-4-164	25 L/S ANNUBUS TUBING-44" G.V. TYPE I			
			3	V049-4-052	VESSEL SUPPORT (HAM)	1	V049-4-165	ANNUBUS TUBING & ION PUMP ASSY. 48" G.V.			
			1	V049-4-053	EXPANSION JOINT (HAM)	1	V049-4-166	25 L/S ANNUBUS TUBING-44" G.V. TYPE II			
			5	V049-4-054	HAN ANNUBUS PIPING	0	V049-4-168	ASSEMBLY BACK TO AIR CART, 50 CFM			
			2	V049-4-055	60 1/2" ID RING DETAIL REDUCING UNION	1	V049-4-172	14KW REGEN HEATER ASSY.			
			1	V049-4-056	30 1/2" ID x 68 1/4" OD FLANGE DETAIL (FLAT FACED)	0	V049-4-177	PSKW REGEN HEATER ASSY.			
			3	V049-4-057	30 1/2" ID x 68 1/4" OD FLANGE DETAIL (GROOVED)	0	V049-4-194	12" OD CONFLAT BLANK x 2 3/4" OD CONFLAT			
			1	V049-4-058	44 5/8" ID x 60 1/2" ID FLANGE DETAIL	1	V049-4-195	12" OD CONFLAT BLANK x 25 KF			
			4	V049-4-059	SHIPPING COVER WITH FILTER UNITS	0	V049-4-196	8" OD CONFLAT BLANK x 25 KF			
			0	V049-4-061	3/4" OD ELBOW x 2 3/4" CF. FLG. ANNUBUS CONN.	0	V049-4-197	10" OD TUBE BELLOWS-TURBO PUMP			
			0	V049-4-064	60 1/2" ID x 68 1/2" OD BE-3A FLANGE (FLAT)	0	V049-4-199	BSC SHIPPING SKID			
			2	V049-4-066	60 1/2" ID x 72 1/4" OD OFFSET FLANGE (BE-3A)	0	V049-4-202	BSC ANNUBUS TUBE SUPPORT			
			2	V049-4-067	61.31" ID x 72 1/4" OD BE-3A FLANGE (GROOVED)	0	V049-4-204	BSC AIR FILTER ASSY.			
			2	V049-4-068	48 1/4" ID x 68 1/2" ID OFFSET FLANGE	0	V049-4-206	HAN ANNUBUS TUBING SHIPPING SUPPORT			
			1	V049-4-070	48BI ID x 68 1/4" OD FLANGE DETAIL (FLAT FACED)	0	V049-4-302	BSC TEST/SHIP ASSY (TWO DOORS)			
			0	V049-4-071	48BI ID x 80 OD FLANGE DETAIL (FLAT FACED)	0	V049-4-303	BSC TEST/SHIP ASSY (THREE DOORS)			
			0	V049-4-072	PS-1 PIPE SUPPORT TEE POST (LINE PIPING)	0	V049-4-304	BSC TEST/SHIP ASSY (ONE DOOR)			
			0	V049-4-073	PS-3 PIPE SUPPORT	0	V049-4-305	BSC TEST/SHIP ASSY (ONE DOOR)			
			0	V049-4-074	PS-3 PIPE SUPPORT TEE POST	0	V049-5-001	EQUIPMENT ARR'T. PLAN, CORNER STA. WA (SHT 1 OF 2)			
			2	V049-4-075	PS-4 PIPE/ELECTRICAL SUPPORT	0	V049-5-002	EQUIPMENT ARR'T. ELEVATION, (SHT. 2 OF 2)			
			0	V049-4-076	PS-5 PIPE SUPPORT & BOK LONG PUMP	4	V049-5-003	EQUIPMENT ARR'T. ISO, CORNER STA. WA			
			2	V049-4-077	75 L/S ION PUMP/MANIFOLDS	1	V049-5-004	EQUIPMENT ARR'T. RIGHT MID STA. WA			
			2	V049-4-078	25 L/S ION PUMP/MANIFOLDS	4	V049-5-005	EQUIPMENT ARR'T. RIGHT END STA. WA			
			1	V049-4-079	48 1/4" ID x 68 1/4" OD FLANGE DETAIL	4	V049-5-006	EQUIPMENT ARR'T. LEFT MID STA. WA			
			1	V049-4-080	SHIPPING COVER ASSY. - WITHOUT FILTER ASSY.	4	V049-5-007	EQUIPMENT ARR'T. LEFT END STA. WA			
			0	V049-4-081	48 1/4" ID FLANGE DETAIL (GROOVED/SLOTTED)	4	V049-5-010	EQUIPMENT ARR'T. ISO, RIGHT MID STA. WA			
			0	V049-4-082	PS-6 PIPE SUPPORTS & BACKING PUMPS	1	V049-5-011	EQUIPMENT ARR'T. ISO, RIGHT END STA. WA			
			0	V049-4-087	60 1/2" ID x 80" OD FLANGE DETAIL (FLAT FACED)	0					
			2	V049-4-090	80K PUMP RESERVOIR-SHORT RIGHT (3 SHTS.)	1					

* = DRAWINGS ADDED/REVISED SINCE MARCH 1997

DWG. NO.	DESCRIPTION	REFERENCE DRAWINGS	DWG. NO.	DESCRIPTION	REFERENCE DRAWINGS
0	V049-2-102	BOK PUMPS	0	V049-2-104	ROUGHING PUMPS
0	V049-2-105	TURBOMOLECULAR PUMPS	0	V049-2-106	ION PUMPS
0	V049-2-107	LARGE GATE VALVES	0	V049-2-108	6", 10", 14" GATE VALVES
1	V049-2-109	CLEAN AIR SUPPLIES			

ISSUED ON	REV	DESCRIPTION	ISSUED ON	REV	DESCRIPTION

ISSUED ON	REV	DESCRIPTION	ISSUED ON	REV	DESCRIPTION

ISSUED ON	REV	DESCRIPTION	ISSUED ON	REV	DESCRIPTION

ISSUED ON	REV	DESCRIPTION	ISSUED ON	REV	DESCRIPTION

ISSUED ON	REV	DESCRIPTION	ISSUED ON	REV	DESCRIPTION

ISSUED ON	REV	DESCRIPTION	ISSUED ON	REV	DESCRIPTION



ATTACHMENT "P"

TO

V049-2-021

GROUT TEST PLAN

1. Purpose

Grout will be placed below vacuum equipment support base plates. Compression tests will be performed to ensure that the quality of the grout is acceptable.

2. Reference Documents

- a. V049-1-101, Procedure for Installation of Concrete Anchors.
- b. V049-1-021, Section 8.3.5, Grout Requirements.
- c. ASTM C1107, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
- d. ASTM C109, Standard Test Method for compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens).

3. Test Method

The test method of ASTM C109 shall apply.

4. Frequency of Tests & Number of Specimens

One set of tests shall be performed for each day that grout is placed. Each set shall consist of three specimens that are cast in accordance with ASTM C109. Compression tests shall be performed at 7, 14, and 28 days.

5. Reports

Test reports shall be provided to the Buyer's Installation Manager within 3 days of completion of the compression tests.

ATTACHMENT

Number:

A V049-2-021

Rev.

4

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: *Bruce Bagby*
 STRUCTURAL ENGINEER: *Raymond D. Ciatto*
 ELECTRICAL/CONTROL: *[Signature]*
 TECHNICAL DIRECTOR: *D.A. McWilliam*
 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.

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
3	MSE 21 JUL 97	REB 21 JUL 97	RELEASED FOR CONSTRUCTION PER AEO # 528
2	MSE 8 JUL 97	REB 8 JUL 97	RELEASED FOR CONSTRUCTION PER AEO # 0511
1	MSE 6 MAY 96	REB 5 DEC 96	RELEASED PER AEO # 0377
0	MSE 6 MAY 96	REB 6 MAY 96	RELEASED PER AEO # 0177
PROCESS SYSTEMS INTERNATIONAL, INC.		SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED DATE
	<i>MSE</i>	8 JUL 97	REB 8 JUL 97
		Number	Rev.
		V049-2-021	3
		LIGO-E970140-C3-V	

CONTENTS

ATTACHMENT LISTING3

1 INTRODUCTION4

2 DEFINITIONS.....4

3 SITE VISIT5

4 CONTRACTOR CONTACTS.....5

5 PERMITS AND CODES.....5

6 SAFETY REGULATIONS.....7

7 GENERAL REQUIREMENTS7

8 SCOPE OF WORK13

9 TESTING.....21

10 MATERIAL / SERVICES PROVIDED BY CONTRACTOR22

11 MATERIALS FURNISHED BY OTHERS/BUYER24

12 PROJECT DOCUMENTS LIST24

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 KFabricated Class 100 Vacuum and Air Piping V049-2-178
- Attachment LConcrete 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
A V049-2-021	3

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	Rev
A V049-2-021	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.

SPECIFICATION

Number

A V049-2-021

Rev

3

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 LN₂ 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 LN₂ 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	Rev
A V049-2-021	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	Rev
A V049-2-021	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 OC/QA plan and procedures no later than one month after he has been awarded the contract.

SPECIFICATION

Number

A V049-2-021

Rev

3

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

- 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.

SPECIFICATION

Number

A V049-2-021

Rev

3

**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 ± 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

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

- 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"

SPECIFICATION

Number

A V049-2-021

Rev

3

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
A V049-2-021	3

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.

SPECIFICATION

Number

A V049-2-021

Rev

3

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

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), LN₂ 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.

LN₂ 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 LN₂ 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 LN₂ tank area foundation and LN₂ tank anchor bolts are provided by the Buyer. The Contractor is responsible for installing the LN₂ 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, LN₂)

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.

SPECIFICATION

Number

A V049-2-021

Rev

3

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

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. LN₂ (V.J./LN₂ 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

SPECIFICATION

Number

A V049-2-021

Rev

3

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 2×10^{-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 LN₂ 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
A V049-2-021	3

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	Rev
A V049-2-021	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
A V049-2-021	3

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

WASHINGTON SITE	DRAWING SIZE	DOCUMENT NUMBER
P&ID's		
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
DRAWING/ BOM STRUCTURE		
General Project (Sht. 1 of 3)	D	V049-0-100
Washington Site (Sht. 2 of 3)	D	V049-0-100

ATTACHMENT

Number: A V049-2-021	Rev. 3
-----------------------------	---------------

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:

A V049-2-021

Rev.

3

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:	Rev.
A V049-2-021	3

Title: LIGO VACUUM EQUIPMENT INSTALLATION AND COMMISSIONING – WASHINGTON SITE

WASHINGTON SITE

MECHANICAL DRAWINGS

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

	DRAWING SIZE	DOCUMENT NUMBER
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) Slt'd	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:

A V049-2-021

Rev.

3

WASHINGTON SITE

MECHANICAL DRAWINGS

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

	DRAWING SIZE	DOCUMENT NUMBER
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 ₂ 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.
A V049-2-021	3

Title: LIGO VACUUM EQUIPMENT INSTALLATION AND COMMISSIONING – WASHINGTON SITE

WASHINGTON SITE

MECHANICAL DRAWINGS

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

	DRAWING SIZE	DOCUMENT NUMBER
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:

A V049-2-021

Rev.

3

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 1 of 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

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

	DRAWING SIZE	DOCUMENT NUMBER
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-Washinton	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:	Rev.
A V049-2-021	3

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

ATTACHMENT "B"
TO
V049-2-021
BUILDING CRANE COVERAGE

ATTACHMENT

Number:	A V049-2-021	Rev.	3
---------	---------------------	------	----------

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:
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)

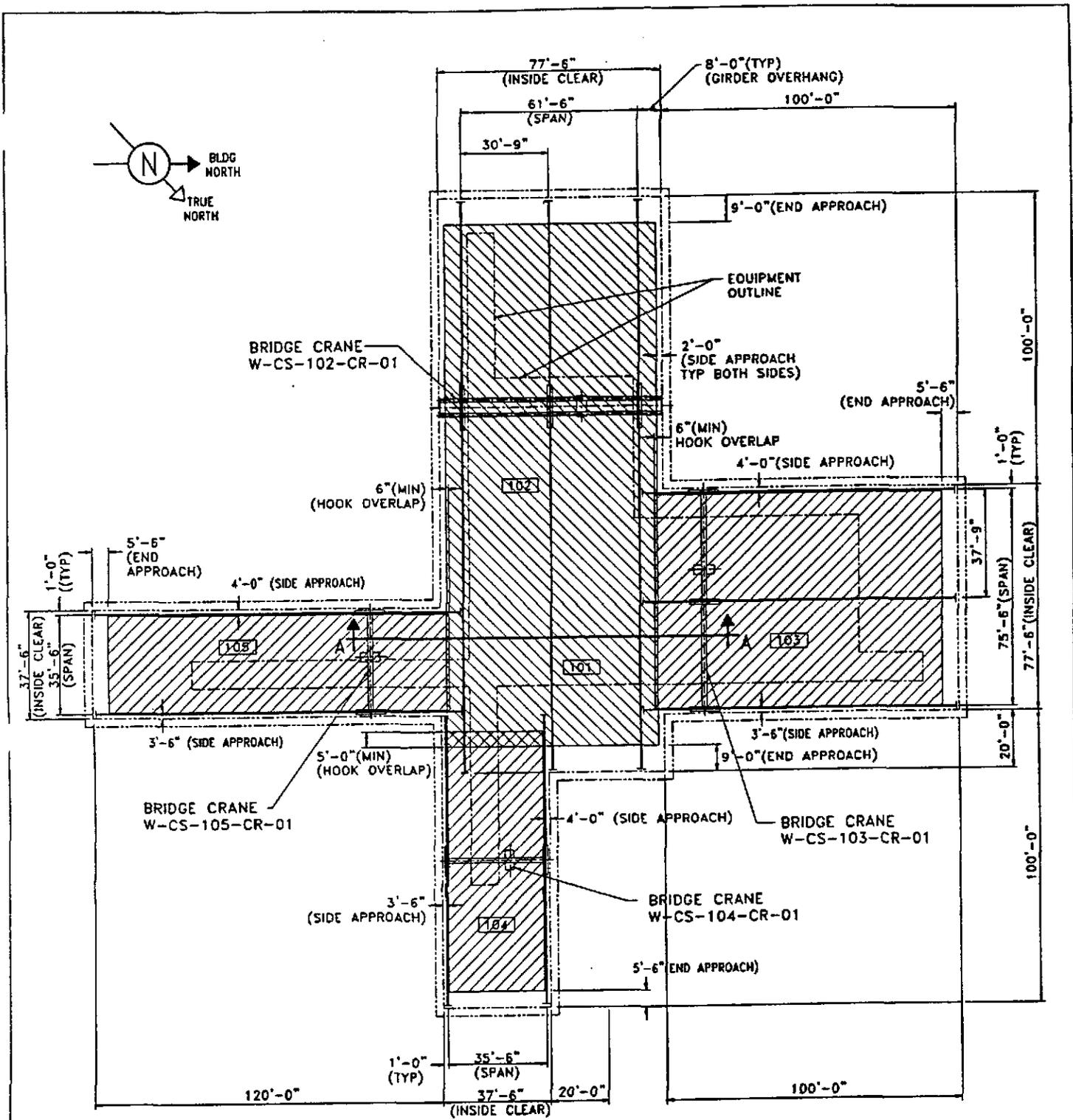
1. Location: LVEA Corner Station
2. Number Required: One (1)
3. Tag No.: W-CS-105-CR-01
4. Arrangement: Refer to Figures 3
5. Type: Electric, Single-Girder Under-Running
6. Number of Hoists: One(1)
7. Class: CMAA, Class A
8. Capacity: 5-Ton
9. Span: 35'-6"
10. Height of Lift: 26'-6", true vertical lift
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

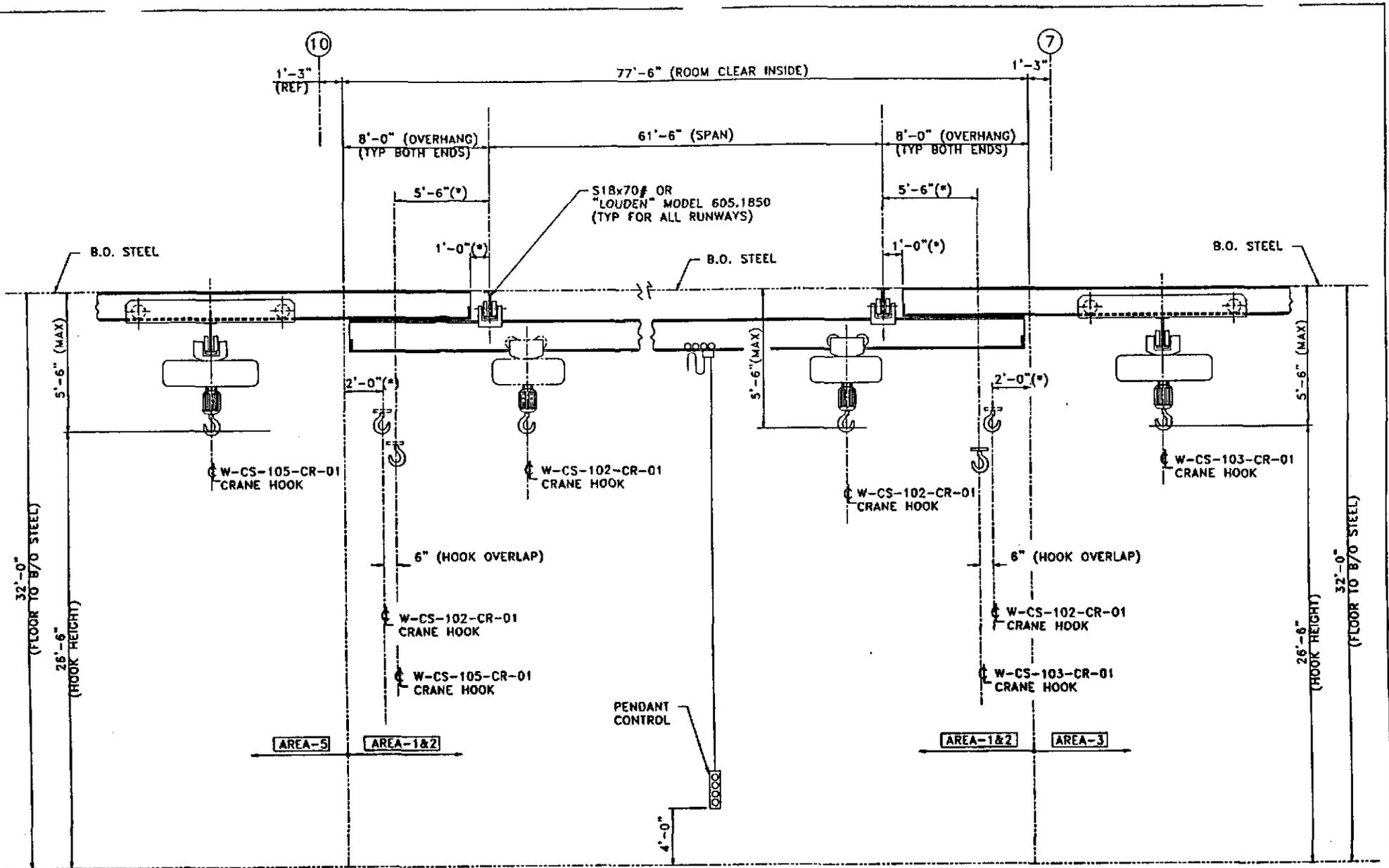
NOTE: "LOUDEN" Rail No. 605.1850 may be used instead the specified.



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]

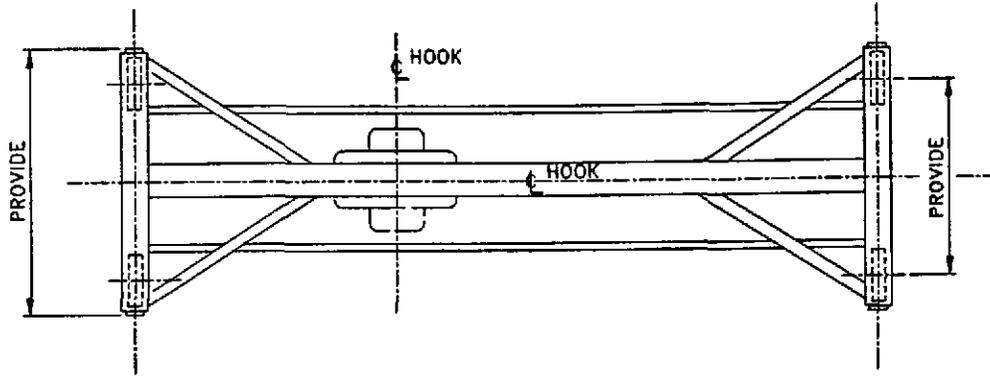


- NOTES:
1. DIMENSIONS ARE NOMINAL. CONTRACTOR SHALL VERIFY ALL BUILDING AND CRANE DIMENSIONS.
 2. DIMENSIONS INDICATED BY ASTERISKS(*) TO BE ADJUSTED, IF REQUIRED, TO ACHIEVE THE SPECIFIED 6-INCH HOOK OVERLAPS.

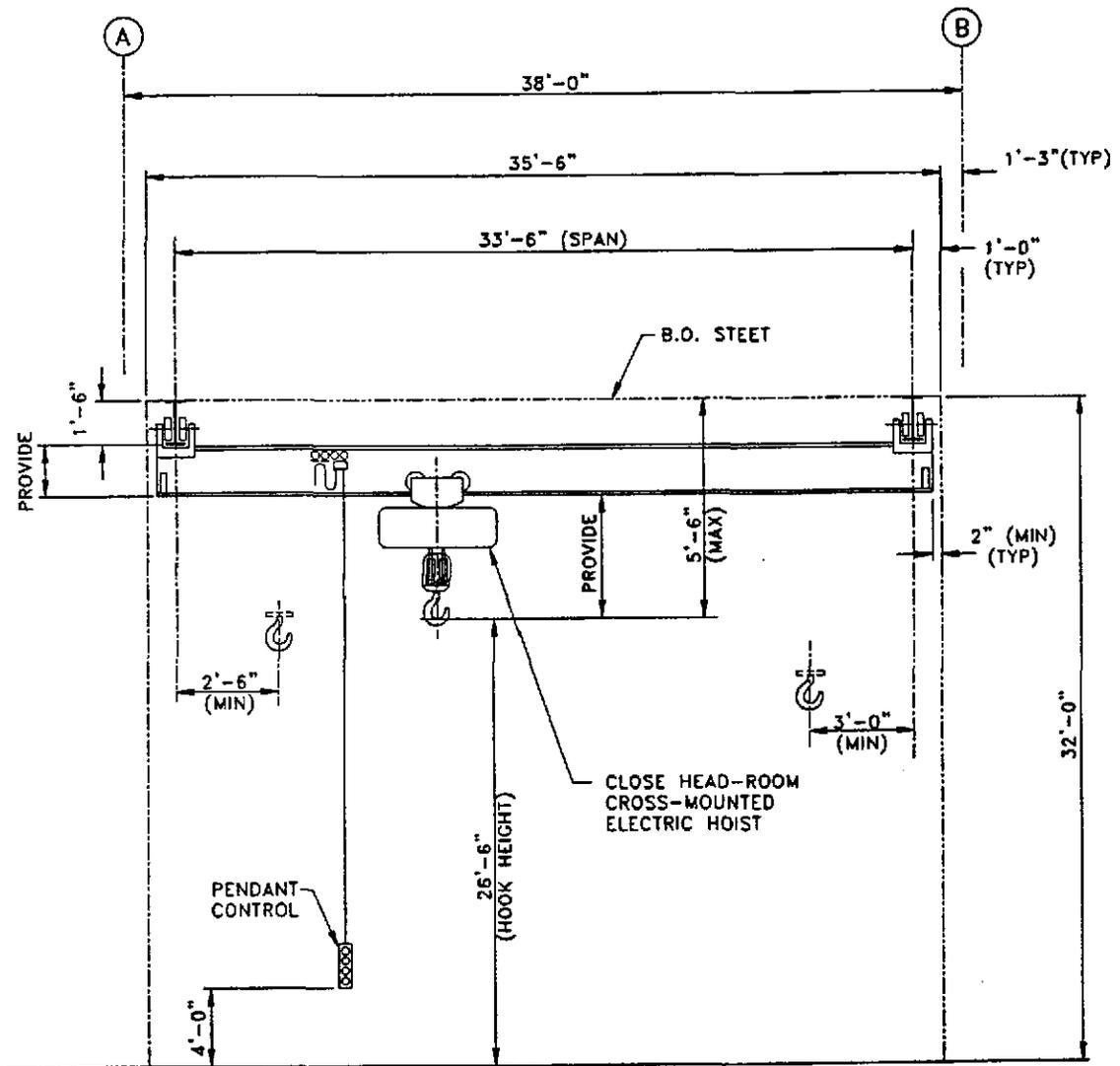
SECTION A-A
(LOOKING WEST)

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

06 7069



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 ₂ Tanks-14,000 Gal.	6	41,000
LWDX	LN ₂ 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 ₂ Piping Run (One per LN ₂ 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"

ATTACHMENT

Number:	Rev.
A V049-2-021	3

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

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 4/30/97</i>	<i>REB 7-1-97</i>	RELEASED FOR CONSTRUCTION DEO # 0510
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
		BY—DATE	APPD—DATE	DESCRIPTION OF ACTION

PROCESS SYSTEMS INTERNATIONAL, INC				SPECIFICATION	
INITIAL APPROVALS	PREPARED BY D. Parenti	DATE 4/29/96	APPROVED BY REB	DATE 4/29/96	Number LIGO-E970086-02-V 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
A 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.

SPECIFICATION	
Number	Rev
A V049-2-022	2

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)

By Others Work not under this Contract.

Contractor Company doing electrical and instrumentation work as defined in the Contract Documents.

PSI Process Systems International, Inc.

Indicated Shown or noted.

Install Place, secure, and connect.

Labeled Equipment marked with an identifying symbol authorized by a nationally recognized testing company such as UL, FM, ETL indicating sample of product has been tested and determined it complies with their safety standards.

Owner California Institute of Technology and The US Government

Owner's Persons designated by Owner

Representative

Permitted As by code, Contract Documents, or PSI.

Provide Furnish and install.

Required As by code, Contract Documents, or prevailing conditions.

Submittal Information required to show that the proposed equipment complies with project requirements.

Use Provide material or equipment referenced.

Work Material and equipment and their installation and other requirements as established in the Contract Documents.

Wire (Verb) Connect to equipment indicated and provide wiring required for connection.

Wiring Conductors, raceways, and accessories as required for a complete installation.

SPECIFICATION

Number

A V049-2-022

Rev

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

SPECIFICATION

Number

A V049-2-022

Rev

2

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
--------	--------------	-----	---

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

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

A V049-2-022

Rev

2

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

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

- 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	Rev
A V049-2-022	2

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

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:

<u>Line</u>	<u>208/120V</u>	<u>480/277V</u>
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

A V049-2-022

Rev

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

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

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

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

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.

— E N D —

SPECIFICATION

Number

A V049-2-022

Rev

2

ATTACHMENT "A"
DRAWING LISTS

<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
A V049-2-022	2

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
A V049-2-022	2

<u>DRAWING</u>	<u>DESCRIPTION</u>
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
A V049-2-022	2

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
A V049-2-022	2

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
A V049-2-022	2

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

ITEM	INSTRUMENT TAG/EQUIPMENT DESIGNATION	
		V INDICATES VACUUM ENVIRONMENT LOCATION
		DESCRIPTION (INDICATED ON DRAWING/SHEET)
23	LT-500	— CRYOPUMP WCP8 LEVEL TRANSMITTER* (V049-3-501)
24	LT-505	— CRYOPUMP WCP8 DEWAR LEVEL TRANSMITTER* (V049-3-501)
25	PNL-100A	— CORNER STATION ION CONTROLLER PANEL (V049-3-116)
26	PNL-100B	— CORNER STATION ION CONTROLLER PANEL (V049-3-116)
27	PNL-200	— LEFT MID STATION ION CONTROLLER PANEL (V049-3-204)
28	PNL-300	— RIGHT MID STATION ION CONTROLLER PANEL (V049-3-304)
29	PNL-400	— LEFT END STATION ION CONTROLLER PANEL (V049-3-404)
30	PNL-500	— RIGHT END STATION ION CONTROLLER PANEL (V049-3-504)
31	PT-101	— CRYOPUMP WCP1 PRESSURE TRANSMITTER* (V049-3-102)
32	PT-151	— CRYOPUMP WCP2 PRESSURE TRANSMITTER* (V049-3-103)
33	PT-201	— CRYOPUMP WCP3 PRESSURE TRANSMITTER* (V049-3-201)
34	PT-251	— CRYOPUMP WCP4 PRESSURE TRANSMITTER* (V049-3-201)
35	PT-301	— CRYOPUMP WCP5 PRESSURE TRANSMITTER* (V049-3-301)
36	PT-351	— CRYOPUMP WCP6 PRESSURE TRANSMITTER* (V049-3-301)
37	PT-401	— CRYOPUMP WCP7 PRESSURE TRANSMITTER* (V049-3-401)
38	PT-501	— CRYOPUMP WCP8 PRESSURE TRANSMITTER* (V049-3-501)
39	TE-103A, 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
A V049-2-022	2

Title: SPECIFICATION FOR ELECTRICAL & INSTRUMENT CONSTRUCTION WORK

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

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

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

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

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:	Rev.
A V049-2-021	3

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

"DRAWINGS SHIPPED LOOSE"

(31 Sheets Total)

ATTACHMENT

Number:

A V049-2-021

Rev.

3

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

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

"DRAWINGS SHIPPED LOOSE"
(List attached)

ATTACHMENT

Number:

A V049-2-021

Rev.

3

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

ATTACHMENT	
Number: A V049-2-021	Rev. 3

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 ₂ Tanks – Outline	CS-12004, 2 Sheets	4	C	Process Engineering
15A.	LN ₂ 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 ₂ 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:	A V049-2-021	Rev.	3
---------	---------------------	------	----------

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

ATTACHMENT	
Number: A V049-2-021	Rev. 3

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

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

- | | | |
|---|---------------------|---------------------|
| 1. 12 Shipping crates (valves, instrs.,
ion pumps, blankets, o-rings
(COMMON CARRIER TRUCK). | 3,500 lbs
each | 4'x4'x4' Ea. |
| 2. 1 Truckload of vac. pump equip. air
compr + misc. items (airride, closed
trailer). | 20,000 lbs
total | 7'Wx8'Hx30' Lg. |
| 3. 1 Truckload misc. equip. (airride,
closed trailer). | 20,000 lbs
total | 7'Wx8'Hx40'Lg. |
| 4. 1 Return trip from Handord., WA.
to Westboro, MA.
6-BSC skids & ship covers
stacked with cradles loose. | 28,000 lbs
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. W x 11 ft. 6 in. H x 22 ft. 6 in. L	Per P.O.
WBSC 2	20000 lbs.	11 ft. 6 in. W x 11 ft. 6 in. H x 22 ft. 6 in. L	
WBSC 3	20000 lbs.	11 ft. 6 in. W x 11 ft. 6 in. H x 22 ft. 6 in. L	
WBSC 4	20000 lbs.	11 ft. 6 in. W x 11 ft. 6 in. H x 22 ft. 6 in. L	
WBSC 7	20000 lbs.	11 ft. 6 in. W x 11 ft. 6 in. H x 22 ft. 6 in. L	
WBSC 8	20000 lbs.	11 ft. 6 in. W x 11 ft. 6 in. H x 22 ft. 6 in. L	
WHAM 1	9000 lbs.	10 ft. W x 9 ft. H x 9 ft. L	
WHAM 2	9000 lbs.	10 ft. W x 9 ft. H x 9 ft. L	
WHAM 3	9000 lbs.	10 ft. W x 9 ft. H x 9 ft. L	
WHAM 4	9000 lbs.	10 ft. W x 9 ft. H x 9 ft. L	
WHAM 5	9000 lbs.	10 ft. W x 9 ft. H x 9 ft. L	
WHAM 6	9000 lbs.	10 ft. W x 9 ft. H x 9 ft. L	
WHAM 7	9000 lbs.	10 ft. W x 9 ft. H x 9 ft. L	
WHAM 8	9000 lbs.	10 ft. W x 9 ft. H x 9 ft. L	
WHAM 9	9000 lbs.	10 ft. W x 9 ft. H x 9 ft. L	
WHAM 10	9000 lbs.	10 ft. W x 9 ft. H x 9 ft. L	
WHAM 11	9000 lbs.	10 ft. W x 9 ft. H x 9 ft. L	
WHAM 12	9000 lbs.	10 ft. W x 9 ft. H x 9 ft. L	
WHAM Spare	9000 lbs.	10 ft. W x 9 ft. 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.
A V049-2-021	3

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:	Rev.
A V049-2-021	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.
A V049-2-021	3

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.
A V049-2-021	3

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

ATTACHMENT

Number:

A V049-2-021

Rev.

3

Title: SPECIFICATION FOR PREFABRICATED VACUUM AND CLASS 100 AIR PIPING

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. McWilliam

PROJECT MANAGER:

Paul Byrd

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
Ø	MSE 16 JUL 97	REB 7/2/97	RELEASED FOR CONSTRUCTION PER NEO # 0535
P1	REL 12/20/96	12/20/96	ISSUED FOR QUOTES DEO 0393

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number
	<i>REL</i>	<i>12/20/96</i>	<i>[Signature]</i>	<i>12/20/96</i>	V049-2-178
					LIGO-E970110-00-V
					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 1×10^{-9} torr l/s. Spools shall be given unique serial numbers (1 to ___) to control testing documentation.

SPECIFICATION

Number **A** V049-2-178

Rev. *0*

Title

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** V049-2-178

Rev. *0*

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. **2**

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>
MECHANICAL DRAWINGS				
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 <i>e</i>

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.

3

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.

Ø

Title:

SPECIFICATION FOR PIPING DESIGN AND MATERIAL

SPECIFICATION FOR PIPING DESIGN AND MATERIAL

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
And
Livingston, Louisiana



EX-105 8/5/99

7/21/97

PROCESS ENGINEER: Robert Tran
PROJECT ENGINEER: A. Moten
CIVIL/STRUC. ENGINEER: R. D. Ciatto
MANUFACTURING ENGINEER: Phillip Falco
QUALITY ASSURANCE ENGINEER: Alan & Budbrook
PROJECT MANAGER: Stan Byg

5	JM 11/14/97	D.M.W. 1-18-97	Clarified 181 flange/gasket requirements DEO # 0411
4	REL 11/27/96	D.M.W. 11-28	REVISED T3 CLASS, MAT'L TO BE 304S/S, 17 WAS 304L. DEO 0369
3	JRM 10/16/96	D.M.W. 10-17-96	Added "C2" SPEC. SHT for cryogenic copper lines. Revised 181-Flanges DEO # 0314
2	REL 8/24/96	PH/REB 8/28/96	REVISED "T4" SPEC. SH. 17, 17EM5. DEO. 249 RELEASED FOR PURCHASE.
1	REL 7/25/96	REB 8/13/96	REVISED "T4" SPEC. SH. 17 RELEASED FOR PURCHASE. DEO # 0236
0	REL 1-19-96	D.M.W.	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
	R. Ciatto	1-11-96	D.M.W.	1-18-96	A V049-2-037 LIGO-0960117-05-V
					Rev. 5

Title:

SPECIFICATION FOR PIPING DESIGN AND MATERIAL

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

SPECIFICATION

Number **A** V049-2-037

Rev. **5**

Page **3** of **20**

Number

Rev.

2.3 Specification Compliance

The equipment shall comply with any drawings, data sheets, specifications, codes and standards (latest editions) referred to or attached as part of this specification. State or local codes or regulations, if applicable, will be provided as an attachment to this specification. The Vendor is responsible for compliance with such standards, specifications, codes and regulations, if attached.

3.0 MATERIAL/MANUFACTURING REQUIREMENTS

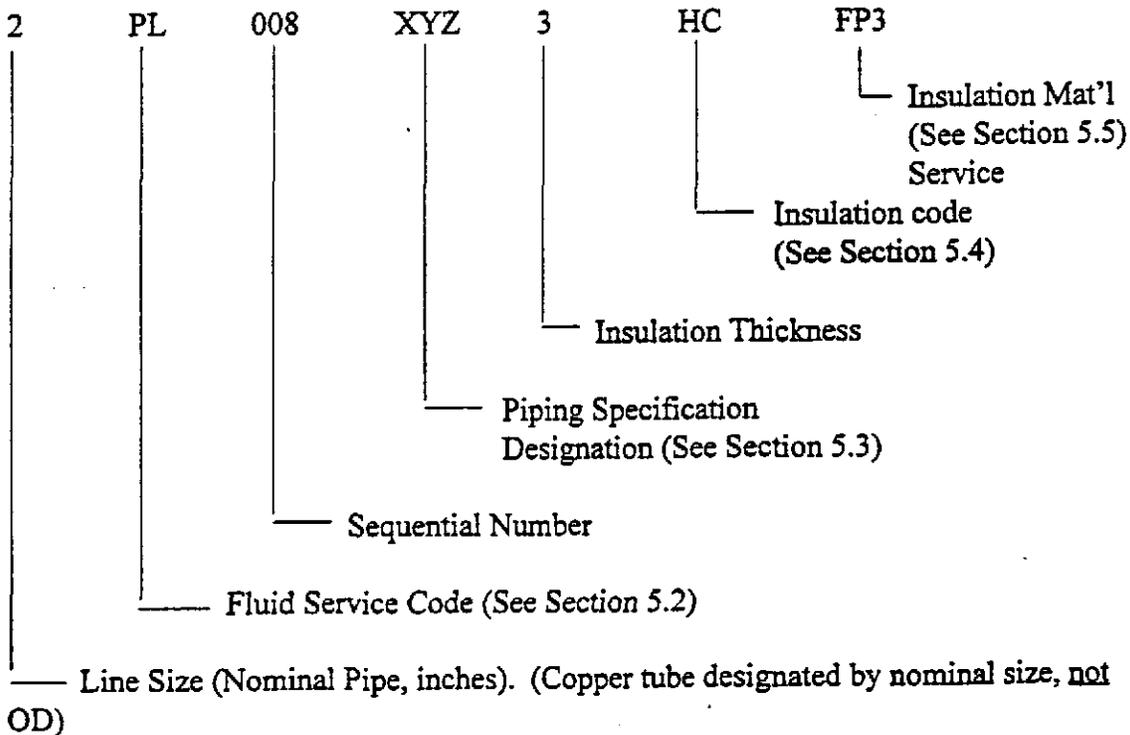
3.1 All materials used to manufacture the piping, tubing, flanges or fittings, as designated per this specification, are to be of U.S.A. origin and manufacture.

4.0 EXAMINATION AND TESTING

Examination and Pressure Testing as required by ANSI B31.3-1990 Chapter VI.

5.0 LINE NUMBER SYSTEM

4.1 Lines shall be numbered according to the following chart:



Number
Rev.

SPECIFICATION		
Number	V049-2-037	Rev. 5

5.2 Fluid Codes

Code	Fluid
IA	Instrument Air
CA	Class 100 Clean Air
CWS	Cooling Water Supply
CWR	Cooling Water Return
NGS	Natural Gas Supply
LN2	Liquid Nitrogen
GN2	Gaseous Nitrogen
PV	Process Vacuum
PUV	Process Ultra High Vacuum
VA	Vent and Relief To ATM
N2	Nitrogen Gas
N	Nitrogen (Either Gas or Liquid)

5.3 Piping Specification Designation**4.4.1 "X" First Digit Identifiers**

1 = 150 # ANSI

4.4.2 "Y" Second Digit Identifiers

A = 6061 T6 Aluminum
 B = 304 Stainless Steel
 C = Type L Copper Tubing
 T = Stainless Steel Tubing

4.4.3 "Z" Third Digit Identifiers

1 = Cryogenic
 2 = Non-Cryogenic
 3 = Vacuum
 4 = Ultra High Vacuum
 5 = Class 100 Clean Air

5.4 Insulation Service

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

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

Number

Rev.

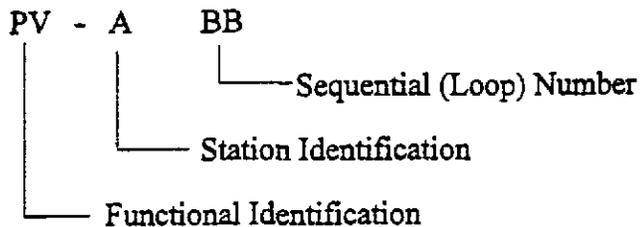
5.5 Insulation Material Codes

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

SPECIFICATIONNumber **A** V049-2-037Rev. **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 SSTL

Design Conditions:
Pressure 0 to 192 psig
Temperature -320°F to 350°F
Corrosion Allowance Zero

Pipe:
12" and smaller ASTM A312 TP304

Pipe Schedule:
1 1/2" and smaller Schedule 10S SMLS
8" and smaller Schedule 10S SMLS or EFW
10" thru 12" Schedule 10S EFW

Note: Vacuum jacketed piping will be designed and fabricated in accordance with the manufacturer's standard, and PSI spec. V049-2-016.

Fittings:
1 1/2" and smaller Socket Welded 3000#
2" and larger Butt Weld
ASTM A403 WP304 WPS, WPW
O'Let's ASTM A182-F304

Flanges: Not allowed, except on atmospheric vent lines as indicated on P&ID's. 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 A	V049-2-037	Rev. 5
-------------	------------	-----------

Title

SPECIFICATION FOR PIPING DESIGN AND MATERIAL

1B1

Branch Connections:

<u>Run Size "</u>												
1/2	04											
3/4	06	04										
1	12	06	04									
1 1/2	05	05	06	04								
2	05	05	06	06	04							
3	05	05	05	05	06	04						
4	05	05	05	05	12	06	04					
6	05	05	05	05	12	12	06	04				
8	05	05	05	05	12	12	12	06	04			
10	05	05	05	05	12	12	12	12	06	04		
12	05	05	05	05	12	12	12	12	12	06	04	
Branch Size	1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	

SPECIFICATION

Number **A** V049-2-037

Rev. **5**

Number

Rev.

Title

SPECIFICATION FOR PIPING DESIGN AND MATERIAL

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. _____

SPECIFICATION

Number **A** V049-2-037

Rev. **3**

1B2

Branch Connections:

Run Size "													
½	04											04 - Tee	
¾	06	04										05 - Sockolet	
1	12	06	04									06 - Tee Then	
1½	05	05	06	04							Reducer or		
2	05	05	06	06	04						Reducing Tee		
3	05	05	05	05	06	04						12 - BW O'let	
4	05	05	05	05	12	06	04						
6	05	05	05	05	12	12	06	04					
8	05	05	05	05	12	12	12	06	04				
10	05	05	05	05	12	12	12	12	06	04			
12	05	05	05	05	12	12	12	12	12	06	04		
Branch Size	½	¾	1	1½	2	3	4	6	8	10	12		

Note:

1. Piping and fittings to be internally cleaned, 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.

SPECIFICATION

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

Tube Size (OD):	Minimum Wall Thickness (Inches)
------------------------	--

1/4"	0.035"
3/8"	0.035"
1/2"	0.049"
3/4"	0.049"
1"	0.065"

Fittings: All Fittings to be Parker Weld tube fittings SA479 or ASTM A276 GR TP316 and ASTM A182 GR TP316, or equal.

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

Note:

1. Tubing to be internally cleaned, 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	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.
-----------	--

Tube Size (OD):	Minimum Wall Thickness (Inches)
------------------------	--

1/4"	0.035"
3/8"	0.035"
1/2"	0.049"
3/4"	0.049"
1"	0.065"

Fittings: All Fittings to be Parker A-LOK tube fittings SA479 or ASTM A276 GR TP316 and ASTM A182 GR TP316 or equal.

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

Note:

1. Tubing to be internally cleaned, 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	V049-2-037
A	

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

Number

Rev.

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.

Number
Rev.

SPECIFICATION

Number **A** V049-2-037

Rev. **5**

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

V049-2-037

Rev.

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

Title

SPECIFICATION FOR PIPING DESIGN AND MATERIAL

TS

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:					SPECNO: V049-2-037
TESTING INSPECTION AND DOCUMENTATION RECORD	Submittal After P.O.	Witnessed by PSI	Approval by PSI	Copies Req'd for PSI Files	Record in Mfr's File	Remarks:
						Inspector:
VENDOR Q.A. PLAN			X	2	X	
CLEANING PROCEDURE			X	2	X	
PREP FOR SHIPMENT PROCEDURE			X	2	X	
CERTIFICATE OF COMPLIANCE				2	X	

REV. 5
09.20.
SPEC V049-2-037

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. Stan
 PROCESS ENGINEER: Robert Thum
 QUALITY ASSURANCE: Alan L. Brudlow
 TECHNICAL DIRECTOR: D. C. McWilliam
 PROJECT MANAGER: Paul 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. McW 7-10-97	REVISED FOR PURCHASE TO ADD QTY. 12 - 1/2" VALVES DEO 0520
1	TMS 9-25-96	D. McW 9-26-96	REVISED FOR PURCHASE PER DEO 0274
0	TMS 3-1-96	D. McW 2-5-96	RELEASED FOR QUOTE PER DEO 077

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION			
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number	V049-2-060	Rev.
	T. M. Stan	3-1-96	RES		A	LIGO-E9700192-02-V	2

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.

SPECIFICATION		
Number		Rev.
A	V049-2-060	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*

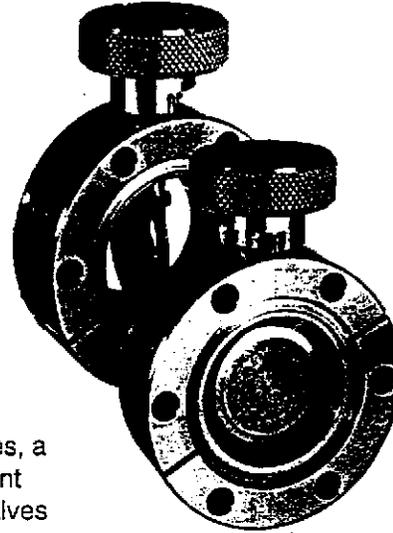
DESCRIPTION

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.

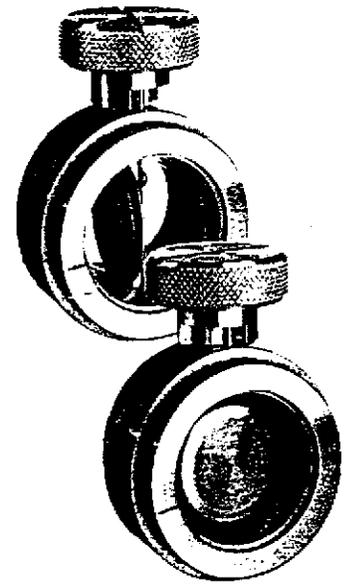
These quick-acting Butterfly Valves feature an improved sealing action. The opening in the body of the valve has been machined at a slight angle to the plane of the flapper. The flapper is set to rotate slightly off-center. On closure, this causes the sealing pressure to be applied more uniformly all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



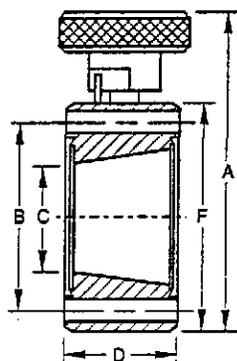
Del-Seal Flange
BFV-150



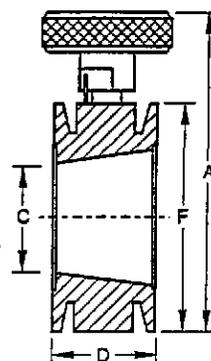
Kwik-Flange Flange
KBFV-150

Butterfly Valves

Toll Free Outside CA 1-800-443-8817



Del-Seal Flange



Kwik-Flange Flange

Valves

ORDERING INFORMATION

Please order by Part Number

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

Dimensions are in inches



ATTACHMENT "D"

TO

V049-2-178

SPECIFICATION FOR SMALL VACUUM VALVES

V049-2-059

ATTACHMENT

Number:

A V049-2-178

Rev.

Title: SPECIFICATION FOR SMALL VACUUM VALVES

SPECIFICATION FOR
SMALL VACUUM VALVES
FOR
LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

PREPARED BY: Theron M. Stern
PROCESS ENGINEER: Robert Thom
QUALITY ASSURANCE: Alvin B. Bradbrook
TECHNICAL DIRECTOR: D. G. M. W. Allen
PROJECT MANAGER: Burt 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. W.	REVISED FOR PURCHASE PER DEO 0224
0		TMS 2-29-96	D. M. W.	RELEASED FOR QUOTE PER DEO 0075

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION		
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number	Rev.
	T. Stern	2-29-96	RCS	2/21/96	V049-2-059 LIGO-E970089-01-V	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.

Number
Rev.

SPECIFICATION		
Number	A	V049-2-059
		Rev. 1

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 1×10^{-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.

Number
Rev.

SPECIFICATION	
Number A	Rev. 1
V049-2-059	
Page 3 of 4	

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.

SPECIFICATION

Number

A

Rev.

1

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:

R. D. Ciatto

INSTALLATION MANAGER:

Paul M. [Signature]

QUALITY ASSURANCE:

Allen J. Bradbrook

TECHNICAL DIRECTOR:

D. A. W. [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			7/18/97	RELEASED FOR CONSTRUCTION PER NEO# 0537
0				ISSUED PER D E U 138 FOR RDR

PROCESS SYSTEMS INTERNATIONAL, INC.				PROCEDURE	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number
	RDC	4/26/96	P. E. B.	4/26/96	V049-1-101
					Rev. 1
					LIGO-E970084-01-V

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

A

Rev. /

CONCRETE ANCHOR INSTALLATION PROCEDURE

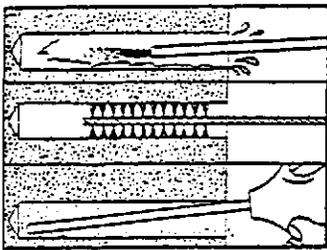
Title

- 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:

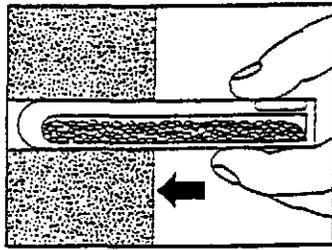
Number
Rev

SPECIFICATION	
Number A V049-1-101	Rev. 1

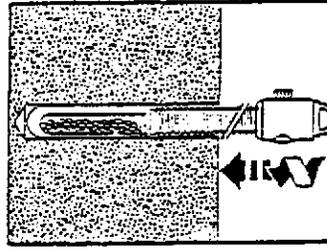
Installation Instructions (HAS Threaded Rod — Option #1)



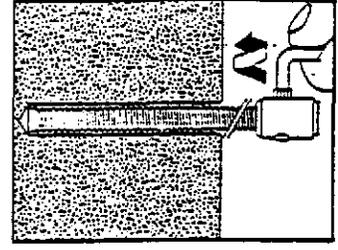
1. Set the drill depth gauge and drill the hole to the required hole depth. **IMPORTANT:** Clear out dust and fragments; preferably using a jet of water or compressed air and a wire brush. The hole may be damp, but the water should be blown out.



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** V049-1-101Rev. **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:	Rev.
A V049-1-101	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 / RES
MANUFACTURING ENGR: N/A
QUALITY ASSURANCE: ALAN BRADSHOCK / RES
TECHNICAL DIRECTOR: D. A. McWilliams
PROJECT MANAGER: Barclay Bay

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 RES 7/18/97		RELEASED FOR CONSTRUCTION PER REQ # 0526
Ø		D.E. 5/6/96 RES 5/6/96		RELEASE PER DRG 176

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION		
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number	Rev.
	D. E.	5/6/96	RES	5/6/96	A V049-2-123	1
					LIGO-8970120-01-V	

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

Title: COMPONENT PACKAGING, HANDLING AND SHIPPING

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 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

Title: COMPONENT PACKAGING, HANDLING AND SHIPPING

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.

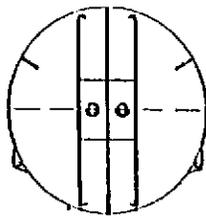
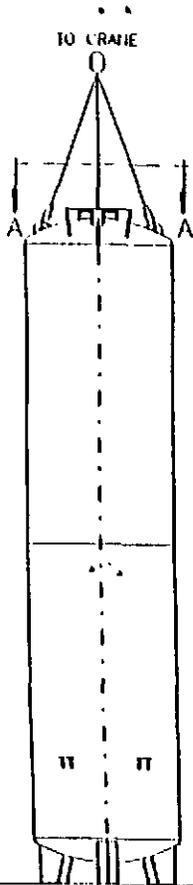
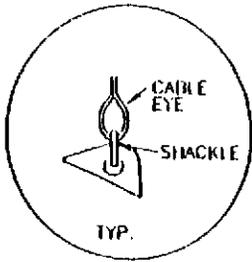
All LIGO components shall be handled (i.e. lifted, pulled, etc.) per the component handling data sheet. This sheet will detail weight, center of gravity, spreader beam requirements, rigging and offloading instructions, etc. Spreader beams are shall be used on all Beam Splitter vessels.

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).

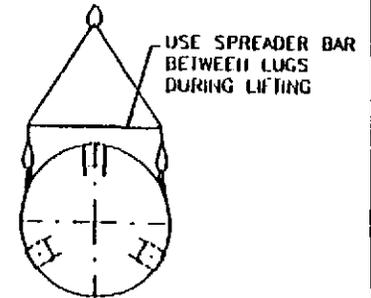
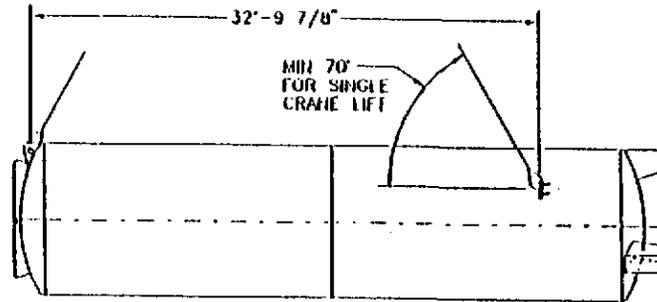
SPECIFICATION

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

Rev.
1



FRONT VIEW "A-A"



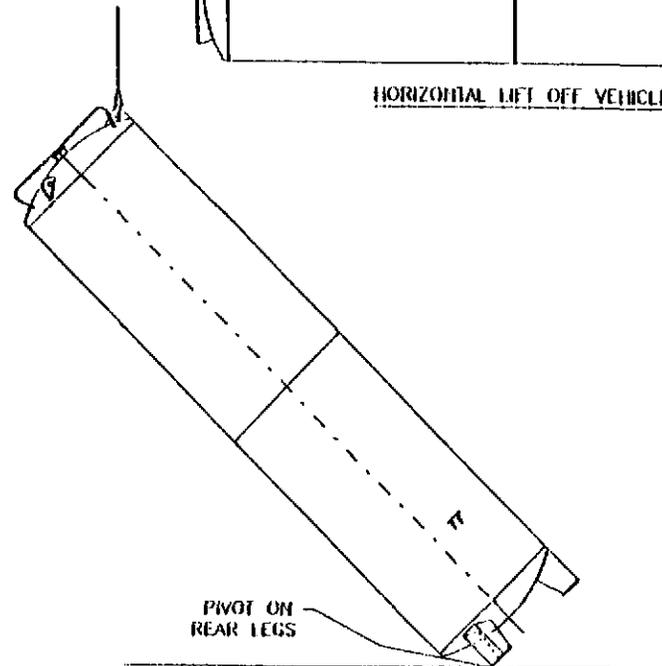
CAUTION

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"

✓

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

TOLERANCES ARE:
2 PL DECIMALS +/-
3 PL DECIMALS +/-
ANGLES 1/-
FITTINGS +/-

APPROVALS	BY	DATE
DESIGNER	RI	5/15/07
CHECKER		
ENGINEERING DESIGN		
MANUFACTURING		
WELDING ENGINEERING		
QUALITY ASSURANCE		
MATERIALS PLANNING		

PROCESS ENGINEERING
146 Main Street, PO Box 467
Plaistow, NH 03885

This design is the property of Process Engineering. The reproduction, manufacture or use of any assembly, sub-assembly or part is permitted only if authorized by Process Engineering.

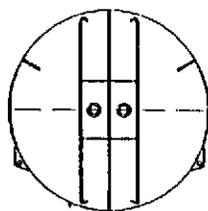
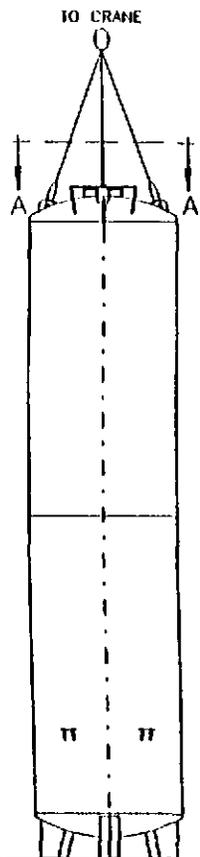
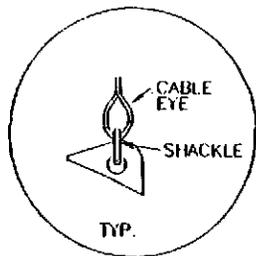
**LIFTING DIAGRAM
FOR MODEL 14400-8-50-LN2**

JOB No: C-090/09396	U/M	SCALE: NTS
PART No: 880.405	DRAWING No:	
SHEET No: 1 OF 1	B-30049	0 REV

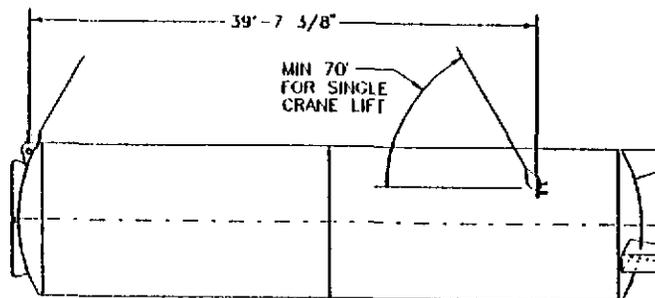
VERTICAL LIFT TO SET TANK IN PLACE

NO	DATE	BY	REVISION

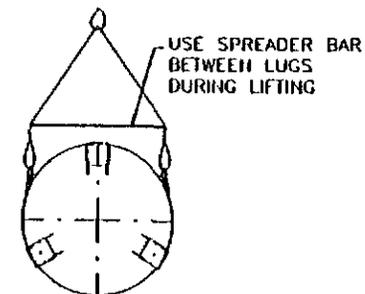
RECORD OF REVISION



FRONT
VIEW "A-A"



HORIZONTAL LIFT OFF VEHICLE



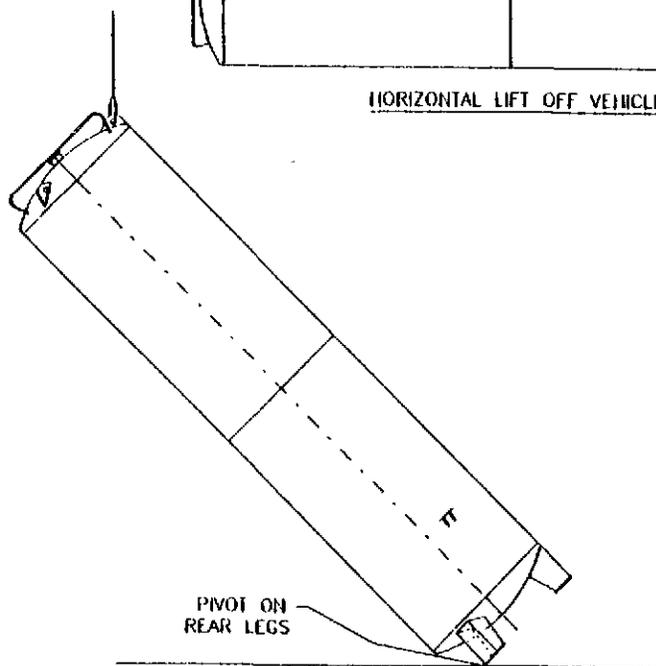
CAUTION

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.



ERECTING TANK

TOTAL WEIGHT = 46,500 Lbs
OVERALL HEIGHT = 46'-3"

SHT 2 OF 14

VERTICAL LIFT TO SET TANK IN PLACE

NO	DATE	BY	CHK	RECORD OF REVISION

TOLERANCES UNLESS OTHERWISE NOTED PER PEI STD.		
F-19 & TEMA STD.		
TOLERANCES ON:		
2 PL DECIMALS +/-		
3 PL DECIMALS +/-		
ANGLES 1/-		
FRACTIONS +/-		
APPROVALS	BY	DATE
DRAFTER	RI	5/17/1972
CHECKER		
ENGINEERING DESIGN		
MANUFACTURING		
WELDING ENGINEERING		
QUALITY ASSURANCE		
MAT. RES. PLANNING		



PROCESS ENGINEERING
146 Main Street, PO Box 467
Plaistow, NH 03865
This design is the property of Process Engineering. The reproduction, manufacture or use of any assembly, sub-assembly or part is permitted only if authorized by Process Engineering.

LIFTING DIAGRAM FOR MODEL 17260-8-50 LN2		
JOB No: C-094/09796	U/M	SCALE: N.T.S.
PART No: 880.605	DRAWING No:	
SHEET No: 1 OF 1	B-30050	
		0 REV.