LIGO VACUUM EQUIPMENT
FINAL DESIGN REPORT
CDRL 03
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FINAL DESIGN REPORT

VOLUME I

PROJECT MANAGEMENT PLAN

CONTRACT NO:	**PC 175730**
PSI DOCUMENT NO:	**V049-1-002 Rev. 1**
PROGRAM I.D.	**LIGO VACUUM EQUIPMENT**
ISSUE DATE:	**MAY 01, 1996**
CDRL NO:	**03**
APPROVAL STATUS:	**X**

SUBMITTED TO:

California Institute Of Technology
391 South Holliston Avenue
Pasadena, CA 91125

SUBMITTED BY:

Process Systems International, Inc.
20 Walkup Drive
Westborough, MA 01581

Technical Director: David A. McWilliams
David McWilliams

Project Manager: Richard Bagley
Richard Bagley, P.E.

Rev. 1

PROJECT MANAGEMENT PLAN

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1.0 PURPOSE

The purpose of the Project Management Plan (PMP) is to document the detailed plans, procedures, systems and responsibilities required to successfully execute a PSI project. It also formally documents contractual requirements.

The requirements and nomenclature of this PMP are based on an ISO-9001 approach to project execution.

The requirements of the PMP are intended to ensure that design output meets criteria established by the design input requirements, has been developed against known acceptance criteria and conforms to appropriate regulatory and contractual requirements. In this respect, the word design covers all process, project and specialist engineering, design, procurement, fabrication, construction, contracts, etc.

2.0 GENERAL

The LIGO Vacuum Equipment Project will be executed and controlled via requirements, plans, procedures and systems detailed in this Final Design Report, (FDR). The Vacuum Equipment FDR consists of five sections as follows:

Volume I Project Management

Volume II Design

Volume III Fabrication

Volume IV Installation

Volume V Drawings

The FDR has developed during the LIGO Phase B - Final Design and will be updated (by section) throughout the project life. It will provide detailed instructions for executing all phases of the project including administrative, contractual and technical aspects.

The FDR is available to all members of the project team and to PSI management. Weekly meetings are held by the project team to discuss job performance and to measure progress against schedule milestones. Problem areas which may arise are identified and a plan is immediately developed and implemented to remedy the problem. Status reports are distributed to PSI management personnel who monitor the status of all projects.

The FDR also mandates planning, design review, risk management, cost analysis and schedule monitoring procedures designed to ensure consistent cost effective project execution.

Some section of the FDR are independent documents (Eng. Plan, Q.A. Plan, Fab. Plan, etc.) to facilitate revision control during the project.

The revised detailed Vacuum Equipment Program Schedule is included in Attachment 2 of this volume.

Current status information (as of 5/1/96) on the various aspects of the Vacuum Equipment contract are detailed in Sections 9, 10, 12, 13 and 15.

3.0 RESPONSIBILITIES

The LIGO project organization is structured to ensure responsiveness to the customer and schedule requirements of the contract.

To fulfill these objectives, the project will be staffed by a competent and versatile project team with the capability to effectively execute in the following program areas:

- Project Management
- Process Engineering
- Project Engineering
- Civil/Structural Engineering
- Electrical and Instrumentation Engineering
- Design/Drafting
- Procurement/Expediting
- Manufacturing
- Construction
- Contract Administration
- Scheduling
- Document Control
- Quality Assurance

3.1 Project Management

The PSI Project manager directs all project efforts and is responsible and accountable for successful achievement of all project objectives. The PSI project manager is delegated the authority to execute the project according to the contract documents by the President of PSI. This includes all material expenditures and decisions and the negotiation of change orders, if required. It also includes the commitment of PSI labor resources to perform to the contract, and to resolve any situations that might arise during the course of a project.

The PSI Project Manager has overall responsibility for technical performance, quality, costs and schedule. This organizational structure provides a single point of contact on all matters relating to the project.

Specific responsibilities of the Project Manager include:

- Direction and control of the project team
- Definition, planning, budgeting and assignment of work elements.
- Allocation, scheduling and control of resources necessary to perform these work elements in a timely, cost-effective manner.
- Implementation of corrective action when potential problems arise.
- Interface with and commitment to the customer.

The project manager is assisted by an MIS function at PSI called Effective Management System (EMS). EMS provides material resource planning, material control and accounting information for both labor and materials.

Various departments at PSI input information directly into EMS, and access the reports necessary to control their operations. The project manager accesses EMS on a regular basis to provide information needed for status and planning reports. He prepares a formal project review monthly. This report contains information on all labor and material expenditures to date, and all expenditures and labor utilization planned for the duration of the project. It also contains schedule information.

PSI recognizes the need for frequent, clear communication between LIGO and PSI throughout the course of the project. All formal communication from the Institute will go through the PSI Project Manager. It is realized, however, that there is a need for direct lines of communication between the corresponding parties of both PSI & LIGO to avoid misunderstanding due to the involvement of third parties. This direct communications is encouraged. All matters will be documented by conversation minutes by PSI and forwarded to the customer.

All technical direction and change of scope items will be instituted by Cal-Tech and issued via "Technical Direction Memorandums" (TDM) or by "Technical Information Memorandums" (TIM).

3.2 Project Team

The Project Team is responsible for executing the project under the direction of the Project Manager.

The LIGO Project will be staffed with dedicated engineering/designers/ Q.A./Procurement/Manufacturing/Construction staff for all key positions (see 3.3 LIGO Project organization). Additional staff will be assigned from the Engineering/Administration/Manufacturing pool for peak and intermittent liaison needs.

The technical director and design coordinator are responsible for providing technical direction to the Project Team. The manufacturing coordinator is responsible for directing PSI manufacturing and facilities improvements and for coordinating outside fabricators.

The following LIGO Management Team report to the Project Manager and direct their area of responsibilities:

Technical Director

Design Coordinator

Procurement Manager

Cost/Schedule Manager

Manufacturing Coordinator

Installation Manager

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Technical Director

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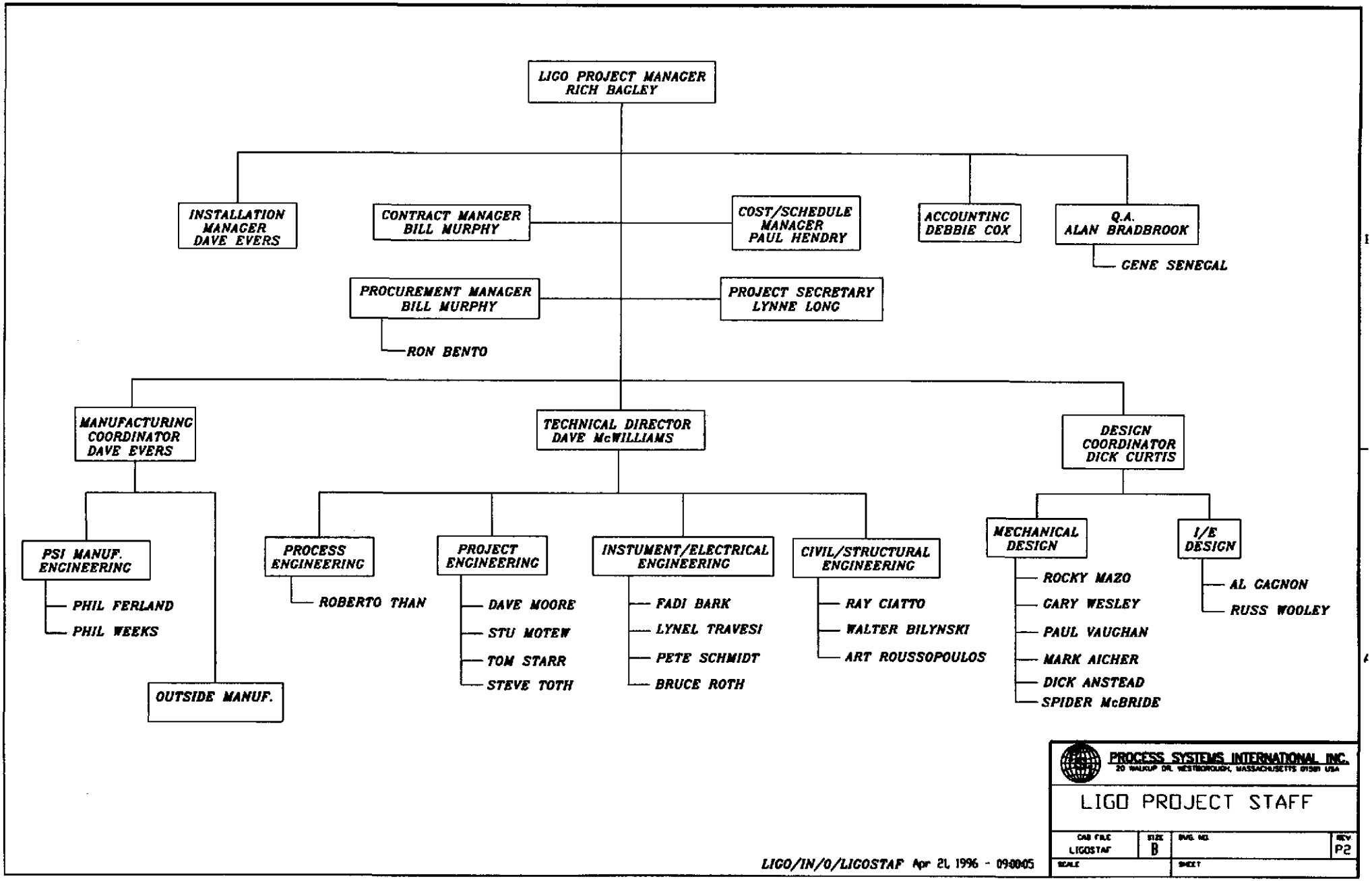
Procurement Manager

Cost/Schedule Manager

Manufacturing Coordinator

Installation Manager

3.3 LIGO PROJECT ORGANIZATION CHART



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

LIGO PROJECT STAFF

CAD FILE	SIZE	DWG. NO.	REV
LIGOSTAF	B		P2
SCALE		SHEET	

LIGO/IN/O/LIGOSTAF Apr 21 1996 - 098005

3.4 Safety Program

All members of the LIGO project team (and associated contractors) are responsible for executing the project in a manner that minimizes risk to personnel, facilities nd equipment.

The Project Safety Plan V049-2-023 (Attachment 5) details the safety organization, objectives of the safety program and plans for project execution.

4.0 CONTRACTUAL BASIS

4.1 Project Proposal

This project is based on PSI's Phase "A" design (CDRL No. 1) developed under contract PP161533.

4.2 Original Contract

The LIGO Vacuum Equipment System project will be executed per Fix Price Contract PC175730 (enclosed). The contract has been updated as required by change orders during The Final Design - Phase B.

FIXED-PRICE CONTRACT

Between
California Institute of Technology
and
Process Systems International, Inc.
for
LIGO Vacuum Equipment Design,
Fabrication, Installation, and Test
(Phase B)

September 12, 1995

FIXED-PRICE CONTRACT
PC175730

BETWEEN

CALIFORNIA INSTITUTE OF TECHNOLOGY
1201 E. CALIFORNIA BLVD.
PASADENA, CALIFORNIA 91125

AND

PROCESS SYSTEMS INTERNATIONAL, INC.
20 WALKUP DRIVE
WESTBOROUGH, MA 01581-5003

THIS CONTRACT FOR

LIGO VACUUM EQUIPMENT
DESIGN, FABRICATION, INSTALLATION, AND TEST
(PHASE B)

IS A

SUBCONTRACT UNDER A NATIONAL SCIENCE FOUNDATION
COOPERATIVE AGREEMENT NO. PHY-9210038

CONTRACT PRICE: $39,100,000

LIGO-C950804-00-V

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PREAMBLE

This contract, entered into on
by and between the CALIFORNIA INSTITUTE OF TECHNOLOGY, (hereinafter called "Institute"), a corporation organized and existing under the laws of the State of California, and Process Systems International, Inc. (hereinafter called the "Contractor"), a corporation organized and existing under the laws of the State of Massachusetts and constituting a subcontract under the Cooperative Agreement No. PHY-9210038, between the National Science Foundation and the Institute;

WITNESSETH THAT:

The Contractor agrees to furnish and deliver the supplies and perform the services set forth in this contract for the consideration stated herein.

Article I. Statement of Work

A. The Contractor shall furnish all personnel, services, materials and facilities necessary for completion of this Statement of Work and the Delivery and Performance Schedule included below.

(1) **Preliminary Design** (updated): The Contractor shall revise (according to action items resulting from the PDR of Phase A) the preliminary design developed in Phase A and submit to LIGO for approval before proceeding with the final design. In addition the Contractor shall revise and submit the Project Management Plan to LIGO for approval.

(2) **Deliverables to the Beam Tube Contractor Final Design**: After approval of the preliminary design the contractor shall perform the final design of the deliverables to the Beam Tube Contractor. After approval by LIGO of the deliverables to the Beam Tube Contractor Final Design, the Contractor shall procure and deliver pump carts and gate valves to the two LIGO sites according to Exhibit III.

(3) **Final Design**: The Contractor shall perform a detailed final design in accordance with the approved design above (1) which meets the requirements of the Specification for the LIGO Vacuum Equipment (LIGO-E940002-02-V). The final design shall be submitted to LIGO for approval before procurement and fabrication is initiated. The contractor shall fabricate, procure any necessary support equipment, and run preliminary tests on a prototype chamber prior to the Final Design Review. Note that no documentation is required for the LA mid stations beyond the gate valve drawings (part of paragraph 2 above). The final design shall include, but not be limited to the following:

a. Final versions of the documentation developed in Phase A, paragraph 1, subject to the updates of paragraph A(1) above. Include all necessary details required for procurement, fabrication, installation and testing of the Vacuum Equipment.

b. All calculations and analyses required to confirm the structural integrity of the vacuum shell and mechanical supports.

c. All calculations and analyses required to confirm the performance of the pumping system. Include all assumptions such as material outgassing rates.

d. All calculations and analyses performed to specify the bakeout system. Provide details of necessary interlocks, power limits, temperature sensors/monitors, control of heating rates and gradients, and overall power requirements.

e. All documents required to control material quality, surface treatments and cleaning processes throughout the fabrication, assembly and installation phases.

f. All documents required to fully identify and control the interfaces between the Vacuum Equipment and the other facility and detector subsystems as listed in the Specification for the LIGO Vacuum Equipment.

g. Control Strategy. All documents required to fully define the hardware (VE hardware only) and software to be used for the control and interlocking of the Vacuum Equipment as required in the Specification for the LIGO Vacuum Equipment.

h. Failure Modes and Effects Analysis.

i. Shock, Vibration, and Acoustic noise. The contractor's proposal for mitigating vibration, shock and acoustic noise shall be performed as stated in proposal number LIGO-C950804-00-V (PSI-VE001AA1A01.) This analysis and the passive solutions proposed for mitigation shall be considered full compliance with paragraphs 4.6.1, 4.6.2, and 4.6.3 of the Specification for the LIGO Vacuum Equipment.

j. Hazard Analysis. The hazard analysis shall include a risk assessment of the conditions which may lead to a mishap. (A mishap is an unplanned event or series of events resulting in death, injury, occupational illness, or damage to or loss of equipment or property, or damage to the environment, i.e. accident). The analysis shall rate hazards according to hazard probability and hazard severity. MIL-STD-882C section 4.5.1 and 4.5.2 are suggested as guides to performing these analysis.

k. Vacuum Equipment Maintenance Requirements.

l. Site Installation and Assembly Plan including schedules, special equipment requirements, laydown areas and alignment tests.

m. Acceptance Test Plan.

(4) **Fabrication and Procurement**: After LIGO approval of the final design documentation the Contractor shall begin fabrication and procurement of the Vacuum Equipment in accordance with the approved Project Management Plan per paragraph A(1) above. The prototype vessel fabrication and procurement shall begin prior to FDR approval.

(5) **Installation**: After *joint occupancy for the Washington site has been accomplished the Contractor shall begin installation of the Vacuum Equipment. The Contractor shall begin installation of the Vacuum Equipment at Louisiana after joint occupancy for this site has been accomplished.

*Joint Occupancy is defined in Article 1. (m) of the General Provisions

(6) **Deliverable Hardware and Acceptance Testing**: The equipment to be delivered and tested is listed in Exhibit IV, "Hardware Deliverables." After installation has been completed the Contractor shall conduct the acceptance tests of the Vacuum Equipment according to the approved Acceptance Test Plan and the schedule in Article II, Delivery and Performance Schedule, of this contract.

(7) **Management**: The Contractor shall implement the approved Project Management Plan described in paragraph A(1) above. In addition the Contractor shall:

a. Provide technical and administrative management throughout the life of the contract.

b. Maintain informal technical liaison between the LIGO cognizant engineer(s) and the Contractor's equivalent(s).

c. Accept and implement in-scope technical direction as provided via Technical Direction Memorandum (TDM). Such direction shall be accepted only from the Contract Technical Manager by the contractor's project manager.

d. Notify the Contract Technical Manager at least 5 days prior to technical meetings where major decisions may be made.

e. Notify the Contract Technical Manager at least 5 days prior to the start of major fabrication, assembly, installation, or testing at any location.

f. Arrange non-escort privileges for Government and LIGO representatives to all areas of the Contractor's and subcontractor's facilities where the work is being performed under this contract. This shall include access to fabrication, assembly, cleaning, and test areas for the purpose of monitoring activities.

(8) **Reviews and Meeting**: The Contractor shall conduct the following reviews and meetings at the Contractor's facilities according to the schedule in Article II, Delivery and Performance Schedule and prepare and submit the documentation for these reviews according to Exhibit II, Deliverable Documentation, LIGO Vacuum Equipment.

a. Updated Preliminary Design Review.
b. Beam Tube Deliverables - Final Design Review
c. Final Design Review.
d. Prototype vessel data review.
e. Installation Readiness Review.
f. Acceptance Test Review.
g. Monthly Progress Meeting.

(9) **Deliverable Documentation**: The Contractor shall prepare and submit all plans and documentation in accordance with Exhibit II, "Deliverable Documentation, LIGO Vacuum Equipment." This Exhibit consists of the following:

a. Contract Data Requirements List (CDRL), listing and establishing delivery requirements for documentation to be generated under this contract.

b. Data Requirements Description (DRD), describing the basic requirements for each item of the CDRL.

(10) **Deliverable Hardware**: The Contractor shall deliver and test the Vacuum Equipment in accordance with Exhibit III, Beam Tube Deliverables and Exhibit IV, "Hardware Deliverables."

B. Provided by LIGO:

(1) Space for vacuum equipment to be installed in the mechanical equipment rooms.

(2) Concrete pads outside each station rollup door for the purpose of unloading equipment.

(3) Electrical distribution panels where the contractor may obtain 480/208/120 volt electrical power as required for the Vacuum Equipment task.

(4) Station floor concrete with a minimum 3000 psi strength rating throughout the LVEA and VEA areas. Floors will be flat to +/- 1/4 inch.

(5) Site layout and floor plans according to the following preliminary interface drawings:
Corner Station: WA-SK-101; dated 7/7/95 100% concept submittal.
Mid and End Stations: WA-SK-300; dated 7/7/95 100% concept submittal.
The Louisiana site design will be similar and will allow use of common Vacuum Equipment Designs.

Article II. Delivery and Performance Schedule

	Description	On or Before
(1)	Updated Preliminary Design (Phase B)	One (1) month ARO
(2)	Submit and Implement the Updated Project Management Plan	One (1) month ARO
(3)	Deliverables to the Beam Tube Contractor, Washington	As indicated in Exhibit III. Deliverables to the Beam Tube Contractor
(4)	Deliverables to the Beam Tube Contractor, Louisiana	As indicated in Exhibit III. Deliverables to the Beam Tube Contractor

(5) Final Design	Seven (7) months ARO
(6) Begin Fabrication and Procurement	After approval of final design
(7) Begin Installation, Washington	At *Joint Occupancy Date for WA. Early Date 8/01/97, Late Date 9/01/97
(8) Begin Installation, Louisiana	At Joint Occupancy Date for LA. Early Date 3/01/98, Late Date 4/01/98
(9) Complete Acceptance Testing, WA	Eight (8) months after Joint Occupancy Date for WA
(10) Complete Acceptance Testing, LA	Eight (8) months after Joint Occupancy Date for LA
(11) Deliverable Documentation	As indicated in Exhibit IV, Deliverable Documentation
(12) Project Reviews	Monthly except for special reviews below
(13) Special Reviews:	
• Updated Preliminary Design Review	October 3, 1995
• Deliverables to the Beam Tube Final Design Review	Two (2) months ARO
• Final Design Review	Eight (8) months ARO
• Final Prototype Vessel Data Review	Ten (10) months ARO
• Installation Readiness Review WA	One month prior to Joint Occupancy WA
• Installation Readiness Review LA	One month prior to Joint Occupancy LA
• Acceptance Test Review WA	One month after completion of acceptance testing WA
• Acceptance Test Review LA	One month after completion of acceptance testing LA
(14) Deliverable Hardware	As indicated in Exhibit IV, Hardware Deliverables

*Joint Occupancy is defined in Article 1. (m) of the General Provisions

ARTICLE III

Price And Payment

(Omitted)

IN WITNESS WHEREOF, the parties hereto have executed this Contract as of the day and year first above written.

CALIFORNIA INSTITUTE OF TECHNOLOGY

By _____

COLIN J. SILVIO

PROCESS SYSTEMS INTERNATIONAL

By _____

W. Kent Higgins
(Typed Name)

President
(Typed Name)

Instructions to Contractor:

Do not insert date on Preamble page.

ARTICLE IV. SPECIAL PROVISIONS

A. The Contractor warrants that it has been duly authorized to operate and do business in the states of California, Washington and Louisiana, that it will obtain at no cost to the Institute all necessary licenses and permits required in connection with the contract; and that it will fully comply with all laws, decree, labor standards and regulations of such states during the performance of this contract.

B. The Contractor agrees that all information released by the Contractor for publicity or promotional purposes which is directly related to the contract work will be submitted to the Institute for review of technical accuracy prior to issuance.

C. The Contractor shall provide the Institute copies, for information purposes, of any notification of invention and/or request for intangible property rights resulting from this contract. The same information will be provided for all subcontractors.

D. It is agreed that as a condition of the award of this contract, the Government and the Institute shall have the right to use, duplicate and disclose, and have others do so, the technical data contained in the proposal upon which this contract is based, subject to the restriction set forth in the PSI proposal dated June 19, 1995.

ARTICLE V. ESCALATION

A. The following items under this Contract shall be subject to economic escalation:

1. On-site craft labor rates
2. 9% nickel content steel, and 304L stainless steel.

B. On-site craft labor rates shall be for the following crafts:

1. Sheet metal worker
2. Millwright
3. Electrician
4. Laborer.

Baseline labor rates shall be those in effect in June 1995 for those crafts under the LIGO Project Labor Agreement for Hanford, WA, and the Davis-Bacon-Act Wage Determination for Livingston, LA.

The Contractor shall present a proposal for escalation of the above items to Caltech at the time such escalation is incurred. The proposal shall include the baseline costs proposed in the PSI proposal dated June 19, 1995, evidence of the escalated costs to be incurred (invoices, negotiated labor rates, etc.), and the delta to the contract. Upon conclusion of fact-finding and negotiations, the Contract amount will be adjusted accordingly by the issuance of a Supplemental Agreement to the Contract. Profit will not be applied to the escalated amounts.

C. 9% nickel content steel, and 304L stainless steel shall be escalated as follows:

<u>9% Nickel</u>
Escalation will be based on 25% of Milestone #17/Dewars, WA and Milestone #17/Dewars, LA as set forth in Article III, Price and Payment.
Escalation basis: Increases in Bureau of Labor Statistics Producer Price Indices Table 5 #3356-1.
Base: Average price Apr/May/Jun 1995
Escalate to: Average price three months prior to vessels being available for shipment.

<u>304L Stainless Steel</u>
Escalation will be based on 100% of Milestone #12 Receipt as set forth in Article III, Price and Payment.
Escalation basis: Increases in Bureau of Labor Statistics Producer Price Indices Table 5 #3312-45314.
Base: Average price Apr/May/Jun 1995
Escalate to: Average price two months prior to achieving the milestone.

4.3 Change Orders

(Change orders as they are received are added to this section of the Project Manual.)

4.3.1 PSI CHANGE ORDERS

The following PSI changeorders have been accepted by LIGO via T.I.M. notices and are included in the Final Design Report:

No.	03	Corner Station Pipe Bridge
	04	Failsafe Roughing Pump Gate Valve
	07	304L Machined Gate Valve Weld Stubs
	11	WA Corner Station Spool Change
	12	Freon Cooling Systems - BTD
	13	Revise BSC Floor
	15	8 in. Ion Pump Port
	16	1 Piece To 2 Piece Spools
	17	Pump Cart Modification
	18	Annulus Pump Pumping Speed
	19	30 in. Mode Cleaner Tube Changes

CHANGE ORDER No. 1

to

Contract No. PC175730 (LIGO-C950804-01-V)
Ligo Vacuum Equipment Design, Fabrication, Installation, And Test
(Phase B)
November 1, 1995

Pursuant to Article 4 of the General Provisions, Changes, the subject contract is hereby modified as follows:

1. Delete Article III, Payment, in its entirety, and replace with attached new Article III, Payment.

2. Delete Article IV, Special Provisions, in its entirety, and replace with attached new Article IV, Special Provisions.

3. Delete Article V, Escalation, in its entirety, and replace with attached new Article V, Escalation.

4. Delete the following General Provision articles, and replace with attached new articles:

   a. Article 1 - Definitions
   b. Article 2 - Order of Precedence
   c. Article 10 - Metric System
   d. Article 12 - Liability and Indemnification/ Land Holders
   e. Article 32(d)- Indemnification
   f. Article 37 - Acceptance
   g. Article 40(f) and (j) - Warranty
   h. Article 42(b)2- Suspension of Work
   i. Article 43(c)- Termination for Convenience
   j. Article 44(d)- Default

5. Delete Page 2 of 2 of Exhibit IV, Hardware Deliverables, in its entirety and replace with new Page 2 of 2.

These modifications shall be accomplished at no change in contract price or schedule. All other terms and conditions of this contract remain unchanged.

BY:

Edward J. Jasnow
Subcontracts Manager, LIGO Project

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MASSACHUSETTS			CHANGE ORDER REQUEST	NO.: 3 PAGE 1 OF 1
REV.	DATE	BY	TITLE: Design, fabricate, and install the pipe bridge at the WA and LA corner stations.	
REV. 0	12/05/95	P.F. Hendry		

PROJECT: LIGO VACUUM EQUIPMENT SYSTEM **PROJECT NO.:** V59049

CUSTOMER: CALIFORNIA INSTITUTE OF TECH. **CONTRACT NO:** PC175730

CUSTOMER REFERENCE: LIGO-C950732-00-V
T.I.M. No. 2 (PSI ref # V049-LP-5)

CHANGE ORDER SCOPE:

Design, fabricate, and install the pipe bridge at the WA and LA corner stations for use by PSI only. The structure is to be supported only from the LVEA floor, and clearance underneath will be a minimum of 9 feet.

Please refer to the preliminary sketch attached to this change order.

NOTES:

This change has no overall schedule impact site mechanical completion dates. This pipe bridge will need to be installed very early in the construction program for each site.

Proposed payment terms are net 30 days from the PSI invoice date, which will be transmitted upon installation of the bridge in the Washington corner station (50%) and installation of the bridge in the Louisiana corner station (50%).

TOTAL PRICE: **$49,950.00**
Pricing valid for 30 days from submittal date.

SUBMITTED BY: Buck Bagley **DATE:** 12/4/95

CUSTOMER APPROVAL: **DATE:**

CUSTOMER CHANGE ORDER NO:

COMMENTS:

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MASSACHUSETTS			CHANGE ORDER REQUEST	NO.: 4
REV.	DATE	BY	TITLE: Add fail safe gate valves to the main rough pump inlet (roots pumps - four locations)	PAGE 1 OF 1
REV. 0	12/11/95	P.F. Hendry		

PROJECT: LIGO VACUUM EQUIPMENT SYSTEM **PROJECT NO.:** V59049

CUSTOMER: CALIFORNIA INSTITUTE OF TECH. **CONTRACT NO:** PC175730

CUSTOMER REFERENCE: LIGO-C950732-00-V
T.I.M. No. 2 (PSI ref # V049-LP-5)

CHANGE ORDER SCOPE:

Add a 6 inch air operated, fail safe, high vacuum gate valves to the inlet (chamber side) main roughing pump inlet (roots pumps - four locations). The valve will be suitable for 170 degrees C at 10E-6 mbar of vacuum.

NOTES:

This change has no overall schedule impact on the required at site dates for the main roughing pumps. Minor rework will be required to the roughing pump specifications and P&ID's.

Proposed payment terms are net 30 days from the PSI invoice date, which will be transmitted upon shipment of the pump skids for the Washington Beam Tube contractor (50%) and Louisiana Beam Tube contractor (50%).

TOTAL PRICE: **$16,280.00**
Pricing valid for 30 days from submittal date.

SUBMITTED BY: William J. Murphy **DATE:** 12/11/95

CUSTOMER APPROVAL: **DATE:**

CUSTOMER CHANGE ORDER NO:

COMMENTS:

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MASSACHUSETTS			CHANGE ORDER REQUEST	NO.: 7 PAGE 1 OF 1
REV.	DATE	BY	TITLE: Change buttweld end connections on large gate valves to 304L machined weld stubs	
REV. 0	12/04/95	P.F. Hendry		

PROJECT: LIGO VACUUM EQUIPMENT SYSTEM **PROJECT NO.:** V59049

CUSTOMER: CALIFORNIA INSTITUTE OF TECH. **CONTRACT NO:** PC175730

CUSTOMER REFERENCE: **T.D.M. No. 5 , Dated 11/30/95, Item 4**
V049-TN-13 , Dated 11/29/95

CHANGE ORDER SCOPE:

Change the buttweld ends of the large gate valves to special 304L machined weld stubs (low sulphur *.01 to .02%) and machined per* LIGO fax V049-LP-011.

Revise valve specification and purchase order

Additional quality assurance scope of work

NOTES:

This change has no overall schedule impact on the required at site dates for the large gate valves providing the decision is made by December 15, 1995, because it impacts the design of the valve body by the vendor. Minor rework will be required to the valve specifications and purchase order.

Proposed payment terms are net 30 days from the PSI invoice date, which will be transmitted upon delivery of the gate valves at site.

TOTAL PRICE: **$17,953.00**
Pricing valid until 1/4/96

SUBMITTED BY: Rachel Bagley **DATE:** 12/4/95

CUSTOMER APPROVAL: **DATE:**

CUSTOMER CHANGE ORDER NO:

COMMENTS:

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MASSACHUSETTS			CHANGE ORDER REQUEST	NO.: 11
REV.	DATE	BY	TITLE: Washington Corner Station Beam Manifold Spool Changes	PAGE 1 OF 1
REV. 0	1/18/96	P.F. Hendry		

PROJECT: LIGO VACUUM EQUIPMENT SYSTEM **PROJECT NO.:** V59049

CUSTOMER: CALIFORNIA INSTITUTE OF TECH. **CONTRACT NO:** PC175730

CUSTOMER REFERENCE: T.I.M. No. 10, Dated 12/21/95
LIGO Doc. No. LIGO-C951471-00-V PSI No. V049-LP-23

CHANGE ORDER SCOPE:

In the Washington corner station only:

Delete: 2 A-8 spools, 6 B-1 spools, and 6 BE-1 spools

Add: 2 BE-5 spools in their place
Additional anchors, supports, and shipping costs
Engineering and design rework to existing drawings and designs

NOTES:

A decision is required by January 26, 1996 in order to avoid delays in the completion of the final design effort. No overall schedule impact is anticipated. Design of the equipment arrangements for the WA corner station is currently underway, and this section of the beam manifold is being held pending approval of this change order.

Proposed payment terms are net credit to LIGO by PSI on the invoice for Payment Milestone 17A, Major Vessel Delivery for the Washington Corner Station.

TOTAL PRICE: ($200,577.00) CREDIT TO LIGO
Pricing valid for 30 days from above issued date.

SUBMITTED BY: William J Murphy **DATE:** 1/10/96

CUSTOMER APPROVAL: **DATE:**

CUSTOMER CHANGE ORDER NO:

COMMENTS:

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MASSACHUSETTS			CHANGE ORDER REQUEST	NO.: 12
REV.	DATE	BY	TITLE: Supply 4 freon cooling systems for the Beam Tube Deliverable Turbomolecular Pumps and 2 freon cooling systems for the BTD Main Roughing Pumps	PAGE 1 OF 1
REV. 0	2/28/96	P.F. Hendry		

PROJECT: LIGO VACUUM EQUIPMENT SYSTEM **PROJECT NO.:** V59049

CUSTOMER: CALIFORNIA INSTITUTE OF TECH. **CONTRACT NO:** PC175730

CUSTOMER REFERENCE: **T.I.M. No. 13, Dated 2/2/96**
LIGO Doc. No. LIGO-C960203-00-V

CHANGE ORDER SCOPE:

Supply six (6) freon cooling systems for the Beam Tube Deliverables in Washington, as follows:
- **Four (4) units for the Turbomolecular Pump Carts**
- **Two (2) units for the Main Roughing Pump Carts**
- **Supply a 40 foot hose and fittings for each cooling system to connect to the respective cart**

Engineering and quality assurance required to specify, bid, evaluate, purchase, review vendor drawings, and inspect the six cooling systems.

NOTES:

A decision is required within 30 days of the date of this change order in order to deliver the equipment when required by the Beam Tube Contractor.

Assumptions:
1. **No vibration analysis will be required by Cambridge Acoustical Associates.**
2. **PSI scope of work is equipment supply only, with installation by the Beam Tube Contractor.**
3. **This new scope is excluded from the final design scope of work.**

Proposed payment terms are the 50% of the value of the change order be added to the invoice for Payment Milestone 15A, Main Roughing Pumps Sets At Site, WA; and 50% added to Payment Milestone 15C, Turbo Molecular Pump Sets At Site, WA.

TOTAL PRICE: $61,036.00
Pricing valid for 30 days from above issued date.

SUBMITTED BY: William J. Murphy **DATE:** 2/20/96

CUSTOMER APPROVAL: **DATE:**

CUSTOMER CHANGE ORDER NO:

COMMENTS:

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MASSACHUSETTS			CHANGE ORDER REQUEST	NO.: 13
REV.	DATE	BY	TITLE: Revise the internal floor of the BSC to support a 500 kilogram load	PAGE 1 OF 1
REV. 0	2/14/96	P.F. Hendry		

PROJECT: LIGO VACUUM EQUIPMENT SYSTEM **PROJECT NO.:** V59049

CUSTOMER: CALIFORNIA INSTITUTE OF TECH. **CONTRACT NO:** PC175730

CUSTOMER REFERENCE: T.I.M. No. 1, Dated October 19, 1995

CHANGE ORDER SCOPE:

Revise the internal BSC removable maintenance floor design from the standard engineering practice of support for a 300 pound person, to support of a 500 kilogram load. In order to minimize cost, the following modified scope of supply was requested by LIGO:

- Supply of 7 BSC removable floors made out of 5/8" thick aluminum (4 to WA & 3 to LA)
- Provide removable support beams for each BSC capable of supporting the 500 Kg load
- Engineering and design costs for the revised floor design

This change order represents only the net additional cost for the revised floor costs as LIGO is receiving full credit for the original scope of supply.

NOTES:

A decision is required by March 6, 1996 in order to avoid delays in the completion of the final design effort. No overall schedule impact is anticipated.

Proposed payment terms are the total value of this change order added to Payment Milestone 17A, Major Vessel Delivery, Corner Station, WA.

TOTAL PRICE: $11,748.00

Pricing valid for 30 days from above issued date.

SUBMITTED BY: William F. Murphy **DATE:** 2/14/96

CUSTOMER APPROVAL: **DATE:**

CUSTOMER CHANGE ORDER NO:

COMMENTS:

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MASSACHUSETTS			CHANGE ORDER REQUEST	NO.: 15
REV.	DATE	BY	TITLE: Add an 8-inch port to the Main Ion Pumps	PAGE 1 OF 1
REV. 0	1/24/96	P.F. Hendry		

PROJECT: LIGO VACUUM EQUIPMENT SYSTEM **PROJECT NO.:** V59049

CUSTOMER: CALIFORNIA INSTITUTE OF TECH. **CONTRACT NO:** PC175730

CUSTOMER REFERENCE: Verbal request for future laser detector requirements

CHANGE ORDER SCOPE:

Add an 8-inch port to each of 18 Main Ion Pumps and blind it off with a conflat flange.
Related engineering and design impact.
Leak check new ports in the field.

NOTES:

A decision is required by February 1, 1996 in order to avoid delays in the receipt of vendor information required for the completion of the final design effort, and delays in receiving a main ion pump need for the prototype testing program. No overall schedule impact is anticipated.

Proposed payment terms are 2/3 of total value added to Payment Milestone 20, Begin Installation, Washington, and 1/3 added to Payment Milestone 21, Begin Installation, Louisiana.

TOTAL PRICE: $9,854.00
Pricing valid for 30 days from above issued date.

SUBMITTED BY: William J Murphy **DATE:** 1/25/96

CUSTOMER APPROVAL: **DATE:**

CUSTOMER CHANGE ORDER NO:

COMMENTS:

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MASSACHUSETTS			CHANGE ORDER REQUEST	NO.: 16
REV.	DATE	BY		PAGE 1 OF 1
REV. 0	2/28/96	P.F. Hendry	TITLE: Changes to the configuration of a quantity of 3 BE-3 spools from 1 piece to 2 piece spool	
REV. 1	3/14/96	P.F. Hendry	Rev. 1 generated due to TIM 19, dated 3/12/96, which reduced the scope of work for PSI from Rev. 0	

PROJECT: LIGO VACUUM EQUIPMENT SYSTEM **PROJECT NO.:** V59049

CUSTOMER: CALIFORNIA INSTITUTE OF TECH. **CONTRACT NO:** PC175730

CUSTOMER REFERENCE: **Minutes of meeting V049-MM-8, Item 20, Dated 2/14/96**
Transmitted on V049-PL-097, Dated 2/23/96

CHANGE ORDER SCOPE:

Revise a limited number removable BE-3 spools as detailed below:

Spool BE-3:

Change a quantity of 3 (2 WA, 1 LA) 60 in. spools from a 1 piece spool with 1 set of flanges and 1 expansion joint to a 2 piece 60 in. spool with 2 sets of flanges and 1 expansion joint. The new spools will be installed in WA at WBSC2 and WBSC4, and in LA at LBSC2. New spool designation is BE-3A.

Other Impacts: Engineering/design rework, bakeout blanket mods, installation & testing.

Assumptions:

1. **Spools will be assembled in PSI's shop and shipped as one piece.**
2. **No additional costs for shipping/test covers are included.**
3. **Spools will be installed as one piece and will not be disassembled prior to installation.**

NOTES:

A decision is required by March 21, 1996 in order to avoid delays in the completion of the final design effort. No overall schedule impact is anticipated.

PLEASE NOTE THIS CHANGE ORDER ONLY REPRESENTS ADDITIONAL COSTS ONLY.

Proposed payment terms are 2/3 of total value added to Payment Milestone 20, Begin Installation, Washington, and 1/3 added to Payment Milestone 21, Begin Installation, Louisiana.

TOTAL PRICE: $107,250.00
Pricing valid for 30 days from above issued date.

SUBMITTED BY: William F. Mayerby **DATE:** 3/14/96

CUSTOMER APPROVAL: **DATE:**

CUSTOMER CHANGE ORDER NO:

COMMENTS:

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MASSACHUSETTS			CHANGE ORDER REQUEST	NO.: 17
REV.	DATE	BY	TITLE: Vacuum Pump Cart Modifications	PAGE 1 OF 1
REV. 0	3/1/96	P.F. Hendry		

PROJECT: LIGO VACUUM EQUIPMENT SYSTEM **PROJECT NO.:** V59049

CUSTOMER: CALIFORNIA INSTITUTE OF TECH. **CONTRACT NO:** PC175730

CUSTOMER REFERENCE: **Minutes of meeting V049-MM-8, Items 4 & 7, Dated 2/14/96**
Transmitted on V049-PL-097, Dated 2/23/96

CHANGE ORDER SCOPE:

1. Lower the cart (qty of 10) for the Turbo Molecular Pumps by a minimum of 7/8 inch. ENGINEERING AND FABRICATION OF THIS CHANGE ARE BEING PROVIDED TO LIGO AT NO COST.

2. Change the Main Roughing Pump Carts (qty of 4) as follows:

- **Lower the blower portion of the roughing cart by approximately 3 feet**
- **Design the cart to facilitate movement with a pallet jack**
- **Provide 10 feet of interconnecting flex vacuum hose**
- **Provide 15 feet of interconnecting power and control cabling**
- **Provide 10 feet of interconnecting water hoses between the 2 carts**
- **No interconnecting provisions are being made between the 2 carts for instrument air and purge gas**
- **Provide an installation sketch (by PSI)**
- **Installation for Beam Tube use is by the Beam Tube Contractor**

3. Provide a pallet jack for use during construction, which is to be retained by LIGO.

NOTES:

A decision is required by March 8, 1996 in order to support the delivery schedule of the main roughing pumps to the Beam Tube Contractor.

Proposed payment terms are 50% of total value added to Payment Milestone 15A, BTD Main Roughing Pumps At WA Site; and 50% added to Payment Milestone 15B, BTD Main Roughing Pumps At LA Site.

TOTAL PRICE: $39,316.00
Pricing valid for 30 days from above issued date.

SUBMITTED BY: William J Murphy **DATE:** 3/1/96

CUSTOMER APPROVAL: **DATE:**

CUSTOMER CHANGE ORDER NO:

COMMENTS:

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MASSACHUSETTS			CHANGE ORDER REQUEST	NO.: 18
REV.	DATE	BY		PAGE 1 OF 1
REV. 0	3/1/96	P.F. Hendry	TITLE: Reduce the annulus pump speed requirement from 0.3 liters per second to 0.2 liters per second in order to minimize overall project cost.	

PROJECT: LIGO VACUUM EQUIPMENT SYSTEM **PROJECT NO.:** V59049

CUSTOMER: CALIFORNIA INSTITUTE OF TECH. **CONTRACT NO:** PC175730

CUSTOMER REFERENCE: **Minutes of meeting V049-MM-8, Item 21, Dated 2/14/96**
Transmitted on V049-PL-097, Dated 2/23/96

CHANGE ORDER SCOPE:

By reducing the annulus pump speed requirement from 0.3 liters per second to 0.2 liters per second, PSI is able to offer LIGO a credit for the savings in flange cost due to overall reductions in flange forging thickness'.

Additional engineering and design costs are offset by other savings in annulus piping material changes due to small diameter reductions.

NOTES:
A decision is required by March 8, 1996 in order to support the final design schedule.

Proposed payment terms are 50% of total value credited to Payment Milestone 17A, Major Vessel Delivery, Washington Corner Station, and 50% credited to Payment Milestone 17B, Major Vessel Delivery, Louisiana Corner Station.

TOTAL PRICE: ($40,687.00) **CREDIT TO LIGO**
Pricing valid for 30 days from above issued date.

SUBMITTED BY: William F Murphy **DATE:** 3/1/96

CUSTOMER APPROVAL: **DATE:**

CUSTOMER CHANGE ORDER NO:

COMMENTS:

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MASSACHUSETTS			CHANGE ORDER REQUEST	NO.: 19
REV.	DATE	BY	TITLE: 30-Inch Mode Cleaner Tube Changes	PAGE 1 OF 1
REV. 0	3/21/96	P.F. Hendry		

PROJECT: LIGO VACUUM EQUIPMENT SYSTEM **PROJECT NO.:** V59049

CUSTOMER: CALIFORNIA INSTITUTE OF TECH. **CONTRACT NO:** PC175730

CUSTOMER REFERENCE: **Minutes of meeting V049-MM-9, Item 23, Dated 3/14/96**
Transmitted on V049-PL-123, Dated 3/18/96

CHANGE ORDER SCOPE:

Revise the Mode Cleaner Tube Spools (B-2/3/5 & A-5) as follows:

- **Delete 12 sets of 30 inch flanges and machining associated with these flanges**
- **Delete 12 o-rings**
- **Delete the annulus piping for the above flange sets**
- **Delete the conical section of the A-5 spool (12 places)**
- **Add 6 new 30 inch expansion joints**
- **Add 6 new supports for the Mode Cleaner Tubes**
- **Redesign the equipment arrangement drawings of the corner stations**
- **Revise the affected equipment detail drawings for the Mode Cleaner Tube spools**
- **Engineering and design of the new supports for the Mode Cleaner Tube**

This impacts 4 Mode Cleaner Tubes in WA (8 A-5 spools) and 2 in LA (4 A-5 spools)

Implementing this change yields the following benefits:

- **Further reduce vibration reaching the HAM by adding a bellows on the vertex end of the mode cleaner tube between the turbo pump nozzle and the HAM**
- **Reduce o-ring offgassing by eliminating 12 o-rings**

NOTES:

A decision is required by March 26, 1996 in order to support the final design schedule.
Proposed payment terms are 67% of total value credited to Payment Milestone 17A, Major Vessel Delivery, Washington Corner Station, and 33% credited to Payment Milestone 17B, Major Vessel Delivery, Louisiana Corner Station.

TOTAL PRICE: **($35,298.00) CREDIT TO LIGO**
Pricing valid for 30 days from above issued date.

SUBMITTED BY: William F. Murphy **DATE:** 3/21/96

CUSTOMER APPROVAL: **DATE:**

CUSTOMER CHANGE ORDER NO:

COMMENTS:

5.0 DESIGN INPUT

5.1 Scope

Project Scope is detailed in Section 5.2.

5.2 Design Basis

This project is based on LIGO Vacuum Equipment Specification No. LIGO-E9400020-01-V Revision 2 and the contract documents (SOW, etc.) in Section 4.0. Specification E9400020-02-V is attached in Section 5.2.1.

The contract documents apply in the following order of precedence:

1. The Contract (Including S.O.W.)
2. Specification No. LIGO E9400020-02-V
3. General Provisions
4. PSI Proposal of June 19, 1995

EXHIBIT I

VACUUM EQUIPMENT SPECIFICATION
LIGO-E940002-02-V

Vacuum Equipment Specification

1.0 SCOPE

This specification defines the technical requirements for the design, procurement, delivery, qualification, installation, and acceptance testing of the LIGO (Laser Interferometer Gravitational-Wave Observatory) vacuum equipment. The LIGO includes two installations at widely separated sites, near Hanford, WA and Livingston, LA. Each installation includes laser interferometers in an L shape with 4-km long arms, a vacuum system for the sensitive interferometer components and optical beams, and other support facilities. The vacuum equipment consists of interconnected vacuum vessels, pumping systems, valves and a monitoring and control system for each site. The vacuum equipment will be located in structures called stations, located at the corners, mid points, and ends of the L-shaped pattern. See Figure 1.

The vacuum tube joining the vacuum equipment in the stations is provided under separate contract, and is described by LIGO 1100004, Beam Tubes Specification. Cleaning, alignment and leak checking are critical processes. Vacuum levels during operation may range from a nominal 10^{-6} torr at the chambers to 10^{-9} torr in the beamtube.

2.0 APPLICABLE DOCUMENTS

If more than one document applies to a technical requirement, the more stringent standard shall have precedence. Requirements set forth in this specification shall have final precedence.

2.1 Industry Documents

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

2.1.2 American Society for Testing and Materials
ASTM E498 Standard Test Methods for Leaks Using the Mass Spectrometer Leak Detector.

2.1.3 Handbook of Acoustical Measurements and Noise Control
Chapter 43, Noise Criteria for Heating, Ventilating, and Air Conditioning Systems.

2.1.4 International Standards Organization
ISO Standard 2861 Flange standards.

2.1.5 American Society of Civil Engineers
Minimum Design Loads for Buildings and Other Structures, ASCE 788.

2.1.6 Expansion Joint Manufacturer's Association (EJMA)
Standards of Expansion Joint Manufacturer's Association.

2.1.7 National Fire Protection Association (NFPA) Standards

No. 70-National Electrical Code.

2.2 Government Standards

Building and safety codes: local, state, and federal, including OSHA.

Federal Standard 209 for clean rooms.

2.3 LIGO Documents

2.3.1 LIGO Drawings

LIGO Drawing 1101100, Vacuum Equipment, Corner Station, Washington Site, Phase A, attached.

LIGO Drawing 1101101, Vacuum Equipment, Corner Station, Louisiana Site, Phase A, attached.

LIGO Drawing 1101102, Vacuum Equipment, End Stations, Phase A, attached.

LIGO Drawing 1101103, Vacuum Equipment, Mid Stations, Washington Site, Phase A, attached.

LIGO Drawing 1101009, Beam Splitter Chamber (BSC).

LIGO Drawing 1101010, Horizontal Access Module (HAM).

LIGO Drawing 1101051, Attachment Brackets.

2.3.2 LIGO Specifications

LIGO 1100004, Beam Tubes Specification.

2.4 Interface Control Documents

2.4.1 Provided by LIGO

LIGO document TBD, LIGO Interferometer to the Vacuum Equipment.

LIGO document TBD, Vacuum Equipment to the Beam Tube.

2.4.2 Provided by the Vacuum Equipment Contractor

Contractor document TBD, Vacuum Equipment to the Buildings and Utilities.

Contractor document TBD, Vacuum Equipment to the LIGO CDS.

3.0 SYSTEM DESCRIPTION

The LIGO vacuum system is divided into two parts: the beam tube modules and the vacuum equipment. The beam tube modules are two kilometers long and are addressed in a separate contract. The vacuum equipment is housed in buildings located at the intersection (corner) and ends of the beam tube modules. These buildings are the corner station, mid stations, and end stations. The vacuum equipment consists of the following subsystems:

- Vacuum enclosure subsystem
- Pumping subsystem
- Valve subsystem
- Vent and purge subsystem
- Bakeout subsystem
- Monitor and control subsystem

Together these subsystems, along with the beam tube modules, make up the vacuum system. The Washington site schematic is shown in Figure 2 and the Louisiana site schematic is shown in Figure 3. A description of the vacuum equipment according to station is given below.

3.1 Corner Station Washington Site

The vacuum enclosure for the corner station of the Washington Site is shown in Figure 4 and is divided into four vacuum sections as shown in Figure 2. The Vertex Section includes three beam splitter chambers (BSC), six horizontal access modules (HAM), and the two 76 cm diameter mode cleaner tubes. Two 122 cm gate valves isolate this section from the Beam Manifold Sections. All gate valves at the 80K pump locations shall provide 112 cm of clear aperture. Each Beam Manifold Section includes one BSC, a section of 183 cm diameter beam manifold, and one 80K pump. The beam manifolds provide for the addition of more chambers in future expansions. The Diagonal Section includes one BSC chamber, six HAM chambers, and two 122 cm gate valves. All major optical components are housed in the two chamber types (BSC, HAM). Removal of access covers from the chambers will allow for servicing the optical components during normal operations; the seals on these covers shall be designed as double O-rings with a pumped annulus for economical reuse during operations. A clean air vent and purge system shall be provided to break vacuum and maintain cleanliness of the optical components whenever a chamber is open.

The corner station pumping system shall include two 80K pumps (liquid nitrogen, continuous flow, or refrigerated) near the beam tube interfaces, and main ion pumps as shown in Figure 2. Ion pumps shall also be used to pump the annuli of double O-ring seals except as noted herein. Rough pumping from atmosphere shall be done with portable and stationary pump stations.

3.2 Corner Station Louisiana Site

The vacuum equipment for the corner station at the Louisiana site is similar to that at the Washington site, except that only one of the BSC/HAM groupings shall be installed. See Figures 3 and 5 for details.

3.3 End Stations Both Sites

The vacuum equipment for the end stations is shown in Figure 6. Vacuum enclosures shall include one BSC. The pumping system shall include one 80K pump with 112cm isolation valves, and ion pumps for both the enclosure and the annuli. Rough pumping from atmosphere shall be done with portable and stationary turbo molecular pump stations.

3.4 Mid Station Washington Site

The vacuum equipment for the mid stations is shown in Figure 7. The pumping system shall include two 80K pumps with 112 cm isolation valves, and ion pumps for both the enclosure and the annuli. Rough pumping from atmosphere shall be done with portable and stationary turbo molecular pump stations.

3.5 Midpoint Pumping Station Louisiana Site

No equipment or utilities are to be installed here. One electrically operated 122 cm diameter gate valve shall be supplied for others to install. Refer to Figure 7.

4.0 SYSTEM REQUIREMENTS

4.1 Leak Rate

All leaks greater than 1×10^{-9} torr liters/sec of helium shall be repaired according to LIGO approved procedures. Leak checking procedures shall conform to ASTM E498 Standard Test Methods for Leaks Using the Mass Spectrometer Leak Detector.

4.2 Pump Down Time

Each vacuum section (an isolatable volume) of each corner station, without interferometer components, shall pump down from atmosphere to 1×10^{-6} torr in less than 24 hours. Of this time, acoustic noise and vibration may exceed the limits described below in Section 4.6 for no more than the initial 4 hours. Turbo pumps are exempt from the acoustic noise criteria at all times. In the case of the vertex and offset vacuum sections, two pump stations may be connected at once. Otherwise, only a single pump station shall be connected at one time.

4.3 Ultimate Pressures

Each vacuum section shall attain a total pressure of 2×10^{-8} torr, measured with an RGA at an ion pump pumpout port, after 100 hours of pumping. If the hydrogen content of the steel prevents the attainment of this value, then the total pressure of all gases, other than H_2 and H_2O, shall not exceed 6×10^{-9} torr. The partial pressure goals below will be adjusted, as mutually agreed upon by LIGO and the contractor, so that they are consistent with the prototype chamber results and the design margins required for reliable implementation, but in any case not less than

Table 1: Partial Pressures Goals

Gas Species	Partial Pressure - torr
H_2O	5×10^{-9}
H_2	5×10^{-9}
N_2	5×10^{-10}
CO	5×10^{-10}
CO_2	2×10^{-10}
CH_4	2×10^{-10}
All Others	5×10^{-10}

shown in Table 1.

This ultimate pressure test shall be performed after a 48 hour, 150 C bakeout and subsequent cool-down period. The section under test shall be exposed to the operating 80K pumps. The only other pumps allowed are the installed main ion pumps, the annulus ion pumps and the pumps required for temporary pumping of the gate valve annuli.

4.4 System Control and Protection

Each vacuum section shall have sufficient instrumentation and hardware to allow safe and reliable operation of valves, pumps and gauges under all conditions. LIGO will supply process control functions (hardware and software programming) needed for safe acceptance testing as well as normal operations.

4.5 Bakeout/Degassing Capability

A means shall be provided to heat all vacuum surfaces in a given section to any desired temperature, ranging from ambient to 150 C, with a maximum variation of -20 C to + 20 C. No vacuum seals shall be damaged by non-uniform temperatures or by overheating. Ramping of temperatures shall be controllable. Power density shall be limited in order to provide fail safe protection. The rate of temperature rise during warmup shall not exceed 1.8C/hour. Particulate generation or shedding caused by placement or removal of the insulation shall be minimized. The surfaces may be blanketed or entire vacuum sections may be insulated by rigid or flexible partitions.

4.6 Special Environmental Requirements

The LIGO vacuum equipment and laser areas house instrumentation which is potentially highly sensitive to vibration and acoustic noise, shock-induced damage or misalignment, electromagnetic interference, and contamination.

4.6.1 Shock

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

4.6.2 Acoustic Noise

Acoustic noise from all simultaneously operating equipment in normal operation shall not exceed NC-20 (Noise Criterion 20) at any location within LIGO vacuum equipment and laser areas. Limited narrowband exemptions may be permitted subject to LIGO approval. Rough pumping equipment, used intermittently to initiate pumpdowns, may be exempted for limited periods as provided in Section 4.2.

4.6.3 Vibration

The Vacuum Equipment shall be designed in such a way that vibration from all simultaneously operating vacuum equipment, in the absence of vibration from other sources, shall not induce motion of the walls of any vacuum chamber or of the facility floor within 1 meter of any chamber which exceeds the following spectral density limits (Table 2). Limited narrowband exemptions may be permitted subject to LIGO approval. Rough pumping equipment, used intermittently to initiate pumpdowns, may be exempted for limited periods as provided in Section 4.2. Compliance with this specification may be demonstrated by any combination of measurements and analysis, subject to LIGO approval.

Table 2: Maximum allowable spectral density of chamber or floor vibration induced by operation of LIGO vacuum equipment.

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

4.6.4 Electromagnetic Emissions

All electrical equipment shall meet commercial standards for EMI.

4.6.5 Particulates and other contaminants

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

out insulation may be exempted from this if it can be shown that reasonable cleaning procedures and a reasonable time period will restore the environment.

4.7 Interfaces

The following interfaces shall be provided for and fully documented:

- LIGO Interferometers to the vacuum equipment.*
- Vacuum equipment to the beam tube.**
- Vacuum equipment to the buildings and utilities.***
- Vacuum equipment to process control system.***

* ICD to be provided by LIGO.

** ICD to be provided by Beam Tube Installer.

*** ICDs to be provided by the Vacuum Equipment Contractor.

4.8 Design Life

The contractor shall design the vacuum equipment for a minimum serviceable life of 20 years assuming equipment is maintained and operated in accordance with vendors' recommendations.

4.9 Environmental

Under normal operations, the vacuum equipment will be operated in a temperature and humidity controlled environment. In case of power or control failure, and during the construction phase, conditions will be dictated by diurnal and seasonal ranges. Exposure to these conditions shall not damage the vacuum equipment provided that equipment is maintained, stored and operated in accordance with vendors' recommendations.

5.0 SUBSYSTEMS

5.1 Vacuum Enclosure Subsystem

The vacuum enclosure includes all components such as chambers, tubes, flanges, elbows, tees, blank-offs, and other fittings, which form the barrier between atmosphere and vacuum. These components are required to be compatible with use at 1×10^{-9} torr. Specific requirements are below.

5.1.1 Materials

All fabricated components exposed to vacuum shall be made from type 304L or 316L stainless steel, using low carbon weld filler wire, or aluminum alloys where required. Standard catalogue items of 304 or 316 stainless steel are acceptable if not available in 304L or 316L. Copper, aluminum, and prebaked Viton may be used for seals. Vacuum feedthroughs may utilize UHV compatible glass or ceramic. All other materials are subject to LIGO approval. Copies of mill test reports of chamber, tube and flange materials shall be furnished. Internal surface finish is subject to LIGO approval.

5.1.2 Cleaning

All surfaces exposed to vacuum or purge gas shall be cleaned in accordance with procedures approved by LIGO prior to fabrication and installation; surface recontamination shall be prevented during all subsequent processes.

All items shall be wrapped or sealed after cleaning to maintain cleanliness through handling, transportation, and storage. Care shall be taken to minimize exposure to corrosive environments, such as those containing chloride compounds. No visible contaminant (viewed with the naked eye, under both natural and ultraviolet light) of any form shall be left within the vacuum enclosures or purge system piping when installed (for example: water, dust, sand, hydrocarbon film, etc.).

5.1.3 Welding

All welding exposed to vacuum shall be done by the tungsten-arc inert-gas (TIG) process. Exceptions may be allowed subject to LIGO approval. Welding techniques shall deviate from the ASME Code in accordance with the best ultra high vacuum practice to eliminate any virtual leaks in the welds; 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.

5.1.4 Alignment and Dimensions

All chambers shall be aligned to within 2mm of the design optical axis in both transverse directions and to within 25mm of the design position in the axial direction. Unless noted otherwise, dimensions of chambers (including interconnecting tubes) refer to nominal internal dimensions. All other dimensions shall be +/- 3mm, +/- 1 degree, and +/- 3mm per 3 meter section of tube.

5.1.5 Mechanical Loads

All vacuum components shall be anchored to the floor or to each other so as to restrict all motion to bellows units. The floor anchors shall be supplied and installed by the contractor. The design of the vacuum enclosure shall allow for strains and stresses due to the following: normal cycling of the station HVAC (heating, ventilating, and air conditioning) system (expected to maintain temperature within a range of +/- 2 C); variations in atmospheric pressure; vacuum cycling of other sections of the vacuum enclosure; bakeout of any vacuum section; failure or non-operation of the HVAC.

5.1.6 Design

Each vacuum element with a diameter greater than 12 inches shall be designed according to the latest edition of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1

and its subsequent addenda (except as noted in 5.1.3), even though vacuum chambers lie outside of the scope of that document. Alternate design methods may be employed subject to LIGO approval. Code certification and stamping are not required. All separable parts shall be fully interchangeable between assemblies. Adequate clearance shall be provided for assembly of mating flanges, and for handles. External access shall be provided to all vacuum seams for leak checking. All vacuum elements heavier than 50 lbs shall have lift lugs installed and each chamber assembly shall have an electrical ground connection (removable for diagnostic purposes). Calculations shall be made to determine design features, including the need for and the size of any reinforcements due to openings. Chambers shall be designed to withstand the loadings exerted by all applicable loads in accordance with the provisions of all applicable codes and standards. All chambers shall be designed to be free standing to allow blanked-off leak checking. To determine the probability of earthquakes and seismic coefficients in various areas of the United States, Standard ANSI A58.1 (ASCE Minimum Design Loads for Buildings and Other Structures) shall be applied.

5.1.7 Chambers

All optics are housed in two types of chambers. These chambers contain the seismic isolators and alignment mechanisms which support the optical elements. The two chambers are designated BSC and HAM.

5.1.7.1 Beam Splitter Chamber (BSC)

The Beam Splitter Chamber (BSC) configuration is shown in Figure 8.

5.1.7.2 Horizontal Axis Module (HAM)

The Horizontal Axis Module (HAM) configuration is shown in Figure 9. One spare HAM is required at the Washington site.

5.1.8 Attachment Brackets

Both chamber types shall have internal attachment brackets as shown in Figure 10. These brackets will be used to support lightweight optical components.

5.1.9 Flanges and Ports

Dual O-ring flanges shall be designed for convenient, quick and easy disassembly and assembly, consistent with reliable sealing. O-rings shall be vacuum quality Viton, free of lubricant, and baked to remove contaminants. O-ring grooves shall retain the O-ring during assembly/disassembly. Flange centering pins shall be tapered, rounded, and replaceable; centering pins for flange sets in the vertical plane shall support the weight of the mating cover. Except for the case of chamber to chamber connections, flange centering pins shall be included in the chamber flange of flange sets in the vertical plane, and the lower flange of flange sets in the horizontal plane. Port designs shall provide for maximum aperture and minimum neck length. Where applicable designs shall conform to ISO Standard 2861.

5.1.10 Access Connectors

The 152 cm diameter short tube sections located at BSC 2 and BSC 4 are defined as access connectors, and shall be designed for convenient removal and installation. As a minimum the total axial space required at these locations is 90 cm. The bellows portion shall be as short as practical to allow addition of side access ports in the future. A similar access connector is required at BSCs 7and 8.

5.1.11 Optical Baffles

All connecting tubes shall be designed to allow for installation of optical baffles at a later date. This requirement can be met by allowing access to all internal surfaces.

5.1.12 Annular Spaces

The annuli of each chamber shall be connected to a single flange. Pumping speed between this flange and any point of the pumped annulus is to be greater than 0.3 liters/sec for air. in molecular flow. Interconnecting tubing shall be routed close to the chamber wall, with all connections to be welded or CF flanges.

5.1.13 Fasteners

Flange fasteners shall be of high quality, appropriate for efficient assembly and disassembly. All fasteners shall be plated or made of alloys which allow use without lubricants. Floor anchors need not be plated. Where possible plate nuts shall be used.

5.1.14 Component Leak Rate

The contractor shall ensure that all leaks greater than 1×10^{-9} torr liter/second of helium on each chamber or tube section are repaired at the site of manufacture according to LIGO approved procedures. Leak checking procedures shall conform to ASTM E498 Standard Test Methods for Leaks Using the Mass Spectrometer Leak Detector.

5.1.15 Workmanship, Finish, and Appearance

The finished product shall be free of weld spatter, cutoff spatter, free iron, weld oxidation and defects. There shall be no grinding or abrasion of completed welds or internal vacuum surfaces.

5.1.16 Marking

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

5.2 Pumping Subsystem

Vacuum pumps include portable roughing pumps, stationary backing pumps, annulus pumps. main ion pumps, and 80K pumps. The roughing pumps are used to pump the systems down from atmosphere to 10^{-6} torr. The ion pumps, and 80K pumps are used for vibration-free pumping during normal operation.

The main pumping phases include:

- Initial Pumpdown (from 760 torr to less than 1 torr): Roots roughing pump sets are to be used. Smaller volumes may only require roughing with the turbo backing pumps. The duration of this phase is limited to 4 hours per vacuum section for all sections in the corner stations. See Section 4.2.
- *Intermediate Pumpdown* (from 1 torr to less than 10^{-6} torr): Turbo molecular pump sets are to be used. The duration of this phase is expected to be of order 24 hours. Low noise and vibration are required.
- Final Pumpdown and normal operation (below 10^{-6} torr): No mechanical pumps may be used. Ion pumps and cryogenic pumps are to provide continuous pumping without vibration.

5.2.1 Roughing Pumps

The roughing pumps shall consist of two types of portable pump stations and stationary backing pumps, the main roughing pump set and the turbo molecular pump sets. The main roughing pump set shall be used for pumping from atmosphere to less than 1 torr while the turbo molecular pump set shall be used for pumping from 1 torr to less than 10^{-6} torr. The main roughing pump sets are exempt from the vibration and acoustic noise limits. The turbo molecular pump sets, however, shall be designed to operate for extended periods of time without contributing to vibration and noise levels beyond those described in Section 4.6. The design of the roughing pumps shall preclude contaminating the beam tubes and chambers during the life of the equipment, even with equipment failures and operator mistakes.

5.2.1.1 Main Roughing Pump Sets

Each main roughing pump set shall consist of a roots blower backed by one or more backing pumps. Four sets are required in total. The minimum pumping speed at 1 torr at the pump inlet shall be 500 CFM and at 0.1 torr, 1000 CFM. There shall be no oil in the pumping path. The pump set shall be self contained so that under power failure or pump failure, interlocks shall prevent the pumped chambers from being vented. The pump set shall be capable of roughing volumes as large as the 2 km beam tube module (volume 2000 m^3) without overheating. Provisions for connection to the control system shall be provided. Provision for sealed connection to a ducted facility exhaust system shall be provided. There shall be vacuum gauges located at each pump inlet (both the roots pump and the backing pump) and there shall be auxiliary valved (manual) ports to allow connection of a leak detector. All unused connections shall be fitted with blankoff flanges.

5.2.1.2 Turbo Molecular Pump Sets

Each turbo molecular pump set shall consist of a wide range magnetically levitated turbo molecular pump backed by an oil free pump (diaphragm, piston, or scroll pump). Ten sets are required in total. The minimum pumping speed at the roughing port shall be 1400 liters/sec for nitrogen at 10^{-3} torr. Throughput at a backing pressure of 1 torr shall be at least 5 torr liters/second. The pump set shall be capable of pumping large

volumes (2000 m3) without overheating. The pump set shall be self contained so that under power failure or pump failure, interlocks shall prevent the pumped chambers from being vented or exposed to pump lubricants. Provisions for connection to the control system shall be provided. There shall be vacuum gauges located at each pump inlet (both the turbo pump and the backing pump) and there shall be auxiliary valved (manual) ports to allow connection of a leak detector or auxiliary backing turbo. All unused connections shall be fitted with blankoff flanges.

5.2.2 Main Ion Pumps

The main ion pumps, positioned as shown in Figures 2 and 3, have nominal pumping speeds of 2500 liter/sec minimum for nitrogen. Each main ion pump shall have a manual isolation valve as well as a manual pump out valve. The minimum life of the pumps shall be 40,000 hours or more at an operating pressure of 10^{-6} torr. Noble gas diode-type ion pumps shall be used. If required for starting purposes, or to avoid the use of custom power supplies, multiple power supplies and feedthroughs may be employed to operate each pump. The ion pump design shall allow starting at pressures of 1×10^{-5} torr. However, the power supplies need only be capable of providing starting current for 1×10^{-6} torr. Ion pump power supplies shall be mountable in standard 19 inch racks. All ion pump power supplies shall have remote control capability with both current and voltage signals remotely readable.

5.2.3 80K Pumps

There are two types of 80K pumps: long and short. The long 80K pumps shall have a cylindrical cold surface 3.7 m long and the short 80K pumps shall have a cold surface 1.2 m long. All other features of the 80K pumps shall be identical. The pumping surface shall be coaxial with the beam tube axis, and provide a clear aperture of at least 1.30 m, warm or cold. The aperture at the pump flanges and necks shall be that of the adjacent gate valves. The 80K pumps may be of the liquid nitrogen, continuous flow, or refrigerated design. In any case the vibration requirements of section 4.6 shall be met.

Certain parts of the 80K pumps may have large thermal gradients which may give rise to local, intermittent release of gas. The design shall preclude the sudden and direct release of this gas into the optical path. Each 80K pump shall have a removable beam tube section at one end to allow insertion of optics components. The minimum length required for this section is 60 cm.

5.2.4 Annulus Pumps

Auxiliary turbo molecular pump sets (auxiliary turbo carts) shall be provided for roughing of the annular spaces. Ten pump sets are required. The pump sets shall be self contained so that under power failure or pump failure, interlocks shall prevent the pumped volumes from being vented. Provisions for connection to the control system shall be provided. These pump sets shall use an oil free backing pump to minimize the risk of contamination of the annuli. Each chamber shall have a 200l/s (maximum) ion pump to maintain the annular vacuum. The ion pump shall be isolatable from the annuli with a hand valve. Noble gas diode pumps shall be used. The minimum annulus ion pump used anywhere

shall be at least 20l/s. All ion pump power supplies shall have remote control capability with a remotely readable current signal.

5.3 Valve Subsystem

5.3.1 Gate Valves

All gate valves shall be stainless steel with metal sealed flanges or weld fittings where appropriate, and metal bellows stem feedthroughs. O-ring seals are allowed on the beam line flanges. Only non-contaminating and non-migratory lubrication shall be used on the internal mechanisms. Valve body and flange leakage shall be measured to be less than 10^{-10} torr liter/sec of helium before installation. 112 cm and larger gate valves shall have double viton gate seals. Annular spaces between gate valve seals shall be isolatable. This space shall be provided with a blanked-off port. All gate seals shall be leak free to a level of 10^{-9} torr liter/sec of helium. Valves of the same size and type shall be identical to minimize the number of required spare parts. All valves shall be rated for 10000 cycles before service is required. All valves, regardless of operation (electric, pneumatic, or manual), shall be protected from accidental operation. Such protection may be provided by mechanical, electrical, or procedural means. In instances where accidental venting is possible, redundant means shall be employed.

5.3.2 Small Valves

Small valves (less than 15cm aperture), such as right angle manual valves, shall be all metal and bakeable to 150C. Exceptions are those valves which are used on the o-ring annuli and those which are mounted on the portable pump stations. These may be viton sealed. All metal sealed valves shall be rated for 10000 cycles before service is required.

5.4 Vent and Purge Subsystem

Components inside each of the chambers shall be protected against particulate and hydrocarbon contamination at all times: when chambers are open, while venting to air, during opening and closing, and when closed, including pumpdown. This protection against particulates shall be equivalent to exposure within a Fed. Std. 209 Class 100 clean room. The vacuum enclosure area of each station will be constructed with materials consistent with a Fed. Std. 209 Class 50,000 clean room. Vent and purge systems shall be provided with valved and pressure limited, Class 100 air with a water vapor dew point of less than -60 degrees Celsius. The vent and purge system shall not introduce hydrocarbons into the purge air stream. There shall be one 200 CFM system available in the corner stations and 50 CFM systems elsewhere. No systems are required at the LA mid stations.The air compressors shall be mounted in the designated mechanical room areas. The purge system shall allow for the connection of air shower manifolds in the chambers, used to distribute purge gas over the optical components inside the chambers. Additionally, portable soft-wall cleanrooms shall be provided to allow coverage of open chamber ports. The cleanrooms shall be designed per Federal std. 209 (Methods at rest approach). Air flow shall be designed to optimize particulate removal. Unidirectional air flow is not required. A total of 13 portable units are required (8 for the Washington site).

5.5 Bakeout Subsystem

Insulation and heating equipment shall be modular so as to allow efficient removal and placement. There need only be enough equipment to bake the largest contiguous vacuum section at one time; however, the equipment shall be capable of baking any of the vacuum sections. Bakeout controls shall be sufficient to ensure that the performance requirements are met.

5.6 Monitor and Control Subsystem

Vacuum monitoring and control equipment includes Pirani gauges, ion gauges (cold cathode), process controllers for the large valves, and process controllers for the 80K pumps. Gauge tubes shall be mounted on 2 3/4 inch metal seal CF flanges at the locations shown in Figures 2 and 3. There shall be two auxiliary ports (one 2 3/4 and one 4 1/2 inch CF) complete with all metal valves and blankoffs for each BSC chamber. The 4 1/2 inch CF port is reserved for RGA sensors (to be provided by LIGO). There shall be sufficient controls logic (including hardware and software) to safely operate and commission each vacuum section. Site wide functions such as data logging and control room operations will be provided by the LIGO control system. The interfaces to this system shall consist of discrete digital and analog signals. Signal types, cabling and connectors are subject to LIGO approval. The suggested signal levels are listed below:

- Analog Input 0 to 10 VDC, input impedance greater than 1 Kohm.
- Analog Input 4-20 mA, input impedance 600 ohms nominal.
- Analog Output 0 to 10 VDC, output current drive 10 mA minimum.
- Analog Output 4-20 mA, voltage compliance 15 VDC maximum.
- Discrete Input 24 VDC, input impedance greater than 1 Kohm, or contact closure with contacts rated at 24VDC, 500mA.
- Discrete Output 24 VDC, 100 mA maximum.
- Discrete Contact Output 24 VDC, 1 A maximum.
- RTD Temperature Measurement ISO 385 curve platinum RTDs, 100 or 1 Kohm.
- Thermocouple Measurement Types B, R, S, E, T, J, K.

Input is defined as an input to LIGO controls from the Vacuum Equipment. Output is defined as output from LIGO controls to the Vacuum Equipment. All Vacuum Equipment electronics shall be supplied complete with standard 19" racks, however, vacuum gages are allowed to be of the "smart gage" type and do not require rack mounting.

5.6.1 Vacuum Gauges

Vacuum instrumentation shall be provided for pressures from atmospheric down to 1×10^{-9} torr (N_2 equivalent). Each chamber and beam tube section which can be isolated shall have installed one Pirani gauge, and one cold cathode gauge. Vacuum gages may be self contained "smart gage" type. Connectors for all vacuum gauges shall have locking, positive contact to the mating vacuum feedthrough, properly shield the high voltage and signal connectors, and provide proper strain relief.

5.6.1.1 Pirani Gauges

Pirani gauges shall operate from atmosphere to 10^{-4}torr. The controller shall have at least one setable process control contact or setpoint if commercially available. The gauges shall be installed on CF flanges and be bakeable to 200 degrees Celsius.

5.6.1.2 Cold Cathode Gauges

Cold cathode gauges shall operate from 10^{-3} torr to 1x10-9 torr. The controller shall have at least one setable process control contact or setpoint if commercially available. The gauges shall be installed on CF flanges and be bakeable to 250 degrees Celsius.

6.0 QUALITY ASSURANCE

6.1 Test Plans

Detailed plans including descriptions of the test equipment and procedures for the qualification, screening, and acceptance tests shall be approved by LIGO prior to use. Of particular interest are the qualification requirements for large gate valves.

6.1.1 Control of Contamination

Detailed plans to ensure control of cleanliness shall be approved by LIGO.

6.1.2 Component Acceptance Tests

6.1.2.1 Chamber and Tube Leak Tests

The contractor shall document helium leak rates on each vacuum chamber or tube section as part of the fabrication process. No vacuum chamber or fabricated tube section shall be field installed without first demonstrating acceptable leakage.

6.1.2.2 Pumps

Each electrically powered vacuum pump shall be tested (or certified) for speed, ultimate pressure, leakage, noise and vibration, and operation of protective features, before shipment from the manufacturer.

6.1.2.3 Valve Tests

Each vacuum valve shall be tested for leakage prior to shipment from the manufacturer. For dual gate seals, each seal shall be individually tested. As well, each vacuum valve (including each individual gate seal) shall be tested for leakage after installation on the LIGO vacuum system. Operation of each valve shall also be demonstrated.

6.1.3 System Acceptance Tests

6.1.3.1 Leakage

All vacuum leaks greater than the limit set by the system requirements section shall be measured, repaired and documented.

6.1.3.2 Pumpdown

Pumpdown from atmosphere to ultimate pressure (100 hours pumping) shall be performed on all vacuum sections and documented.

6.1.3.3 Noise and Vibration

Acoustic noise shall be measured and documented at the vacuum chamber walls with vacuum equipment operating in each of the 3 modes described in Section 5.2. Additionally, background levels shall be measured and documented as well. Vibration levels at the floor near the chambers shall be measured and documented, both with and without simultaneous operation of all of the vacuum equipment. All tests shall be conducted per the statement of work.

6.1.3.4 Purge System

A test shall be developed to ensure the cleanliness of the purge air supply system.

6.1.3.5 Control and Monitoring

Operation of each vacuum gauge shall be demonstrated after installation. Operation of each vacuum pump and each valve shall be demonstrated after installation. Operation. temperature uniformity, and temperature stability of the bakeout system shall be demonstrated.

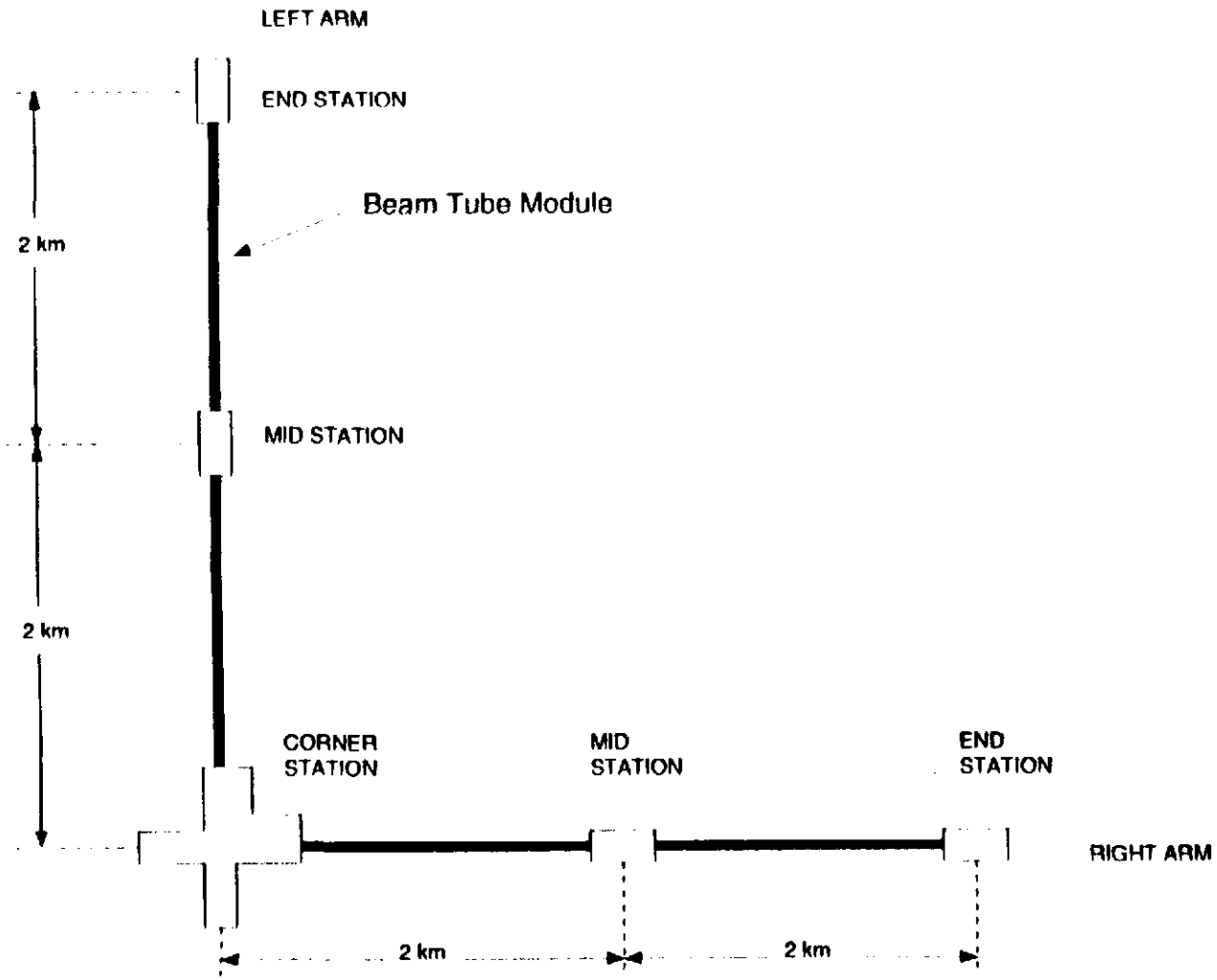


Figure 1. LIGO Geometry

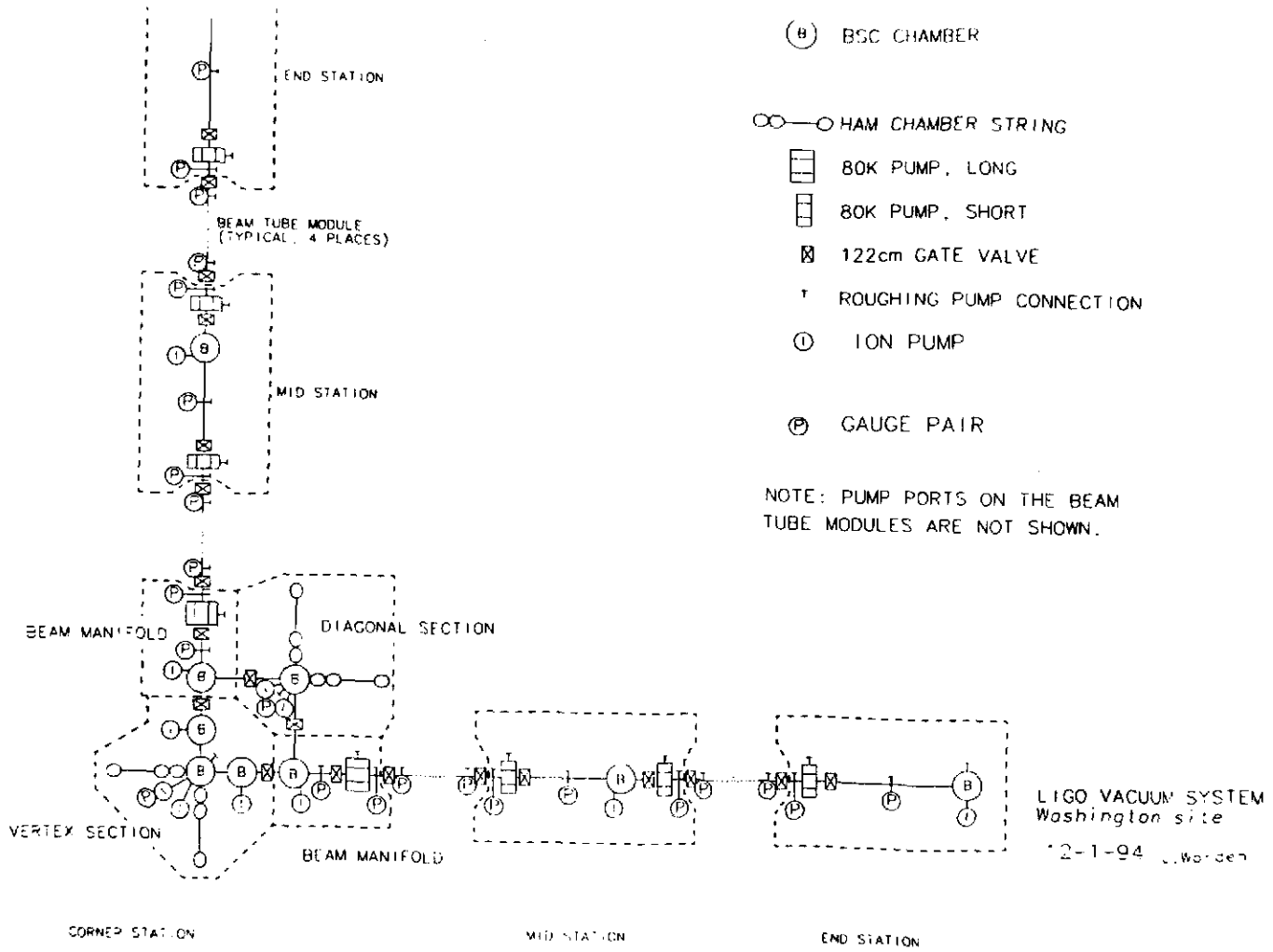
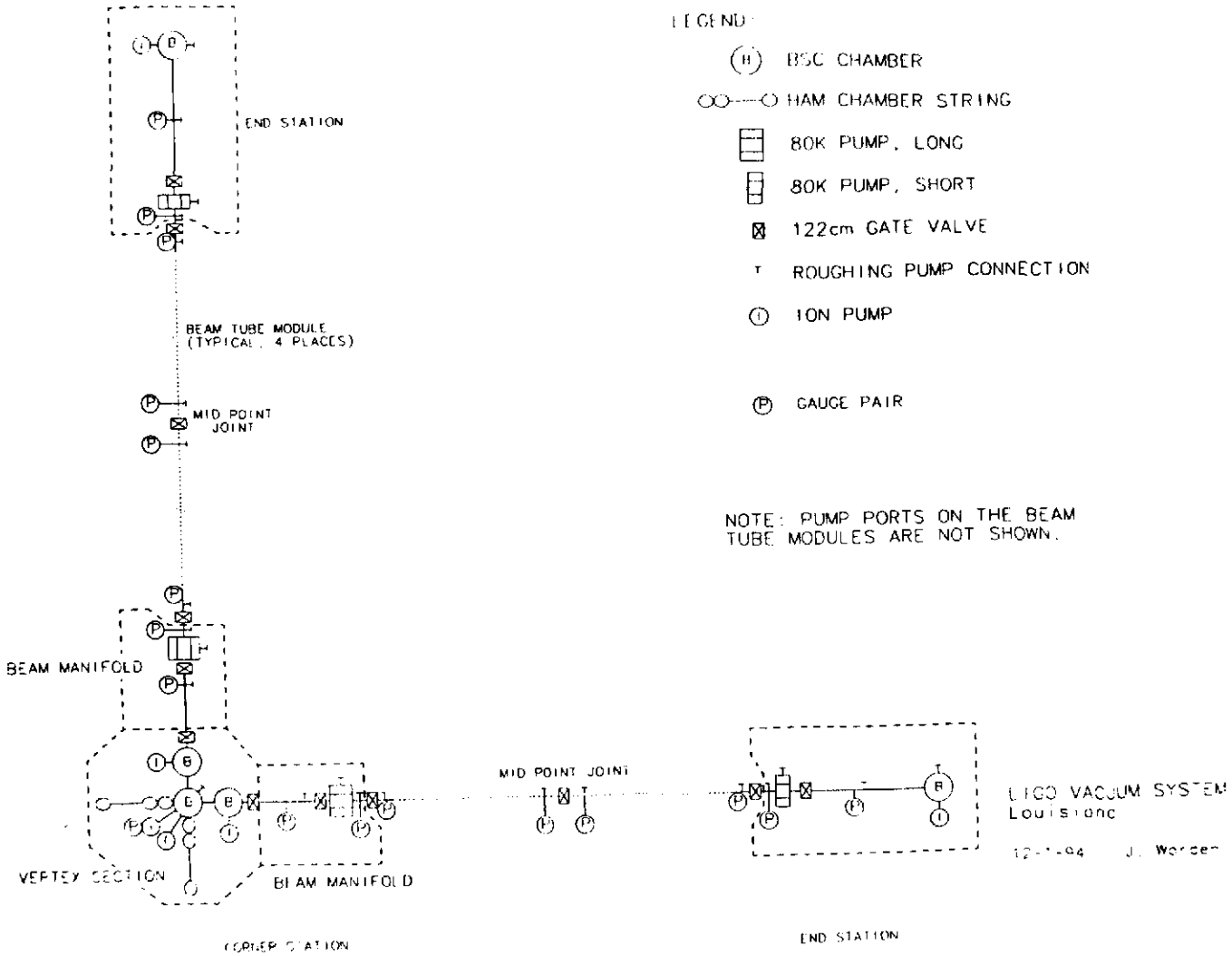
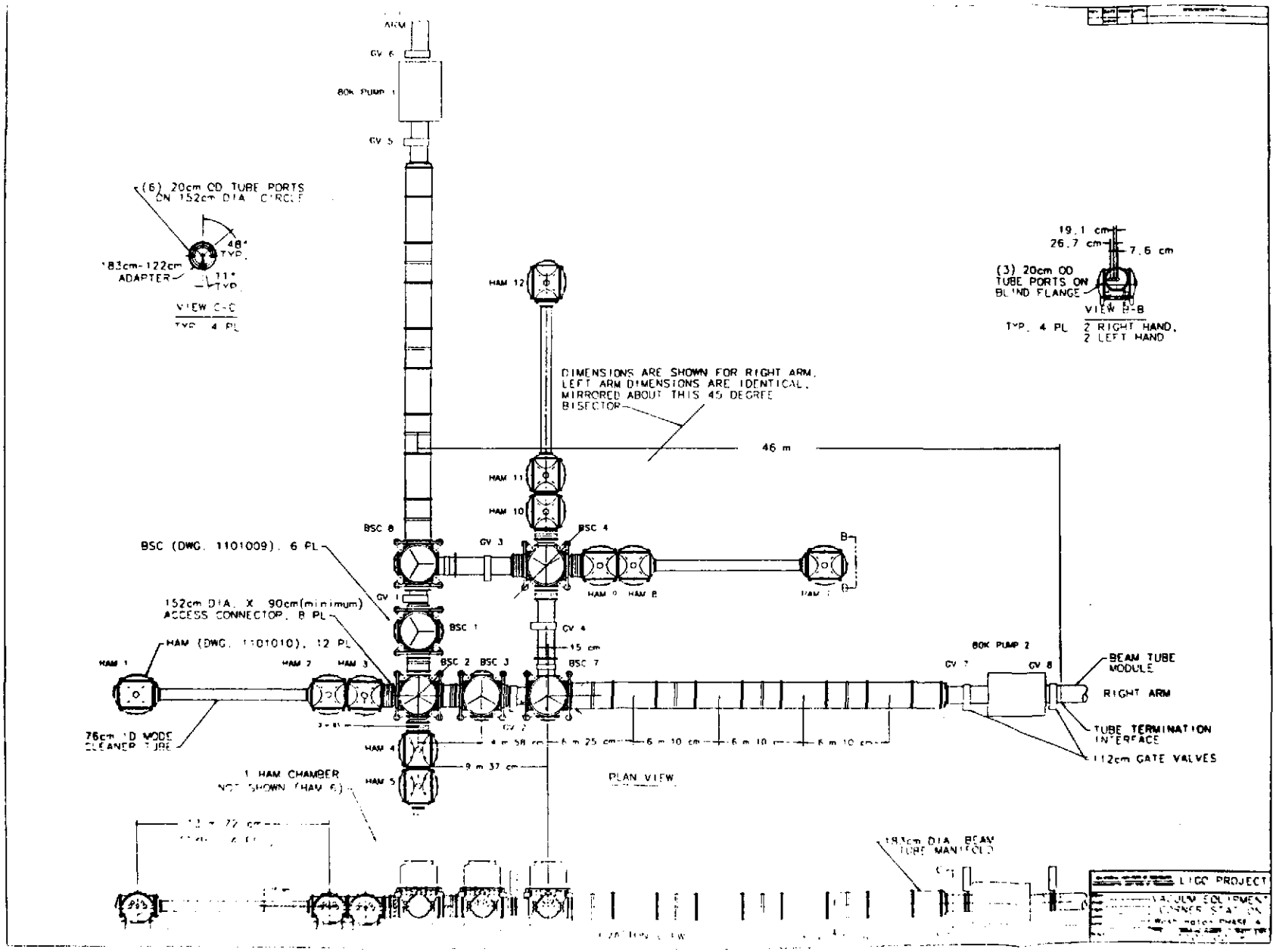
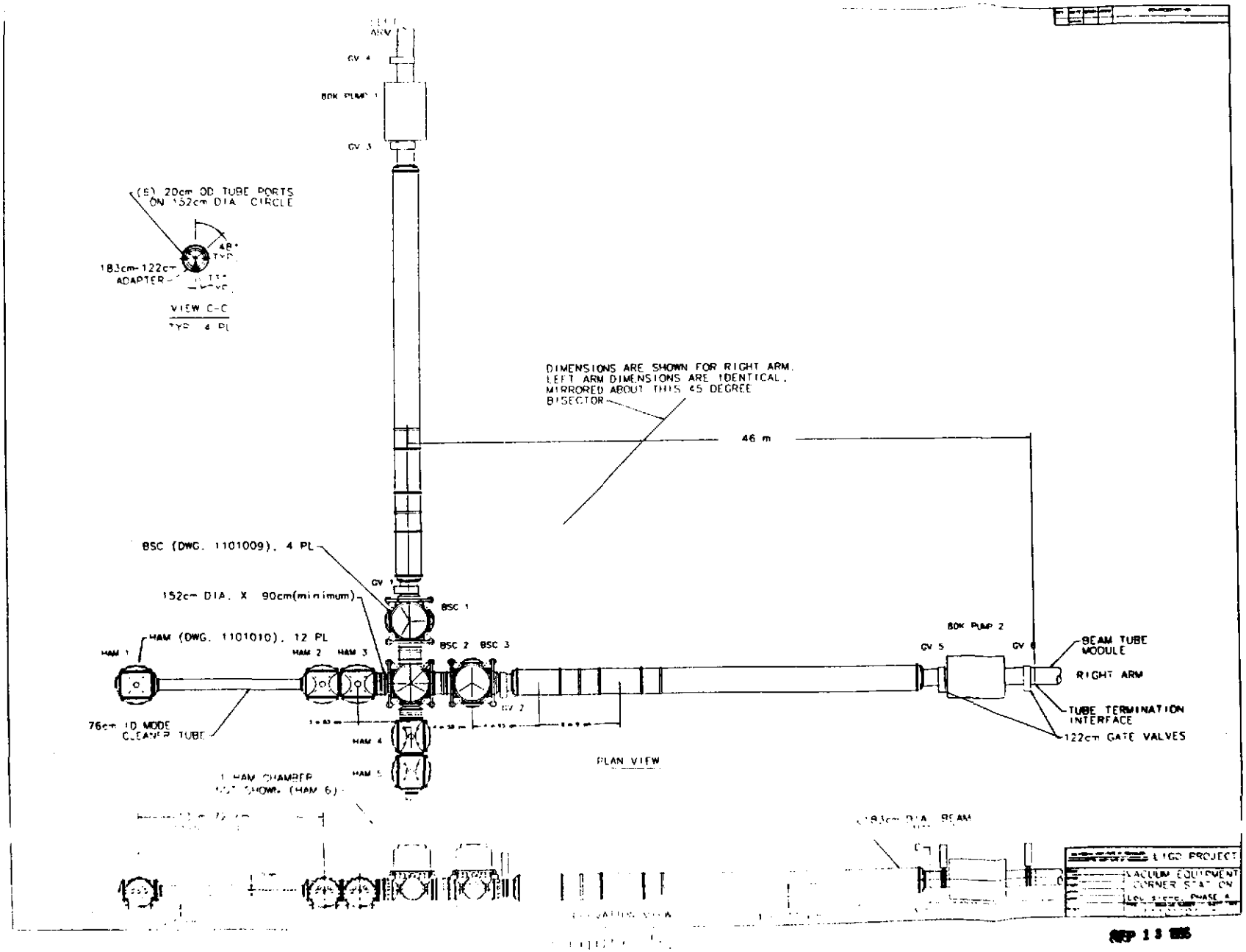
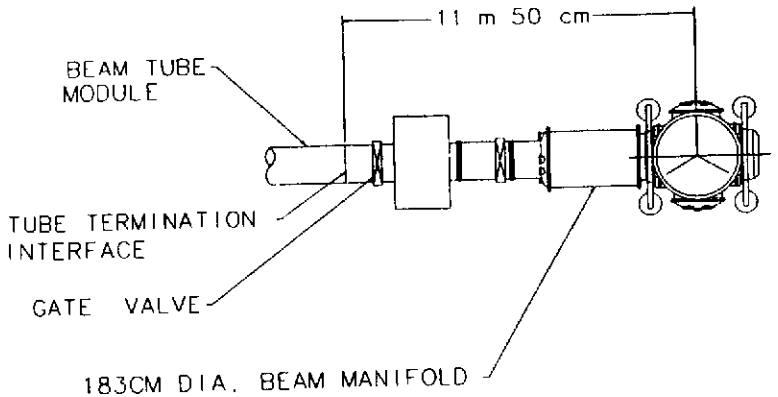


Figure 2.


END STATION
BEAM TUBE MODULE
(TYPICAL, 4 PLACES)
MID POINT
JOINT
BEAM MANIFOLD
VERTEX SECTION
BEAM MANIFOLD
CORNER STATION
MID POINT JOINT
END STATION
LEGEND:
BSC CHAMBER
HAM CHAMBER STRING
80K PUMP, LONG
80K PUMP, SHORT
122cm GATE VALVE
ROUGHING PUMP CONNECTION
ION PUMP
GAUGE PAIR
NOTE: PUMP PORTS ON THE BEAM
TUBE MODULES ARE NOT SHOWN.
LIGO VACUUM SYSTEM
Louisiana
12-1-94 J. Worden


ARM
GV 6
80K PUMP 1
GV 5
(6) 20cm OD TUBE PORTS ON 152cm DIA. CIRCLE
48° TYP.
183cm-122cm ADAPTER
11° TYP.
VIEW C-C
TYP. 4 PL
19.1 cm
26.7 cm
7.6 cm
(3) 20cm OD TUBE PORTS ON BLIND FLANGE
VIEW B-B
TYP. 4 PL
2 RIGHT HAND, 2 LEFT HAND
HAM 12
DIMENSIONS ARE SHOWN FOR RIGHT ARM. LEFT ARM DIMENSIONS ARE IDENTICAL, MIRRORED ABOUT THIS 45 DEGREE BISECTOR
46 m
HAM 11
HAM 10
BSC 8
BSC 4
GV 3
BSC (DWG. 1101009), 6 PL
B
HAM 9
HAM 8
HAM 1
GV 1
152cm DIA. X 90cm(minimum) ACCESS CONNECTOR, 8 PL
BSC 1
GV 4
15 cm
HAM (DWG. 1101010), 12 PL
HAM 1
HAM 2
HAM 3
BSC 2
BSC 3
BSC 7
80K PUMP 2
GV 7
GV 8
BEAM TUBE MODULE
RIGHT ARM
76cm ID MODE CLEANER TUBE
GV 2
4 m 58 cm
6 m 25 cm
6 m 10 cm
6 m 10 cm
6 m 10 cm
TUBE TERMINATION INTERFACE
112cm GATE VALVES
HAM 4
9 m 37 cm
HAM 5
1 HAM CHAMBER NOT SHOWN (HAM 6)
PLAN VIEW
183cm DIA. BEAM TUBE MANIFOLD
LIGO PROJECT
VACUUM EQUIPMENT
SEP 18 95


GV 4
80K PUMP 1
GV 3
(8) 20cm OD TUBE PORTS ON 152cm DIA. CIRCLE
45° TYP
183cm-122cm ADAPTER
VIEW C-C
TYP 4 PL
DIMENSIONS ARE SHOWN FOR RIGHT ARM. LEFT ARM DIMENSIONS ARE IDENTICAL, MIRRORED ABOUT THIS 45 DEGREE BISECTOR
46 m
BSC (DWG. 1101009), 4 PL
152cm DIA. X 90cm(minimum)
GV 1
BSC 1
HAM (DWG. 1101010), 12 PL
HAM 1
HAM 2
HAM 3
BSC 2
BSC 3
80K PUMP 2
GV 5
GV 6
BEAM TUBE MODULE
RIGHT ARM
GV 2
76cm ID MODE CLEANER TUBE
TUBE TERMINATION INTERFACE
122cm GATE VALVES
HAM 4
HAM 5
PLAN VIEW
1 HAM CHAMBER NOT SHOWN (HAM 6)
183cm DIA. BEAM
LIGO PROJECT
VACUUM EQUIPMENT
CORNER STATION



END STATION

BOTH SITES WA and LA

LIGO PROJECT
VACUUM EQUIPMENT
END STATIONS

SEP 2 3 1995

Figure 6.

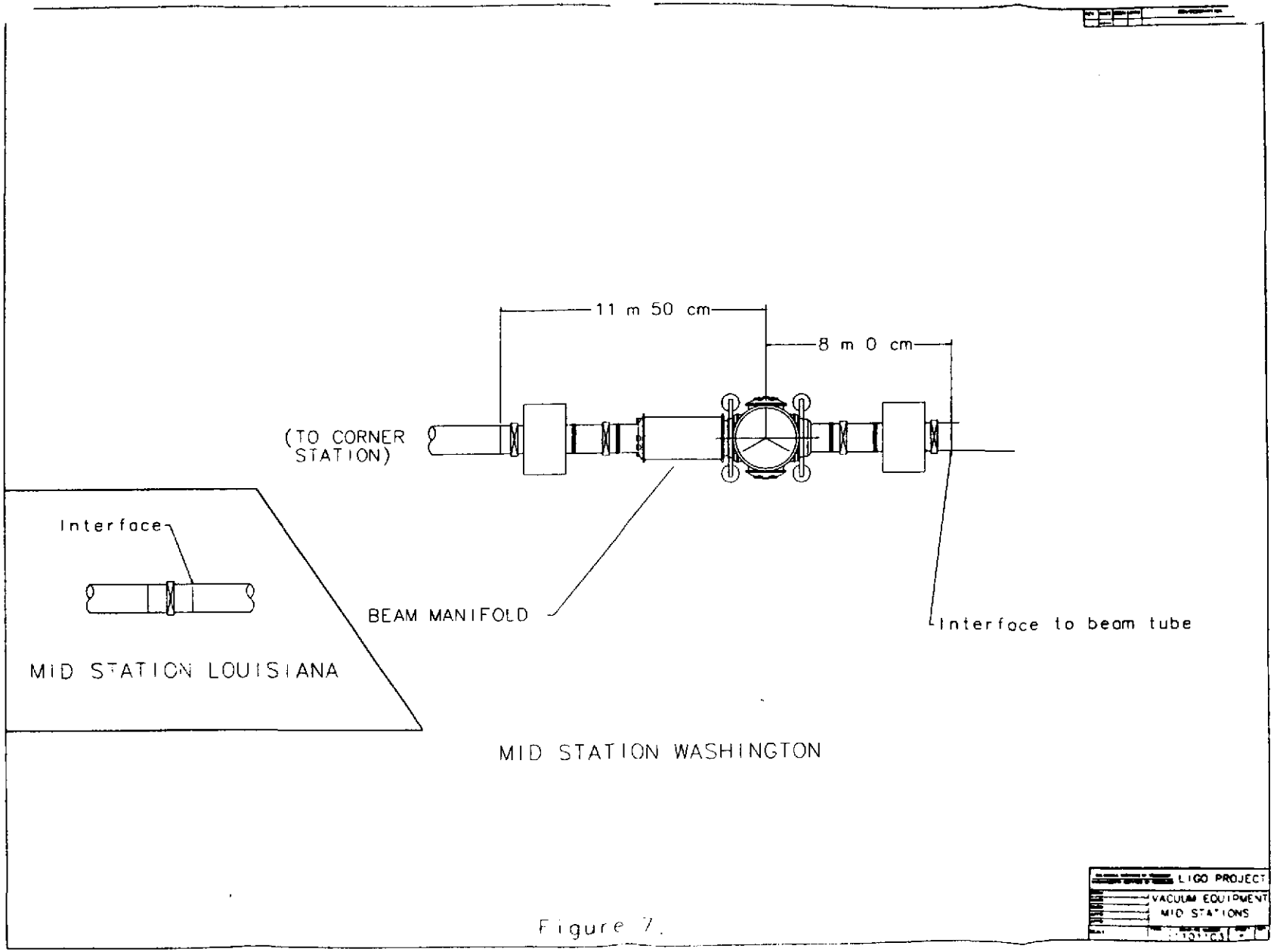

11 m 50 cm
8 m 0 cm
(TO CORNER STATION)
Interface
BEAM MANIFOLD
Interface to beam tube
MID STATION LOUISIANA
MID STATION WASHINGTON
LIGO PROJECT
VACUUM EQUIPMENT
MID STATIONS

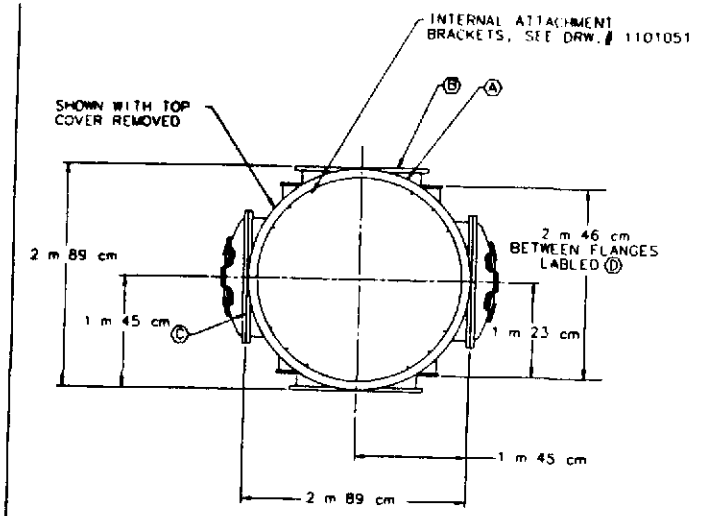
Figure 7.

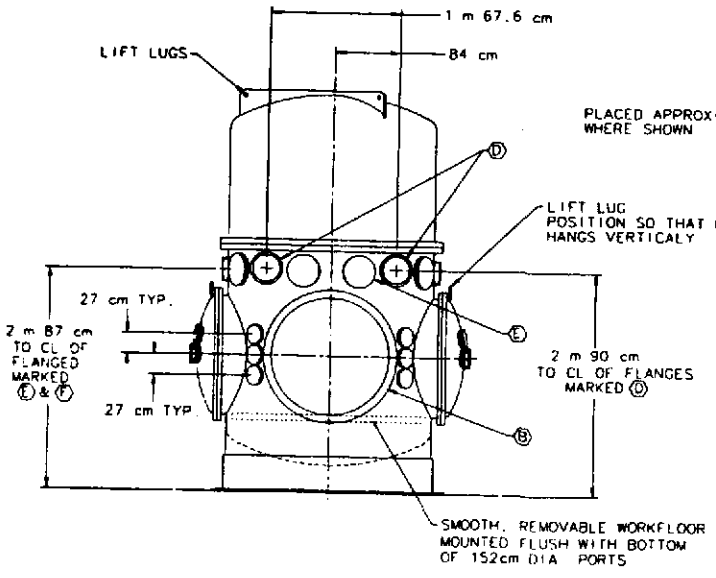
REV	DATE	DRWN	APPD	DCN/DESCRIPTION

NOTES
1. HEADS ARE ASME F&D.
2. INCLUDE CENTERING PINS ON NOZZLE FLANGES WHERE APPROPRIATE.
3. VIEWPORT (ITEM Ⓒ) MEASUREMENTS REFER TO INTERSECTION OF VIEWPORT AXIS WITH OUTER SURFACE OF VACUUM WALL.
4. TOLERANCES, UNLESS OTHERWISE SPECIFIED: LINEAR, ±0.25 CM
   ANGULAR, ± 1 DEGREE
5. NOZZLE SCHEDULE PER TABLE BELOW:

ITEM	SIZE	QUANTITY	FLANGE TYPE	PURPOSE
Ⓐ	264cm ID TUBE	1	O/O-O/METAL*	MAJOR ACCESS
Ⓑ	152cm ID TUBE	2	O/O-O/METAL*	LASER BEAM, ACCESS (MINIMIZE NECK LENGTH)
Ⓒ	152cm ID TUBE	2	O/O-O/METAL*, WITH BLIND FLANGE	ACCESS (MINIMIZE NECK LENGTH)
Ⓓ	35cm OD TUBE	4	CONFLAT**	SUPPORT BEAMS REFERENCE ICD # TBD
Ⓔ	35cm OD TUBE***	8	CONFLAT**, WITH BLIND FLANGE	AIR SHWR, BACK-TO-AIR PURGE ROUGHING & ION PUMPS, UTILITY
Ⓕ	25cm OD TUBE***	6	CONFLAT** WITH BLIND FLANGE	ELECTRICAL FEEDTHROUGHS
Ⓖ	20cm OD TUBE***	22	CONFLAT**, WITH BLIND FLANGE	OBSERVATION, BEAM PICK-OFFS
Ⓗ	3.8cm OD TUBE	1	CONFLAT**, WITH BLIND FLANGE	ANNULUS PUMPOUT (NOT SHOWN)

*DUAL O-RING DESIGN.
THESE FLANGES EACH INCLUDE AN ANNULAR CHANNEL BETWEEN O-RINGS, MANIFOLDED TO A SINGLE PUMPOUT PORT ON EACH CHAMBER, WITH CONFLAT** SEAL.
**REGISTERED TRADEMARK, VARIAN VACUUM PRODUCTS. COMPATIBLE ALTERNATES ARE ACCEPTABLE.
***THESE FLANGES ARE TANGENT TO LOCAL VACUUM WALL, WITH MINIMUM NECK LENGTH.





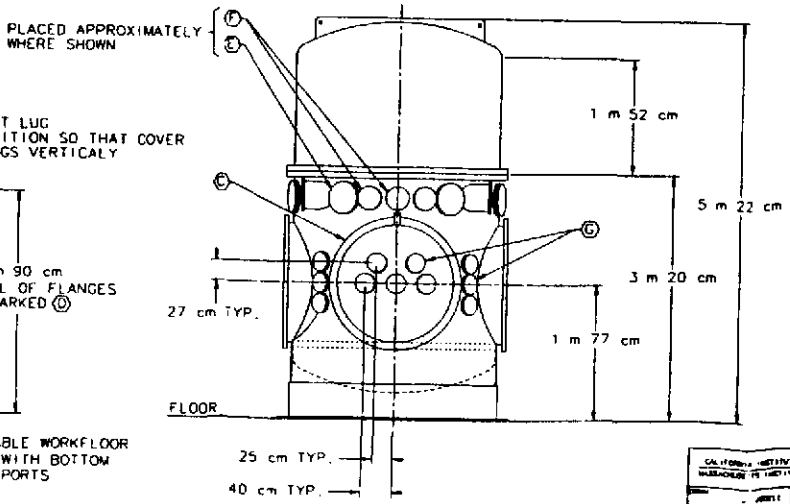


Figure 8.

CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY	LIGO PROJECT
	BEAM SPLITTER CHAMBER (BSC)
SCALE	DRAWING NUMBER 1101009

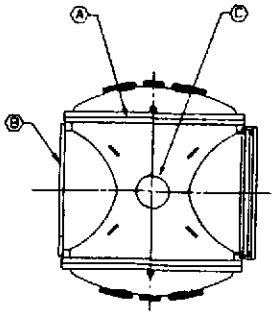
SEP 13 1995

REV	DATE	DRWN	APPD	DCN/DESCRIPTION

NOTES
1. HEADS ARE ASME F&D.
2. INCLUDE CENTERING PINS ON NOZZLE FLANGES WHERE APPROPRIATE.
3. VIEWPORT (ITEM Ⓕ) MEASUREMENTS REFER TO INTERSECTION OF VIEWPORT AXIS WITH OUTER SURFACE OF VACUUM WALL.

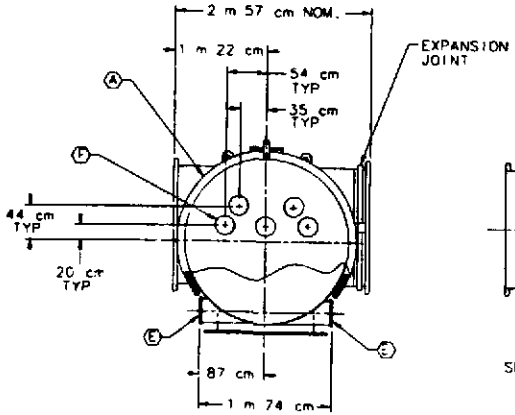
4. TOLERANCES, UNLESS OTHERWISE SPECIFIED: LINEAR, ±0.25 CM
ANGULAR, ± 1 DEGREE

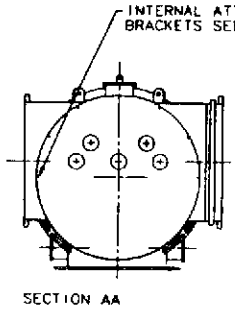
5. NOZZLE SCHEDULE PER TABLE BELOW:



ITEM	SIZE	QUANTITY	FLANGE TYPE	PURPOSE
Ⓐ	213cm ID TUBE	2	O/O-O/METAL*	MAJOR ACCESS
Ⓑ	152cm ID TUBE	2	O/O-O/METAL*	LASER BEAM
Ⓒ	35cm TUBE ***	1	CONFLAT**, WITH BLIND FLANGE	ION PUMP/AIR SHOWERS, BACK-TO-AIR PURGE
Ⓓ	25cm OD TUBE***	8	CONFLAT**, WITH BLIND FLANGE	ELECTRICAL FEEDTHROUGHS, UTILITY
Ⓔ	30cm OD TUBE	4	CONFLAT**	SUPPORT BEAMS REFERENCE ICD # TBD
Ⓕ	20cm OD TUBE***	10	CONFLAT**, WITH BLIND FLANGE	OBSERVATION, PICKOFFS
Ⓖ	3.8cm TUBE	1	CONFLAT**, WITH BLIND FLANGE	ANNULUS PUMPOUT (NOT SHOWN)

* DUAL O-RING DESIGN.
THESE FLANGES EACH INCLUDE AN ANNULAR CHANNEL BETWEEN O-RINGS, MANIFOLDED TO A SINGLE PUMPOUT PORT ON EACH CHAMBER, WITH CONFLAT** SEAL.
** REGISTERED TRADEMARK, VARIAN VACUUM PRODUCTS; COMPATIBLE ALTERNATIVES ARE ACCEPTIBLE
*** THESE FLANGES ARE TANGENT TO LOCAL VACUUM WALL, WITH MINIMUM NECK LENGTH





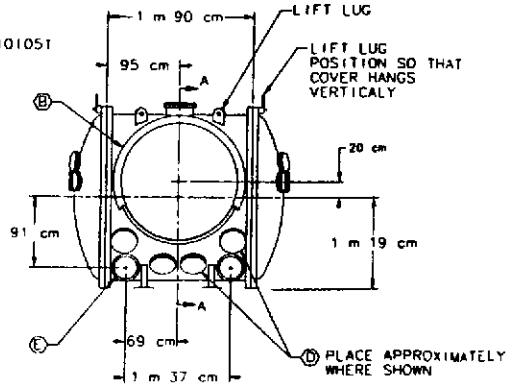


Figure 9.

CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY	LIGO PROJECT	
	HORIZONTAL ACCESS MODULE (HAM)	
	SCALE:	1101010 SHEET 1 of 1 REV

SEP 13 1995

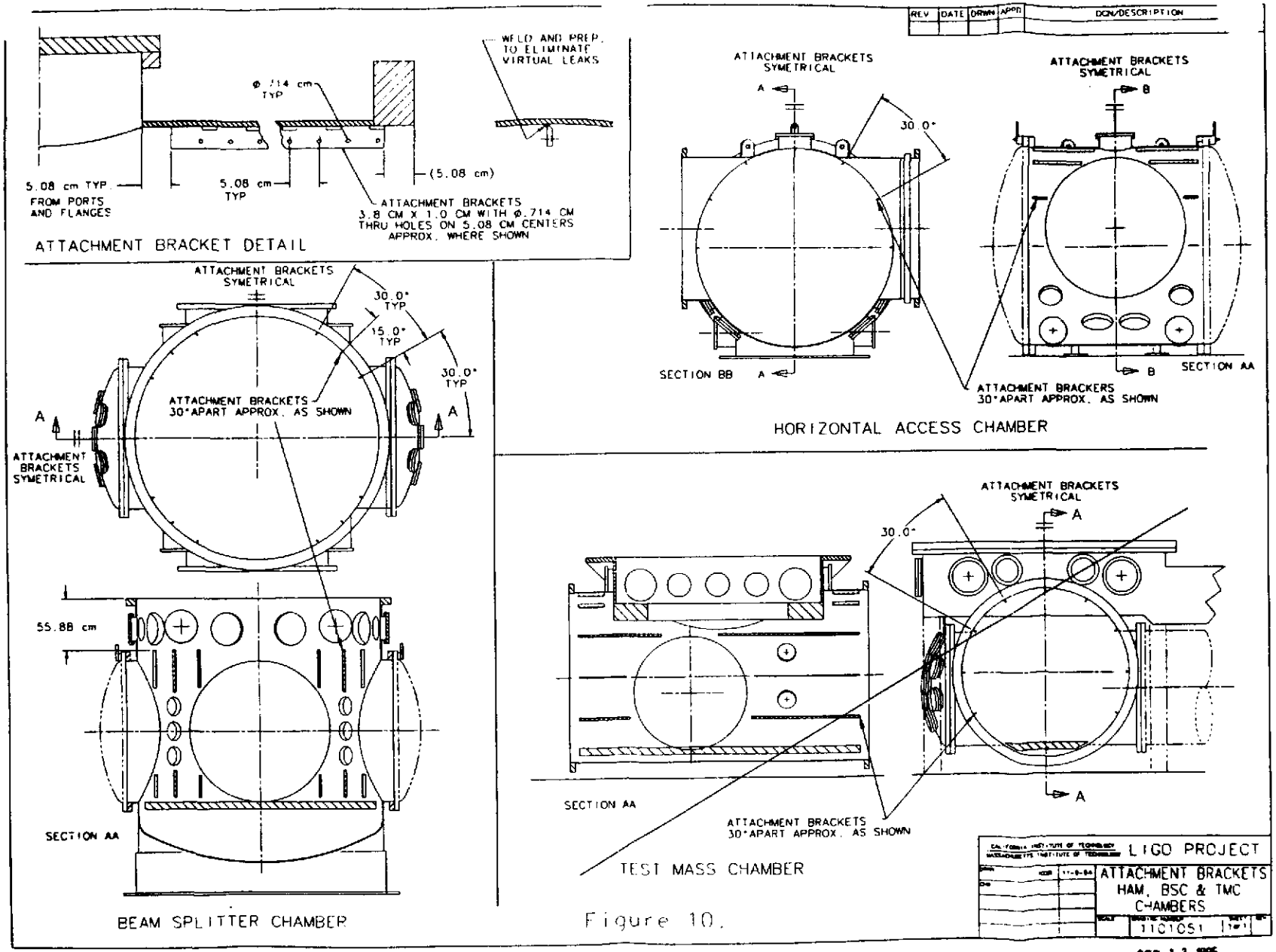


Figure 10.

SEP 13 1995

EXHIBIT II

DELIVERABLE DOCUMENTATION
LIGO-C950804-00-V01

DELIVERABLE DOCUMENTATION

A. The deliverable documentation of this contract is summarized in the following Contract Data Requirements List (CDRL), which identifies the items to be delivered and when delivery is required, the quantity and type of each item, and frequency of issue. Documentation shall be delivered as early as available but no later than the date specified in the CDRL. The Data Requirement Description (DRD) forms referenced in the CDRL describe the specific requirements for the item(s) to be delivered.

B. The Contractor shall display on the cover or title page of all deliverable non-design documentation (i.e., all documents except drawings and specifications) the following minimum information:

- Document Title
- Contract Number
- Document Number (Institute and/or Contractor assigned)
- Program Identification
- Date of Issue
- CDRL Line Item Number
- Approval Status

C. The approval code on the CDRL is defined as follows:
A= Submitted for LIGO's approval.
X= LIGO approval not required.

D. The following applies to all data submitted for approval:

1. The Contractor shall submit the approval draft on or before the date indicated.

2. If the draft is approved, the Contractor will be notified in writing by the LIGO Contract Technical Manager. The Contractor shall then prepare and deliver final copies as indicated in the CDRL.

3. If the submitted approval draft requires significant Contractor modifications before approval will be granted, the following steps shall be taken:

- The required modifications will be transmitted or discussed between the cognizant parties.
- The Contractor shall submit an updated draft, containing the required modifications.
- If the updated draft is approved, the Contractor will be notified in writing by the LIGO

Contract Technical Manager. The Contractor shall then prepare and deliver final copies as indicated in the CDRL.

The approval requirements for revisions shall be the same as applied to the original data item submittal unless otherwise specified.

4. All documentation is to be delivered to the Document Control Center (DCC) in care of MS. Linda Turner, LIGO Project, Mail Stop 51-33, California Institute of Technology, 391 South Holliston Ave. Pasadena CA 91125. The Document Control Center will be the point of official receipt and distribution.

Table 1: CONTRACT DATA REQUIREMENTS LIST

CDRL #	Title or Description of Data	Approval Code	Frequency of issue	Date Due To User	# Copies	Remarks
1	Phase B Update of Preliminary Design					PDR - Preliminary Design Review ARC - After receipt of comments
	Draft	X	Once	3 days prior to PDR	4	
	Final	A	Once	30 days ARC	4	
2	Project Management Plan					
	Draft	X	Once	3 days prior to PDR	4	
	Final	A	Once	30 days ARC	4	
3	Final Design					
	Draft	X	Once	10 days prior to FDR	4	
	Final	A	Once	30 days ARC	4	
4	Preliminary Design Review Data Package	X	Once	3 days prior to PDR	4	Presentation material
5	Final Design Review Data Package	X	Once	10 days prior to FDR	4	Presentation material
6	Acceptance Test Report	A	Twice	TBD	4	One per site.
7	Acceptance Test Review Data Package	X	Once	10 days prior to ATR	4	Presentation material

NOTE: Each issue (submittal) shall contain one camera-ready copy.

Table 1: CONTRACT DATA REQUIREMENTS LIST

CDRL #	Title or Description of Data	Approval Code	Frequency of issue	Date Due To User	# Copies	Remarks
8	Minutes	X	Once for each meeting	7 days after meeting	4	
9	Status Report	X	Monthly	15 days after meeting	1	
10	Deliverables to the Beam Tube Final Design Review Data Package					
	Draft	X	Once	10 days prior to Deliverables to the Beam Tube FDR	4	
	Final	A	Once	30 days after FDR	4	
11	Prototype Vessel Data Review	A	Once	30 days after completion of prototype vessel tests	4	

NOTE: Each issue (submittal) shall contain one camera-ready copy.

Data Requirement Description (DRD) for CDRL No. 1: Updated Preliminary Design

Purpose:
To document the design of the LIGO overall vacuum system and to substantiate that the design meets the requirements.

Preparation Instructions:
Assemble a package of plans, drawings, specifications procedures, calculations etc. which describe the overall vacuum system design. This data package shall include as a minimum the items described in Article I. Statement of Work, Delivery or Performance Schedule. Additional information which may be required to fully describe and assess, the adequacy of the system design shall also be included in this data package.

Data Requirement Description (DRD) for CDRL No. 2: Project Management Plan

Purpose:
To provide the basic operating plan for the project which allows for detailed scheduling, work progress reporting, and tracking of termination liability.

Preparation Instructions:
Update and revise the Project Management Plan generated for CDRL No. 02 of Phase A as described in Article I, Statement of Work.

Data Requirement Description (DRD) for CDRL No. 03: Final Design

Purpose:
To define and document the vacuum equipment design.

Preparation Instructions:
Prepare a stand alone document, consisting of drawings, specifications, plans, procedures, etc., as described in Article I, Statement of Work.

Data Requirement Description (DRD)
for CDRL No. 04: Preliminary Design Review Data Package

Purpose:
To present and substantiate the preliminary design for the vacuum equipment.

Preparation Instructions:
The Data Package to be provided in support of the Preliminary Design Review shall contain all presentation material as well as backup data and information on all topics to be discussed at the review.

Data Requirement Description (DRD) for CDRL No. 05: Final Design Review Data Package

Purpose:
To present and substantiate the final design for the vacuum equipment.

Preparation Instructions:
The Data Package to be provided in support of the Final Design Review shall contain all data and information on all topics to be discussed and presented at the Review.

Data Requirement Description (DRD) for CDRL No. 06: Acceptance Test Report

Purpose:
To document the acceptance test process and results.

Preparation Instructions:
Substantiate that the vacuum equipment complies with the Design documented in CDRL No. 03 and the requirements in Article I. Statement of Work.

Data Requirement Description (DRD)
for CDRL No. 07: Acceptance Test Review Data Package

Purpose:
To present all aspects of as built design and associated fabrication, installation and acceptance testing of the vacuum equipment, and to provide a permanent record of presented material and subsequent closeout of resultant action items.

Preparation Instructions:
The Data Package to be provided in support of the Acceptance Test Review shall contain all data and information on all topics to be discussed and presented at the Review and shall include, but not be limited to, the following for each LIGO site:

- Test report excerpts documenting the results of the acceptance tests, in accordance with CDRL No. 06, Acceptance Test Report.

- Performance verification.
- As-built drawings.
- Disposition of property procured under the contract or made available as Government furnished property.
- Remaining issues and open action items.

Data Requirement Description (DRD) for CDRL No. 08: Minutes

Purpose:
To document proceedings of all formal Institute/Contractor LIGO project meetings.

Preparation Instructions:
The Minutes shall document proceedings of all formal Institute/Contractor project meetings. The Minutes shall include:

- A summary of all business transactions between the Contractor and the Institute, including any alterations and/or clarifications to the Review Data Package generated during the Review.
- Contractor action items and planned completion dates.
- Institute action items and planned completion dates.

Data Requirement Description (DRD) for CDRL No. 09: Status Report

Purpose:

To assess project progress and status.

Preparation Instructions:

The Data Packages to be provided in support of the monthly progress meeting shall contain all data and information on all topics to be discussed and presented at a review, and shall include, but not be limited to, the following:

- All current technical contract activities, and percent complete at the WBS element level.
- Updated schedules including milestones and other events accomplished or missed, reasons for delay and corrective measures taken.
- Problem areas, including those concerns requiring action(s), decision(s) or assistance on the part of the Institute.
- Action items closed during the review period, progress of open action items, and identification of new action items.
- Response to technical direction received.

Data Requirement Description (DRD) for CDRL No. 10: Deliverables to the Beam Tube Final Design

Purpose:
To define and document the deliverables to the Beam Tube Contractor.

Preparation Instructions:
Prepare a stand alone document, consisting of drawings, specifications, plans, procedures, etc., as described in Article I, Statement of Work.

Data Requirement Description (DRD)
for CDRL No. 11: Prototype Vessel Data Review

Purpose:
To document the test results of the prototype vessel.

Preparation Instructions:
Prepare a stand alone document, consisting of test results as described in Article I, Statement of Work.

EXHIBIT III

DELIVERABLES FOR THE BEAM TUBE CONTRACTOR
LIGO-C950804-00-V02

EXHIBIT III
DELIVERABLES FOR THE BEAM TUBE CONTRACTOR

A. The Deliverables consist of pump carts and gate valves which are required for the beam tube pump down (a separate contract). These components are defined in Exhibit I Vacuum Equipment Specification. There are three types of pump carts and one type of gate valve. The required equipment is listed below:

WASHINGTON SITE - Required date: 6/19/96

LOUISIANA SITE - Required date: 8/10/97

Item	Quantity Hanford	Quantity Louisiana
1. Main Roughing Pump (per Exhibit I, paragraph 5.2.1.1)	2	2
2. Turbo Molecular Pump Set (per Exhibit I, paragraph 5.2.1.2)	4	4
3. Auxiliary Turbo Cart (per Exhibit I, paragraph 5.2.5)	2	2
4. 112 cm Gate Valve (per Exhibit I, paragraph 5.3.1)	8	4
5. 122 cm Gate Valve (per Exhibit I, paragraph 5.3.1)	0	2

NOTE: Quantities above are those required for the beam tube pump down only and may not be the same as the total quantity called for in Exhibit I Vacuum Equipment Specification.

EXHIBIT IV

HARDWARE DELIVERABLES
LIGO-C950804-00-V03

EXHIBIT IV
HARDWARE DELIVERABLES

A. The Hardware Deliverables consist of all the Vacuum Equipment to be installed and tested at the two LIGO sites. This equipment is defined in Exhibit I, Vacuum Equipment Specification. Each vacuum section shall be delivered, installed, and acceptance tested*, complete with all chambers, pumps, valves, supports, fittings and gauges. The equipment is listed below, and the acceptance dates are as stated in Article II.

*Acceptance dates will be determined jointly by LIGO, the A-E Contractor and the Vacuum Equipment Contractor.

WASHINGTON SITE - Exhibit I, Figures 4, 6, 7.

Item	Quantity
1. Corner Station Vertex Section	1
2. Corner Station Diagonal Section	1
3. Corner Station Beam Manifolds	2
4. Site Purge/Vent system	1
5. Site Bakeout system *(this system will also be used in Louisiana)*	1
6. Site Pump Carts	1 set
7. Left Arm Mid Station	1
8. Right Arm Mid Station	1
9. Left Arm End station	1
10. Right Arm End Station	1

LOUISIANA SITE - Exhibit I, Figures 5, 6, 7.

Item	Quantity
1. Corner Station Vertex Section	1
2. Corner Station Beam Manifolds	2
3. Site Purge/Vent system	1
4. Site Bakeout system *(the Washington bakeout system will be shipped to Louisiana)*	0
5. Site Pump Carts	1 set
6. Left Arm End station	1
7. Right Arm End Station	1

5.3 Design Input Review

Prior to contract acceptance, a detailed review is held internally at PSI to review the design input basis. The customers contract documents are reviewed against the PSI proposals and any subsequent letter addenda to ensure the project design basis is understood and contractually consistent between all documents. All discrepancies will be resolved before contract acceptance.

This meeting is attended by the Project Manager, the Director of Contracts and Senior Project Team Staff.

6.0 DESIGN OUTPUT

6.1 Project Execution Summary

The LIGO Project will be executed as shown on Chart 6.1 "Project Execution Summary".

Because of the technical challenges and fast track nature of the engineering phase of this project, some engineering, research and fabrication must be done in parallel to maintain the project schedule. This approach is also mandated to properly control risks associated with vessel fabrication, vibration/shock design and very large ultra high vacuum systems design.

6.1.1 VIBRATION STUDY

As part of the Phase B final design, PSI will conduct vibration/noise/shock testing of all the devices that have significant contribution to the vibration/noise spectrum. This source spectrum data (not available from most vendors) will enable PSI to calculate the resulting vibration/noise/shock at the beam tube system and recommend 2nd order remediation for approval by LIGO (NOTE: 1st order remediation is included in the lump sum price). See Volume I, Section 4 for more details of the vibration/noise/shock program.

6.1.2 FIRST ARTICLE FABRICATION

Also, as part of the Phase B Engineering Phase, PSI will fabricate a 1st article vessel (BSC or HAM) to validate proposed fabrication, sealing and cleaning techniques. This approach will provide significant risk management benefits and prevent fabrication false starts or large delays later in the program.

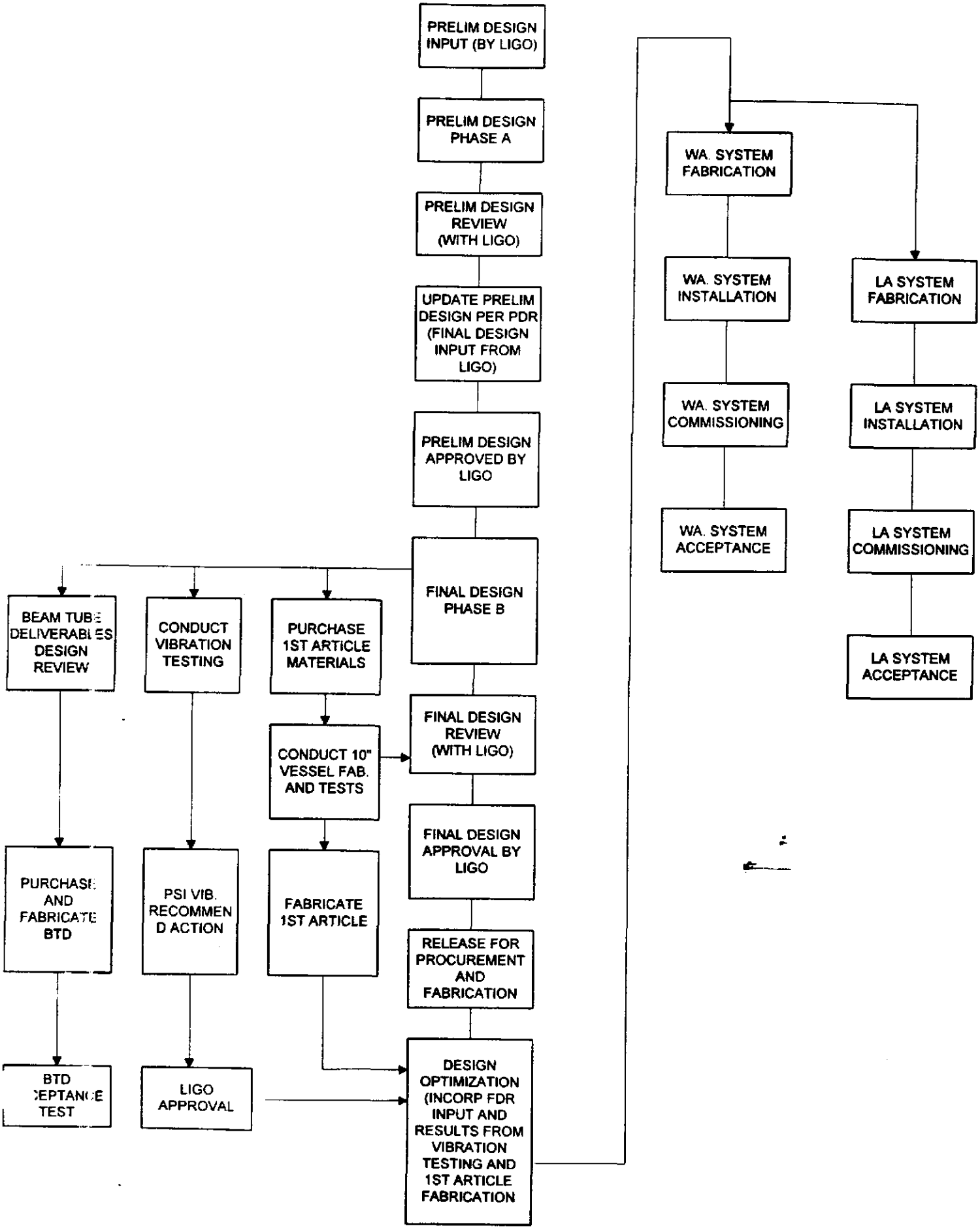
A first article large gate valve program is being executed by PSI. PSI has released one large gate for design and manufacture. This approach will reduce the risk associated with the large gate valves.

Prototype 10" vessels are also being fabricated and tested to validate fabrication and cleaning techniques prior to the Final Design Review.

6.1.3 PROCUREMENT

After final design approval by LIGO, PSI will purchase the remaining system equipment and material. PSI intends to purchase 304L S.S. (plate, flanges and heads) in mill runs to reduce project costs. Due to the future demand for S.S., this purchase will have to be made before the final design approval to maintain the schedule.

CHART 6-1
PROJECT EXECUTION SUMMARY



6.1.4 FABRICATION

Fabrication of the vacuum system components will be conducted at various PSI and vendor facilities to optimize the utilization of space, equipment and staff expertise. (See Section 13). These complicated vessels will require sophisticated fabrication and stress relief techniques to successfully fabricate the units. PSI will draw on its history of cost effective innovation to design internal/external fabrication jigs and fixture to maintain vessel tolerances. See Volume III for additional fabrication information.

6.1.5 INSTALLATION/COMMISSIONING

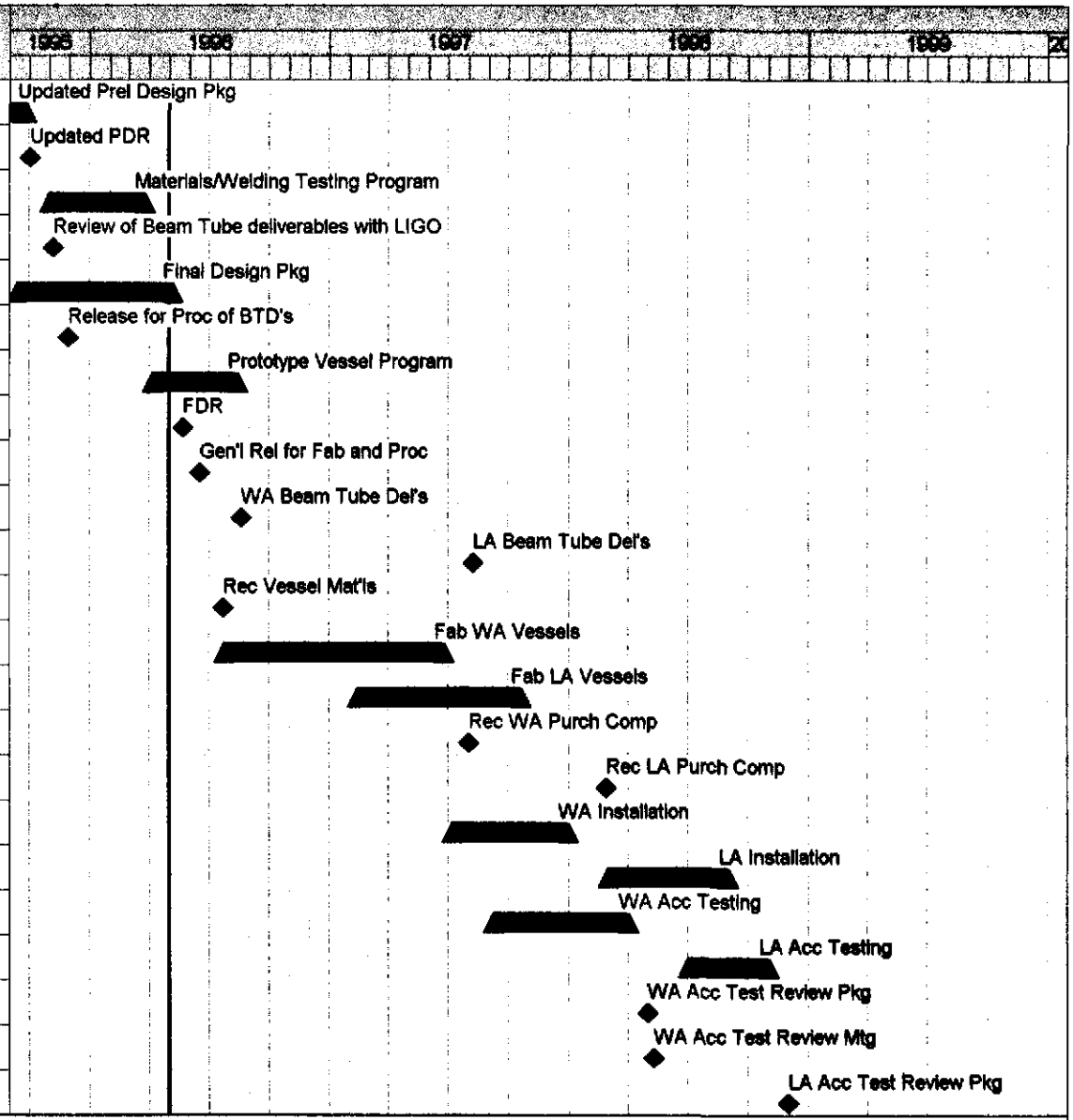
PSI will use local contractors to install the LIGO systems. These contractors will be selected based on precision alignment and clean service experience. A PSI representatives will be present at the site to coordinate activities and interface with LIGO representatives.

The vacuum systems will be tested and commissioned using the control system provided by LIGO. The system components will be commissioned and turned over to LIGO in phases.

See Volume IV for additional installation/commissioning information.

6.2 LIGO SCHEDULE SUMMARY

Act ID	Description	Early Start	Early Finish
1000	Updated Prel Design Pkg	01SEP95 A	27SEP95 A
1010	Updated PDR	03OCT95 A	
1500	Materials/Welding Testing Program	01NOV95 A	25MAR96 A
1600	Review of Beam Tube deliverables with LIGO	07NOV95 A	
2000	Final Design Pkg	12SEP95 A	06MAY96
2010	Release for Proc of BTD's	30NOV95 A	
2015	Prototype Vessel Program	05APR96 A	13AUG96 *
2020	FDR	22MAY96 *	
2030	Gen'l Rel for Fab and Proc	17JUN96 *	
3000	WA Beam Tube Del's	19AUG96 *	
3010	LA Beam Tube Del's	08AUG97 *	
4000	Rec Vessel Mat'ls	23JUL96 *	
4010	Fab WA Vessels	24JUL96 *	24JUN97
4020	Fab LA Vessels	13FEB97 *	20OCT97
5000	Rec WA Purch Comp	01AUG97 *	
5010	Rec LA Purch Comp	27FEB98 *	
6000	WA Installation	07JUL97	31DEC97 *
6010	LA Installation	02MAR98	01SEP98 *
7000	WA Acc Testing	08SEP97	01APR98 *
7010	LA Acc Testing	02JUL98	02NOV98 *
7020	WA Acc Test Review Pkg	01MAY98 *	
7030	WA Acc Test Review Mtg	11MAY98 *	
7040	LA Acc Test Review Pkg	01DEC98 *	



Process Systems International, Inc.

VACUUM EQUIPMENT SUMMARY SCHEDULE

01MAY96

6.3 Documentation Deliveries

Vacuum equipment deliverables are detailed in Volumes I thru V of this Final Design Report.

6.4 Documentation Format

All documents will be supplied in PSI standard drawing format. LIGO title block information (Customer Document No., etc.) will be added to the PSI title block.

All PSI documents will be numbered per PSI Standard SOP-006-003 "Procedure For Assigning Engineering Documents Numbers".

6.5 Required Approvals

The complete design will be submitted to LIGO for approval as part of the Final Design Review.

Installation readiness reviews will be conducted prior to the start of installation at each LIGO site.

7.0 PROJECT ADMINISTRATION/TECHNICAL COORDINATION

7.1 Progress Report

PSI will prepare monthly reports documenting the status and action items from the monthly LIGO/PSI progress meetings.

7.2 Project Filing System

Project/Customer correspondence, internal memorandum, vendor correspondence etc., shall be filed by the project secretary in the project file.

All PSI/Customer correspondence will be assigned a sequential number by category and recorded in the project log. Document numbers shall be assigned as follows:

Correspondence (Letter or Fax): V049-PL-_____
from PSI to LIGO

Correspondence (Letter of Fax): V049-LP-_____
from LIGO to PSI

Any correspondence received out of sequence number shall be investigated and resolved.

All PSI/LIGO correspondence shall be sent and received through the PSI project secretary.

7.3 Project Document Control

All project documents (specification, drawings, procedures, etc.) are reviewed, signed-off, issued and archived per PSI SOP-006-012 "Procedure for Release of Controlled Documents" (See Exhibit I).

All project documents, (hard copy and electronic), are issued and archived through the PSI Document Control Department (DCD).

All PSI and customer submittals are also handled through the DCD. PSI submittals to LIGO shall be documented by PSI transmittal notices and logged by the DCD.

All engineering document submittals from LIGO will be logged in by the project secretary and copies internally distributed. The original will be filed in the LIGO project file.

7.4 Document Numbering System

All PSI documents will be numbered per PSI procedure SOP-006-003 "Assigning Engineering Document Numbers".

7.5 Project Chart Of Accounts

Project labor and costs will be monitored and recorded by means of a Project Chart of Accounts. The breakdown will be based on the Project Work Breakdown Structure (WBS) and tracked via PSI's M.I.S. System (EMS).

7.6 Project Needs List

Requests for information between LIGO and PSI shall be monitored and controlled through a project needs list. This system of consolidated information requests ensures timely closure of technical and commercial requests for information. Two separate lists are kept for each organization request.

The items on the needs list are numbered sequentially (LIGO to PSI V049-NL-LP-1, -2, etc., PSI to LIGO V049-NL-PL-1, -2, etc.) and roll-off the list when completed. The needs list is transmitted between LIGO and PSI as required and is part of the monthly progress report.

See enclosed samples.

7.7 Project Reviews

Internal project reviews are held monthly to review project status with PSI upper management.

During the project review, each phase of the project is scrutinized in an effort to understand project status, identify area of risk requiring further action, and to discuss issues critical to successful project execution.

The project review meeting is attended by the PSI President, Vice president of Operations, Controller, Manager of Contracts, Project Manager, Engineering Manager, Manufacturing Manger and others as appropriate.

7.8 Project Planning/Execution Review

In-depth project planning and reviews (PPER) are held for all major PSI projects at critical milestones of the project. These meetings are designed to review all aspects of the project with an emphasis on "Looking Forward" strategies and planning on a company wide basis.

The first meeting is held within 30 days of project kickoff and is designed to set the project plans and strategies to achieve project goals and schedules. Other PPER meetings are held at key milestones (prior to release for fabrication, construction, etc.).

The PPER meeting is attended by key project team members, PSI senior management, engineering managers and non-project team PSI staff as required who have applicable experience or expertise to contribute.

Typical PPER meeting topics include:

Contract Review

Top Level Program

Engineering Plan

Procurement Plan

QA/QC

Manufacturing Plan

Construction Plan

Commissioning/Startup

Customer Issues

Risk Management

8.0 CLIENT RESPONSIBILITY

8.1 Project Codes and Standards

Project codes and standards are detailed in the LIGO Vacuum Equipment Specification and subsequent technical direction memorandums as detailed in Section 5.2 of this manual.

8.2 Building Drawings/Facilities

LIGO is responsible for providing building drawings for all site facilities for the Hanford, WA and Livingston, LA site to PSI in a timely manner.

LIGO is also responsible for providing site buildings, utilities, control system and operator interface stations at each site building etc., as agreed to in the contract.

8.3 Laser System Design Input

LIGO is responsible for providing design requirements for the laser system relative to the Vacuum Equipment System design in a timely manner. Internal clearance, support, etc., must be established early in the Phase B schedule to avoid project delays and additional costs.

8.4 Drawing Review/Approval

LIGO document review requirements are detailed in Exhibit II, "Deliverable Documentation, LIGO C950804-00-V01". (See Section 5.2).

8.5 Scope Changes

Timely approval of scope changes are necessary to keep major projects on schedule.

Requirements for scope change approval are detailed in Section 4.0, "Contractual Basis".

9.0 ENGINEERING/DESIGN EXECUTION

9.1 General

The engineering phase of a PSI project is executed per the project CPM schedule under the direction of the Project Technical Director in conjunction with the project manager. The Technical Director is assisted by the Project Design Coordinator in coordinating the actives of the engineering and design departments.

PSI employs a system of control over engineering and design activities by implementing procedures which provide for review and approval of specification, drawings and other engineering documents, as well as revision to these documents prior to issuance for use. Such reviews are conducted to verify completeness and adequacy with respect to contract and design input requirements.

PSI will conduct system design reviews at strategic points during the engineering phase of the program. These reviews are attended by the Project Team and PSI's technical management to objectively review and discuss process design, including process flow diagrams, piping and instrumentation diagrams, equipment sizing, mechanical and structure design, electrical instrumentation and controls. Design review meetings ensure that client specifications and design input requirements are adhered to.

9.2 Engineering Plan

9.2.1 GENERAL

The LIGO Engineering Plan has been developed to ensure that the engineering/design output match the criteria established by the design input requirements, has been developed against known acceptance criteria and conforms to appropriate regulatory and contractual requirements.

The Phase B engineering/design effort of the LIGO project will be executed as shown on the attached SureTrack Critical Path Schedule (See Exhibit II).

The goals of the final design phase are as follows:

- Incorporate LIGO PDR comments and laser system requirements into the Vacuum Equipment Design.

- Update vacuum system component specification to incorporate vendor bid data and laser system requirements and suitable design margin to reduce overall project risk.

- Qualify equipment suppliers tentatively selected in Phase A.

- Develop equipment and installation documentation and procedures in sufficient detail to ensure vacuum system integrity, cleanliness, dimensional requirements and overall system performance are met or exceeded.

- Develop operating procedures & control logic to enable LIGO to develop the central control system software.

- Perform failure mode analysis.

Specifications have been generated by the engineering disciplines for unique major purchased parts or items (compressors, pumps, vessels, valves, heat exchangers, electrical, instruments, controls, etc.). These specifications reflect the requirements of the contract which are to be imposed on all subvendors. Each specification is a binding document and is so stated in the body of the PSI purchase order. Completed specifications are reviewed and signed-off by Engineering, Project Management, Quality Assurance and released via a Design Engineering Order (DEO).

Detailed fabrication drawings for manufacturing have been prepared by the design/drafting group under the direction of the project manager and engineering disciplines. Completed drawings are checked by the Design Department and then reviewed by Engineering, Project Management, Quality Assurance and then released on a DEO.

Procedures for welding, cleaning, painting, etc. (when applicable), have been developed, reviewed and released in the same manner as specifications and drawings.

Design changes after the Final Design Review will be executed using PSI's "Request for Change" procedure. Design changes are submitted to Project Management and Engineering for review and sign-off. When review and sign-offs are complete, the Document Control Department assigns a number to the form for control and filing. If fabrication has been released, a copy of the Request for Change is made and is routed to the Material Control Department. It is attached to the affected drawing or document in the manufacturing area. This constitutes authorization to proceed with the required change. Design changes after the Final Design Review will be submitted to LIGO for approval prior to release.

Critical design calculations prepared by the project team have been independently reviewed within the engineering department by a qualified individual other than the person who performed the original design. The design engineer and the reviewer sign the front cover page of each set of required calculations. These calculations are maintained in the engineering job files.

All documents are issued per PSI SOP-006-012 "Release of Controlled Documents".

The LIGO Engineering Plan has been designed to maximize system performance and minimize overall project risk. To this end, PSI has execute additional engineering/testing/fabrication activities designed to develop necessary engineering data and to validate proposed fabrication and testing techniques. These additional activities include cleaning analysis (XPS), plasma welding test, 10 in. vessel testing and Viton o-ring bakeout testing.

9.2.2 VIBRATION/NOISE/SHOCK PROGRAM

As part of the Phase B engineering effort, PSI has retained a world class vibration/noise/shock consultant (Cambridge Acoustical Consultants, Inc.) to study the source levels from vacuum system equipment. They will then make recommendations for remediation of Vacuum System/Vibration/Noise/Shock content beyond what is included in PSI's first order lump sum proposal. In addition, they will develop computer models to predict resultant vibration/noise/shock levels before and after second order remediation.

This approach is mandated since source levels (in the LIGO system configuration) are not available from the vendors. Without accurate source data, it is impossible to predict resultant vibration/noise/shock levels. The lack of current LIGO building/foundation information also contributes to the current uncertainty.

9.2.3 FIRST ARTICLE FABRICATION

As part of Phase B engineering period, PSI is fabricating a first article BSC to validate proposed material specification/preparation, fabrication and cleaning techniques and sealing system. This approach will provide valuable data and risk reduction for the LIGO Program. The information and techniques developed during this program will be incorporated in the Final Vacuum System Design.

9.2.4 VESSEL/SYSTEM ENGINEERING

During Phase B engineering, vessel design has been optimized to meet laser system and vacuum performance requirements. PSI currently employs state-of-the-art Finite Element Analysis (FEA) methodologies for the analysis and design of the structural components. Combined with the requirements of the governing codes, PSI can offer the most cost effective design which will meet all of the client operational and safety related requirements. Our engineering/design programs also have the ability to interface with the AUTOCAD drafting/detailing system. All of the computer software is maintained and updated annually to meet the changes of the relevant codes.

The overall anchorage and structural support systems has been finalized during Phase B of this project. System Vacuum/ATM loads/bakeout loads/failure mode loads, etc. have been investigated and documented. Results from the analysis have been used to finalize system fabrication and installation drawings. A comprehensive analysis/design package will be presented to LIGO at the FDR meeting.

The site anchor bolt systems were moved to PSI's scope of supply during final contract negotiations. The anchor bolts will be field installed by PSI after the concrete floor has been installed (by others).

9.2.5 SHOP CLEANING/TESTING

During the Phase B Engineering Program shop cleaning and testing procedures have been finalized. Information from the 10 in. vessel program and the first article program will be used to optimize the procedures.

PSI has continued with the surface analysis testing program to confirm the effectiveness of the proposed cleaning procedure.

9.2.6 INSTALLATION/COMMISSIONING

Installation and commissioning plans have been optimized and finalized during Phase B. See Volume IV for additional information.

9.3 Project Control Plan

9.3.1 PLANNING/SCHEDULING

Project plans and schedules are developed by the cost/schedule manager in conjunction with the project team and the project manager.

Plans and schedules of major PSI projects are reviewed on a company wide basis at the PPER meetings (See Section 7.8).

PSI Project scheduling is performed on a computer software package from Primavera Systems called SureTrack Project Scheduler. SureTrack is a comprehensive project control software. It produces critical path schedules and various reports used for resource planning. The schedule is periodically updated by the project manager to show status and current critical path tasks.

Schedule updates will be provided to LIGO the monthly progress meetings.

9.3.2 COST CONTROL

PSI project costs are monitored and controlled by the project manager via the project review financial report. This report is generated form data in the PSI MIS/MRP system 'EMS'.

Labor usage is updated weekly into EMS from timecard data. Project material and expense costs are updated monthly as part of the PSI accounting procedure.

9.3.4 PROJECT ESTIMATES

The original estimate is entered into the project review database after contract award. This base estimate form the benchmark data for measuring project financial status.

As project change orders occur, the change order is estimated and if approved, the project budgets are adjusted to reflect the new project scope.

By keeping the project budget current, project performance can be evaluated with the aid of the SureTrack scheduling % complete data.

9.3.5 TECHNICAL PERFORMANCE MEASUREMENTS

Technical performance shall be measured during the engineering/design portion of Phase 'B' by the following means:

- PSI internal design review
- PSI/LIGO design reviews
- First article fabrication and testing
- Vibration/Noise/Shock modeling of proposed remediation programs

Each of these measures will test or predict the results of the vacuum equipment system operating performance.

9.4 Engineering/Design Interface

The engineering and design department work very closely together during the detailed design phase. In addition to the one-on-one contact between engineers and designers, the technical director and design coordinator provide hands-on participation in the engineering/design process.

Weekly project team meetings are held to establish priorities and information needs and to promote project team communication.

9.5 Applicable PSI Standards, Guidelines, and Software Programs

Applicable PSI standards and guidelines to be used on the LIGO project are detailed in Attachment I.

9.6 Engineering QC Program

PSI engineering managers and Q.A. engineers audit PSI projects periodically to verify that company and project procedures are being followed, that engineering quality is high. Vendor Q.A. programs are also audited and approved.

Reports are filed in the project files of all audit results.

9.7 Engineering Document Review

All engineering/design documentation (spec, drawing, procedures, etc.) are reviewed and signed-off before issue.

9.8 Vendor Drawing Review

Drawings are submitted to PSI for approval by vendors for all major purchased equipment. Vendor drawings are logged in through the Document Control Department (DCD) and circulated to the project team for comments.

After the review cycles, they are returned to the vendor by the DCD with the appropriate approval status (approved, approved as noted, rejected) as determined by the project manager.

All documents not "approved" are revised by the vendor and resubmitted. (See SOP-006-011 "Document Control Department" Exhibit I).

9.9 Engineering/Design Status

The engineering and design effort for the Final Design Review has been completed essentially on schedule. The Washington site is presented in the FDR drawing package. The Lousiana site will be issued after the Final Design approval is received from LIGO and the LA building drawings are issued.

10.0 DESIGN VERIFICATION

10.1 Design Reviews

PSI will conduct system design reviews at strategic points during the engineering phase of the program. These reviews will be attended by the Project Team and PSI Management to objectively review and discuss process design, including process flow diagrams, piping and instrumentation diagrams, equipment sizing, mechanical and structural design, electrical instrumentation and controls. PSI will notify LIGO engineering representatives of all reviews well in advance, enabling their participation. Preliminary failure mode and hazards analysis will be conducted during design reviews. This data will be used to produce the final reports for the Final Design Review package.

10.2 Safety Reviews

A failure mode and effects analysis will be conducted on the LIGO vacuum equipment system as part of the final design package.

A hazards analysis will also be conducted as part of the final design package. Each hazard will be identified and rated for severity.

10.3 Comparative Design Analysis/Testing

During the engineering design phase, comparative design analysis investigations will be conducted to compare predicted LIGO vacuum system performance versus systems and experiments documented in technical papers or actual installation data.

Results from the 10 in. vessel program and the first article testing will be extrapolated to predicted full system performance.

10.4 Outside Consultants

PSI has retained outside consultants to assist PSI in revieweing and validating the LIGO Vacuum Equipment design. The outside consultants are listed in Attachment 5.

10.5 10 Inch Vessel/Viton Testing Status

A 10 in. vessel program was included as part of the Final Design Phase. This program we conducted to verify plasma welding, o-ring design, cleaning procedures and cleanroom operation. Various 10 inch vessels were fabricated, heat treated, cleaned; baked and pumped to ultimate vacuum levels.

Viton bakeout testing was also conducted as part of the 10 inch vessel program. This testing was designed to verify the proper heat/time cycle to condition the viton o-rings for UHV service.

Various cleaning protocols were investigated during the 10 inch vessel program to verify the most effective cleaning system.

Results of the 10 inch vessel testing program will be presented at the FDR and are contained in Volume II.

10.6 Prototype BSC Program Status

As part of the Final Design Phase, a full size BSC vessel is being built and tested.

Originally, the prototype BSC was scheduled to be mechanically complete before the Final Design Review meeting. The revised schedule now has the prototype being mechanically complete by the end of June. This delay was caused by late material delivery (winter flood at steel mill) and delays in placing the order with the fabricator. The prototype testing scope was also increased to include testing an 80K pump shroud in the BSC vessel.

In spite of the mechanical assembly delay, the prototype BSC will be mechanically complete before the main BSC production lot is released for fabrication.

Performance testing of prototype should be complete by mid August 1996.

11.0 CONFIGURATION MANAGEMENT

11.1 General

PSI project documentation is issued and controlled via PSI SOP-006-012 "Release of Controlled Documents".

PSI fabrication components are controlled via product structure documentation in PSI's MRP System "EMS". Product structure is controlled per PSI procedure SOP-006-002 "Drawing Tree/BOM Structure".

11.2 In-House Design Change Control

All PSI in-house design changes after the Final Design approval by LIGO will be requested and executed per PSI procedure SOP-006-001 "Requests for Change".

11.3 Contract Change Of Scope

All changes of scope to the Vacuum Equipment project not covered by the existing contract shall be submitted to the PSI contracts department for acceptance.

Once accepted, the Change of Scope shall be implemented by the project manager via the normal design change control procedure (See Section 11.2).

12.0 PROCUREMENT

12.1 Procurement Plan

PSI utilizes a strict program for planning and executing procurement activities in accordance with documented instructions and procedures. Prior to purchase order placement, a material requisition is prepared by the responsible engineer. The requisition is routed to the Project Manager and Quality Assurance Department for review and signature prior to going to the Purchasing Department for processing. The purchasing agent prepares the purchase order and places the order with a vendor or subcontractor.

Changes to a purchase order are handled in the same manner as the original purchase order. Copies of purchase order and change order are routed to the Inspection and Quality Assurance Departments. Provisions are made for evaluation and selection of subcontractors.

The program also provides for the verification of purchased items to procurement documentation requirements by receipt inspection.

During the LIGO Project, extensive vendor interface and surveillance is planned. Major purchased items will be monitored via vendor kickoff meetings, in progress inspections and witnessed testing as appropriate to ensure equipment quality.

The procurement time table for the LIGO Project is detailed in the project schedule. (See Attachment 2).

12.2 Expediting

All major contract purchase orders are monitored and expedited by the project management team and the purchasing department. Periodic vendor interface (and plant visits as required) is used to monitor production status. Vendor progress payments and penalties will be structured to encourage on-time deliveries.

12.3 Inspection/Testing

Major equipment deliveries will be inspected (and tested as appropriate) at the vendor's factory before shipment.

Material and equipment for LIGO project received at PSI will be inspected before release to the manufacturing department or to subvendors.

12.4 Vendor Drawing Control

Vendor drawings will be controlled per PSI procedure SOP-006-011 (also see Section 9.8).

12.5 Transportation Coordination

Transportation of LIGO raw materials and equipment will be coordinated by the Project Manager and the PSI Transportation Department.

This aspect of the project is viewed as critical to the installation phase where site storage may be limited.

12.6 Procurement Status

The Beam Tube deliverables (roughing pumps, turbo pumps and gate valves) have been ordered and are on schedule for an August 1996 delivery to the WA site.

The following purchase orders have been placed:

- Bakeout Blankets (1)
- Cleanroom Air Supply system
- Ion Pumps
- 6, 10 and 14 Inch Gate Valves
- Prototype BSC
- Water Chillers
- Vessel Heads
- Vessel Flanges
- Vessel Plate

13.0 FABRICATION

13.1 Fabrication Plan

The LIGO Vacuum Equipment System will be fabricated per FDR Volume III "Fabrication".

13.2 Fabrication Status

Detailed manufacturing planning has been conducted during Phase B.

The fabrication plan has been scheduled to support the intended site installation schedule.

PSI plans to have outside fabricators build the BSC and the HAM vessels. This will allow PSI to concentrate on the UHV cleaning and testing and the various small spools and cryopumps.

14.0 PROJECT QUALITY ASSURANCE PROGRAM

14.1 Q.A. Organization

The quality assurance organization is headed the PSI Quality Assurance Manager, with a staff of Quality Assurance Engineers/Inspectors. The Receiving Inspection Department is made up of full-time inspectors also reporting to the QA Manager. The QA Manager has the authority and is responsible for implementing of the quality program. In addition, he provides policy administrative guidance to the QA and Inspection Departments.

A lead Q.A. engineer will be assigned to the project for the life of the project. Other engineers and inspectors will be utilized as required.

14.2 Project Q.A. Plan

The LIGO Q.A. plan is detailed in V049-2-029. (See Attachment 4).

14.3 Supplier Q.A.

Suppliers of LIGO equipment and materials will be monitored for quality and technical performance by a combination of engineering and quality assurance personnel. For major equipment purchases, vendor kickout meetings, in progress reviews and witnessed performance testing will be conducted.

14.4 Training/Qualification Program

The Q.A. department will monitor that all personnel performing special skill tasks (tig welding, leak checks) on the LIGO project have been trained and qualified to perform their assigned duties.

15.0 INSTALLATION

15.1 Installation Plan

The LIGO Vacuum Equipment system will be installed per FDR Volume IV "Installation".

15.2 Installation Status

Installation for the WA site is still being planned to start in August of 1997. PSI will be bidding the installation work for WA in August/September of 1996. The LA site installation is planned to start in March of 1998. PSI will be bidding the installation work for LA in mid 1997.

16.0 PRE-OPERATIONAL TESTING

Detailed procedures have been developed during the detailed design Phase B of the LIGO project. These procedures will cover alignment, leak testing, cleanliness testing, valve and pumping operations, etc.

Pre-operational testing will be performed as detailed in FDR Volume IV "Installation".

17.0 SYSTEM COMMISSIONING/ACCEPTANCE

Detailed test procedures have been developed during Phase B covering system commissioning and acceptance testing.

System commissioning and acceptance testing will be performed as detailed in FDR Volume IV "Installation".

18.0 PROJECT TURNOVER

After project award detail plans will be developed for system turnover to LIGO.

Vacuum Equipment turnover to LIGO will be accomplished in phases as detailed in FDR Volume IV "Installation".

19.0 PROJECT CLOSEOUT

19.1 Documentation Transfer to LIGO

After each site is accepted, PSI will update the installation drawings to reflect an as built condition and transfer hardcopy and electronic files (Autocad drawings) to LIGO.

19.2 PSI Documentation Archiving

After the project is complete and the systems accepted, PSI document control will archive the electronic files to backup tapes for storage in the fireproof safe. Hard copies will be moved from the active files to the document warehouse.

19.3 Final Project Report

The project manager shall prepare an internal final project closeout report per PSI standard procedure.

ATTACHMENTS

I. Applicable Company/Department Procedures, Guidelines and Computer Program Listing

SOP-006-001	Requests For Change
SOP-006-002	Drawing Tree/BOM Structure
SOP-006-011	"Document Control Department"
SOP-006-012	"Release of Controlled Documents"

2. Detailed Project Schedule

3. Work Breakdown Structure

4. Project Q.A. Plan V049-2-029

5. Project Safety Plan V049-2-023

6. Outside Consultants

ATTACHMENT 1

APPLICABLE COMPANY/DEPARTMENT PROCEDURES AND GUIDELINES

PROCESS SYSTEMS INTERNATIONAL, INC.

WESTBOROUGH, MA.

DEPARTMENT PROCEDURE

FOR

REQUEST FOR CHANGE NOTICES

(RFC)

PROCESS SYSTEMS INTERNATIONAL – WESTBOROUGH, MA

REV	DATE	DESCRIPTION
0	9/14/93	RELEASE FOR USE

CERTIFIED FOR ISSUE

BY PRR DEPART.MGR. REB V.P. REB

NO. SOP-006-001

SHEET 1 OF 6

DATE 9/14/93

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1.0 PURPOSE

The purpose of this procedure is to define the method for processing a Request for Change (RFC) Notice and to identify the responsibilities of the persons or functions involved.

2.0 GENERAL

Due consideration to all change requests and proper closure thereof are essential routines to optimize product quality and costs as well as to empower all persons associated with that part, process or procedure to contribute to its improvement.

This procedure defines a flexible means of obtaining data necessary to evaluate change requests and implement revisions in an organized and timely fashion while allowing tracking of the process.

The RFC process is required for all drawings and documents that have been released on a Design Engineering Order (DEO) for "design", "fabrication", "construction" or "equipment purchase". The only exception to this is that a Project/Program Manager (PM) may revise and release the drawing or document directly from engineering design input thereby negating the need for an RFC. This type of change is documented by the normal DEO process.

An RFC form signed by the PM may be used to stop work.

The RFC review cycle must be the same (same sign-offs) as for the original document release.

Open RFC's (not signed off) are tracked by the document control database and reports are issued monthly.

RFC numbers for custom projects will start with 001 for each project. RFC numbers for the standard product group will use the 7014-XXXX series.

Please note that while the following generally defines changes to Engineering documents, this procedure may be applied to procedures outside the normal realm of Engineering.

Definitions

2.1 Request for Change Form (RFC) is that document that formally proposes a change and allows for analysis of related cost, effectivity and schedule impact.

2.2 Project/Product Manager (PM) refers to either that manager or his appointed designate.

2.3 Design Engineering Order (DEO) is the procedure by which drawings and specifications are formally entered into a documentation package.

2.4 Document Control Department (DCD) refers to the PSI department that issues and stores engineering/design documents

3.0 RESPONSIBILITY

3.1 Any person recognizing a defect in a drawing or document is responsible for initiating a Request for Change.

3.2 Responsibility for various steps of the process shifts during the RFC review cycle. All people in the review cycle are responsible for timely review and forwarding of the RFC. For urgent RFC's the initiator or a person designated by the project manager shall walk the RFC through the review cycle.

3.3 Responsibility for revising this procedure rests with the Vice President of Engineering.

4.0 PROCEDURE

Area numbers of Exhibit "A" are referred to in the following:

4.1 The Initiator supplies information in Areas 1 and 2. This information should be as complete as possible and may be provided in cooperation with a supervisor, manufacturing engineer or other appropriate person. Marked prints or hand sketches may be added to the RFC as needed.

Upon completing a review with the manufacturing department supervisor, lead engineer or designer, the initiator, or supervisor, forwards the RFC to DCD. At this point, the initiator's responsibility has been fulfilled; however, he may be asked for clarification at a later time.

4.2 DCD assigns an RFC number, enters the description in the RFC log (Exhibit "C")/database and retains a file copy of the RFC.

DCD forwards the RFC to the appropriate (PM) and also sends a copy to the initiator.

4.3 The PM reviews the RFC and decides whether or not to proceed with the RFC.

4.3.1 If the decision is not to proceed, the PM states the reason and returns the document to DCD.

DCD closes out the log and sends a copy of the RFC to the PM and the initiator.

4.3.2 If the decision is to proceed, the PM may add sheet 2 of the RFC (Exhibit "B") and assigns distribution to those Disciplines that are impacted by the change (Area "5") for comments and requested data.

"Urgent" written in Area "6" requests immediate attention by those parties commenting. Urgent RFC's shall be walked through the review cycle.

Under normal conditions, the RFC will be processed by each party within 24 hours of receipt and forwarded through the distribution.

Within the affected departments, the designated persons will evaluate the change and respond in the appropriate area ("8" through "12") and sign (Area "14").

When the ASME Code applies, the AI (Authorized Quality Assurance Inspector) will sign off on the RFC and the revised drawing.

4.4 The RFC is then returned to the PM for cost analysis (Area "13"), product considerations and final approval or disapproval.

4.4.1 If the RFC is not approved, the PM states the reason and returns the RFC form to DCD.

DCD closes out the log and sends a copy of the RFC to the PM and the initiator.

4.4.2 If the RFC is approved, the PM determines the disposition in Area "4" and returns the RFC to DCD for distribution and filing.

4.5 DCD updates the RFC Log/Databases and hand-writes on the original drawings as follows: "An Approved RFC (#____) is pending".

4.5.1 The DCD distributes copies of the approved RFC to concerned parties. This constitutes authorization for the shop and vendors to deviate from current specification or drawing configuration. A RFC issued for immediate action shall be updated by the design group and issued via the DEO procedure.

4.5.2 If a drawing change is to be delayed, the PM determines when the change will be scheduled and notifies DCD. DCD notes the scheduled change in the RFC log.

4.6 Upon issue of the drawing or document, DCD notes the DEO number in the RFC log and notifies the initiator of the action.

5.0 *FLOW CHART*

RFC Procedure Flow Chart dated 5/22/93 is attached.

6.0 REFERENCES

None.

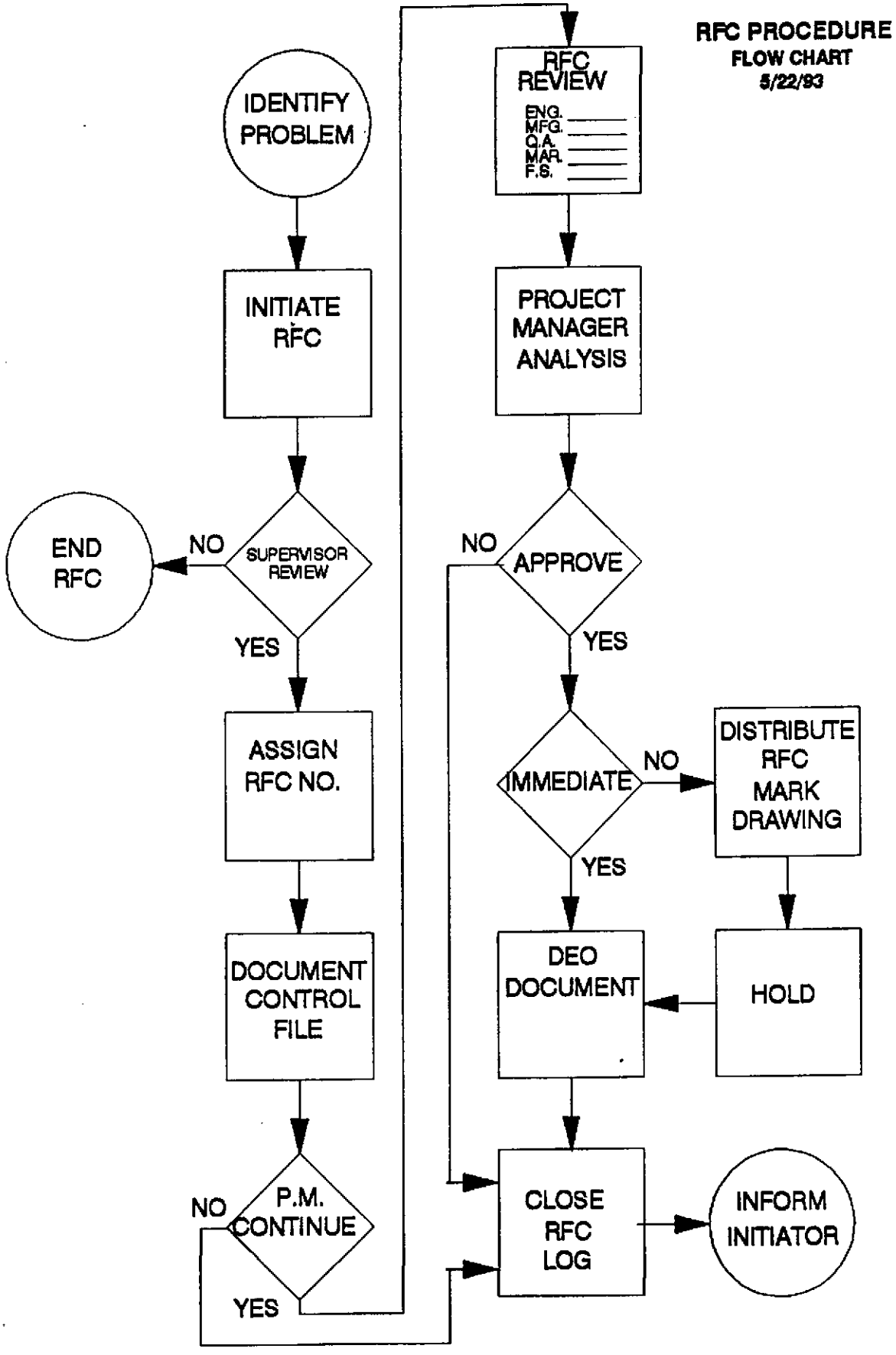
7.0 EXHIBITS

A. RFC Form, Sheet 1

B. RFC Form, Sheet 2

C. RFC Log, Blank

RFC PROCEDURE
FLOW CHART
5/22/93



PROCESS SYSTEMS INTERNATIONAL, INC. 20 Walkup Drive, Westborough, Mass 01581

Name of component affected: (1) **Project:** (6)

Drawing Number: **Prepared By:** **Date:**

Detailed description of change and reason for making same:

(2)

EXHIBIT A

DISPOSITION - PROJECT MANAGER	DISTRIBUTION
_____ IMMEDIATE DRAWING CHANGE (4) _____ HOLD FOR AS BUILT CHANGE _____ HOLD FOR ACCUMULATION CHANGE _____ NOT APPROVED (STATE REASON) BY: Date:	__QA Date __Mfg. Date __Elec. Date __Stress Date __Mech Date __Process Date __Project Date (5)
AI/ANI: (3) DATE:	REQUEST FOR CHANGE DATE: RFC NUMBER: (7)

ALL SECTIONS MUST BE COMPLETED OR MARKED N/A (NOT APPLICABLE)

(8) A. ENGINEERING/DRAFTING

- ☐ Revisions to existing drawings and parts lists. (Estimated cost $_____)
- ☐ New drawings and parts list required. (Estimated cost $_____)
- ☐ Spare parts/Parts List changes.
- ☐ BILL OF MATERIAL CHANGES
- ☐ Specifications and/or Procedure changes.
- ☐ Packing or Kit List changes.
- ☐ Publications changes. (Est. cost $_____)
- ☐ Change will prevent free interchangeability of parts. If "yes", explain.

Engineering time for RFC evaluation. (Estimated cost $_____)

TOTAL ENGINEERING, DRAFTING AND PUBLICATIONS ESTIMATED COST $_____

(9) B. MANUFACTURING EFFECTS

Cost changes: ☐ None ☐ Increase: $_____/Unit ☐ Decrease: $_____/Unit

Stock disposition:

	Use	*Rework	Scrap	Other	Must Conform To Change
Parts in process					
Stock and spares					
Parts on units in process					

*Estimated rework/retrofit costs. $_____

Costs for new ☐ or reworked ☐ jigs and fixtures as a result of this change. $_____

(10) C. MATERIALS STATUS/EFFECTS

Quantity of unchanged parts presently in stock. _____

Change can be scheduled to become effective on Lot No. _____ or unit serial _____ or customer _____ or other _____ if DEO is issued by _____

(11) D. MKTG/SALES/ORDER PROCESSING EFFECTS

- ☐ Repricing/Recosting may be required
- ☐ Sales/Mktg. Product or Ident. changes

(12) E. FIELD SERVICE EFFECTS

- ☐ Field Service familiarity with change mandatory because of possible future service problems.
- ☐ Rework/retrofit all field systems. (Estimated cost $_____)
- ☐ Rework/retrofit only following systems: _____ (Estimated cost $_____)
- ☐ No action.

(13) F. COST vs SAVINGS SUMMARY

Initial Costs:
- Engineering $_____
- Rework (Internal) $_____
- Rework (Field) $_____
- Jigs & Fixtures $_____
- Total $_____

Mfg. Savings or Cost:
- Per unit $_____
- Annual usage _____ units
- Annual total
  - Cost $_____
  - Saving $_____

RFC No. [redacted]

Use this space for added comments or notes.

EXHIBIT B

(1)

(14)

Appr.	Disappr.		Date
☐	☐	Engineering _____	_____
☐	☐	Engineering _____	_____
☐	☐	Mfg. Engineering _____	_____
☐	☐	Qual. Assurance _____	_____
☐	☐	PROJ./PROD. MGR. _____	_____

JOB NUMBER

DEO NUMBER/DATE

SHEET 2 OF _____

RFC LOG SHEET

RFC NUMBER	PROJECT	DWG. NO.	DESCRIPTION	INITIATED BY.	DATE	PRESENT STATUS	DEO# OR REJEC.

EXHIBIT 'C'

PROCESS SYSTEMS INTERNATIONAL, INC.

WESTBOROUGH, MA.

DEPARTMENT PROCEDURE

FOR

DRAWING TREE / BILL OF MATERIAL STRUCTURES

PROCESS SYSTEMS INTERNATIONAL – WESTBOROUGH, MA

REV	DATE	DESCRIPTION
0	3-4-94	RELEASE FOR USE DEO # 006-002

CERTIFIED FOR ISSUE

BY D. Austin DEPART.MGR. R. Bagley V.P.

NO. SOP- 006-002

SHEET 1 OF

DATE

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5.0 FLOW CHART

6.0 REFERENCES

7.0 EXHIBIT A - DRAWING TREE EXAMPLE

1.0 PURPOSE

The purpose of this procedure is to define a uniform method of developing a drawing tree/bill of material structure to be used on PSI projects.

2.0 GENERAL

The drawing tree establishes a bill of material structure for a project and must be created at the beginning of the project. The structure of the tree should define the separation of the job into major components for PSI engineering/design, manufacturing (by packing lists for shipping), purchasing and field installation. This procedure is to be used to organize the project components into a structure of drawings and bills of material which will be entered into PSI's EMS (MRP II) Computer System. For "engineering only" type projects, formal drawing trees are only required when directed by the Project Manager.

The structure should satisfy the needs for design sequence, drawing numbers, bills of material, material control, manufacturing planning, scheduling, fabrication, shipping, field installation, commissioning, and startup. All data in the tree should be complete enough to satisfy the needs of every internal customer in the company. One of the most important uses of the structure is for proper project planning and should include all items to be scheduled by manufacturing or purchasing.

2.1 Effective Management Systems (EMS) - PSI's MRP II software system which contains numerous application packages which manage the bill of material, inventory, planning, purchasing, manufacturing, etc.

2.2 Bill of Material (BOM) - PSI's system of defining, listing, and controlling the product structure of parts which are entered into EMS. The bills must be maintained on-line in the computer to allow all users to share the same bill.

3.0 RESPONSIBILITIES

3.1 The Project Manager is responsible for convening a meeting with engineering, design, manufacturing, engineering, and material control, for the purpose of organizing the drawing tree. The drawing tree is a living document and can be added to during the project. It is critical that the trunk and major branches are defined properly at the beginning of the project and are not changed.

3.2 The Mechanical Design Department will be responsible for maintaining a master copy of the drawing tree, and updating it as required by the project manager. A formal internal issue should be made using the design engineering order (DEO) process.

4.0 PROCEDURE

The customers purchase order and the project scope report creates a demand to produce a product in the EMS system (entered by the manufacturing-scheduling department). The project manager must provide the planned ship date to manufacturing. The product drawing tree/BOM structure is developed from the scope of supply for each project. It should be noted here that the tree structure is project/product dependent.

4.1 Drawing Tree Meeting

The project manager is to convene a meeting during the early phase of the project execution and establish the separation of upper level assemblies, and subassemblies to be manufactured or purchased by PSI, i.e. skid 100, skid 200, spare parts, field parts, etc. The drawing numbering system and chart of accounts for each engineering/design/drafting discipline can be established to coincide with the component numbering, i.e. skid 100, skid 200, spare parts, field parts, etc. This should be done for each skid or unique assembly manufactured or purchased by PSI. The drawing tree structure and the bill of material structure are to be identical structures.

A key item to keep in mind, is to plan and design the structure by the way the end products are built (and shipped) and not how they are designed and drafted.

4.2 Document/Drawing Numbering Procedure

Drawing trees should be numbered in the "O" document class code system.

See PSI Procedure for Assigning and Maintaining Engineering/Design Document Numbers - SOP-006-003.

4.3 Parent - Component Relationship See Exhibit "A"

The tree is developed from the top down.

The parent and component relationship needs to be identified in the tree. A parent can be an assembly (finished product), subassembly or any other created/fabricated/produced or manufactured product. A parent item is always made up of one or more component items.

4.4 Pre-Purchased Items - *Major purchased components items with long delivery or special materials*

There are two (2) methods of getting parts on order which can be used by the project manager. Before deciding what method should be used, discuss the types of materials with manufacturing.

The items can be purchased as either advanced ordered parts and not directly linked to the project in EMS, or they can be linked to a project via a BOM structure entered into EMS.

4.4.1 Advance Ordered Items Linked to a Project Bill of Material

For special items unique to one project, the preferred method is to link ordered parts to a job. This method requires a BOM structure entered into EMS and developed down to the level where the equipment or components are identified as parts. The basic drawing tree, as developed for the project, will provide the structure of parent/component relationships for this purpose. This method will establish the project and part

demands in EMS for MRP purposes. They must also be defined in the item master database. They are to be given a custom part number (either job number and P&ID tag number or special "M" or "E" number).

4.4.1.1 Advance Ordered Items on a Temporary BOM

Advance ordered parts can be put on a temporary BOM which can easily be unlinked (not deleted) from the parent when the pre-ordered parts are re-assigned to real detail drawing BOM's. This method will reduce the work required to unlink the parts from the advance BOM and re-assign them to the real BOM's. When this procedure is used, the temporary BOM No. should be shown on the drawing tree. Use Job No. and Bulk 1, or Bulk 2, etc., if more than one temporary BOM is needed.

For additional information on using this method and when the re-linking process should take place, see PSI procedure for loading bills of material, SOP-006-007.

NOTE: When pre-purchased parts are entered on a drawing BOM use exactly the same characters as used in the original EMS entry, including any dashes, spaces, etc.

4.4.2 Advance Ordered Items Not Linked to a Project in EMS

Normally common items or special materials which could be used on more than one project are purchased to inventory. All items to be pre-purchased from a purchase requisition (without a DEO) or a specification need to have an item master created for the parts in EMS before the request goes to purchasing to buy. Purchasing buys the parts and updates EMS when the parts are purchased. These items will show as extra items in EMS until the demand is entered in a BOM. Pre-purchased items are initially entered in EMS at $0.0 cost. They are to be given a SCS (6 digit) standard part number or a custom part number. NOTE: When pre-purchased parts are entered on a drawing BOM use exactly the same characters as used in the original EMS entry (if the exact part number is <u>not</u> used, extra parts will be ordered).

4.5 <u>Level Q</u>

The top level parent item for each job is the project number. It will always be a quantity of one. When this number is called up in EMS the complete listing of groups of packing lists, assemblies and their subassemblies, linked to the parent can be obtained from EMS. The computer can output the drawing tree in indented form.

4.5.1 Other Items Sent to Client or Site

Packing lists or shipping orders for other equipment, parts, etc., which are purchased from vendors and shipped directly to the client, are also shown in a separate branch of the tree. When these items are shown, they provide a means for planning when the transmittals will be made. These items link to the Level 0 parent.

4.6 Level 1 - Packing Lists - *Required for each unique skid or major assembly shipped as a unit*

4.6.1 Items Manufactured by PSI

The packing list is the parent item for each major Product/assembly (i.e. skid) manufactured by PSI and includes all items shipped loose from PSI to the client. This list should include installation interface drawings, valves, valve actuators (if removed for shipping), piping, mounting hardware, etc. (All items to be shipped with the system)

4.6.2 Skid Numbering/Drawing Numbering

(Refer to Document Numbering Procedure SOP-006-003, item 4.1.3)

For custom projects, normally each major skid assembly will be given a 100 series name and the drawing package for the skid will have the same 100 series number. Included in the last three (3) sequential numbers. For example: The packing list for skid 100 = PT077-1-100. The general assembly drawing for skid 100 = T077-5-100.

4.7 Level 2 - General Assembly Drawings

This is the general assembly drawing which is the parent of all the subassembly drawings for a final product or skid.

4.8 Level 3 - Discipline Assemblies

This is the top assembly drawing of each design discipline, i.e. electrical, mechanical/piping, structural, etc. The drawing number normally indicates the discipline and skid number.

4.9 Level 4 - Component Items or Sub-assemblies of Level 3 Assemblies

These items can also be used to group various sub-assemblies into one shop work order. For example: All the piping isometric piping drawings used on a skid are linked to an imaginary item called the piping spool assembly.

The use of additional BOM levels to aid manufacturing in the reduction of work orders should be determined during the development of the drawing tree.

4.10 Level 5 - Components/Parts of Level 4 Items as Required

Additional levels may be used, if required.

4.11 Parts shall be defined and numbered per PSI procedure for numbering parts SOP-740-006 (formerly S-100/S-200).

4.12 Drawings Used as Parts

All drawings in the project are considered parts or assemblies of parts and loaded into EMS with the drawing number as the part number.

The assembly drawing should be the last item in each BOM so that it is issued to the shop with the BOM kit. The revision number should also be shown.

NOTE: It is extremely important that all parts are entered into EMS via a BOM which links to a drawing. This includes all nuts and bolts, paint, insulation, etc. All parts are to be linked to the drawing which is used to install the parts in an assembly. For additional information and examples, see PSI Part Numbering Procedure SOP-006-006 (formerly STD. S-200).

4.13 Specifications Used as Parts

Specifications are only listed in the drawing tree as parts when the specification number is the part number being purchased (no tag numbers). When items have tag numbers (example: T077-FT101), the tag number becomes the part number and the specification number is shown in the part description for reference.

4.14 Manufacturing's Influence in the Tree Structure

Manufacturing should identify the following during the tree development and continue to review the structure during the design phase:

A) All components which will not be manufactured by PSI.

B) Determine what the assembly process will be for each major assembly and subassemblies.

C) Determine a plan of how the structure will be separated into shop orders and how that may affect the tree structure.

D) For advance ordered parts, determine whether they should be purchased to inventory or linked to a project.

4.15 Number of Levels

The structure should contain as few levels as possible.

4.16 Parts Manufactured Outside PSI

Parts that are to be manufactured outside PSI are to be detailed on separate drawings. This will help avoid any misunderstanding by the vendor or PSI manufacturing. Parts manufactured outside PSI do not need detailed BOM.

4.17 Drawing Title Blocks

The drawing tree should show the appropriate format to be used consistently on all the drawings used on the project. On custom projects the title will normally be shown as follows:

Drawing Name
Skid Designation or Unit Name
Client/Project Name
Site or Client Location

4.18 Drawing Tree Reference Documentation

The following items should be shown in the reference documentation branch of the drawing tree:

P&ID's
Shop Job Book
Engineering Lists (valve, instrument line)

4.19 Project Document List

A complete project document list of all issued documents is available from the Document Control Department. Only manufacturing or procurement documents are shown in a project drawing tree.

5.0 FLOW CHART: (see next page)

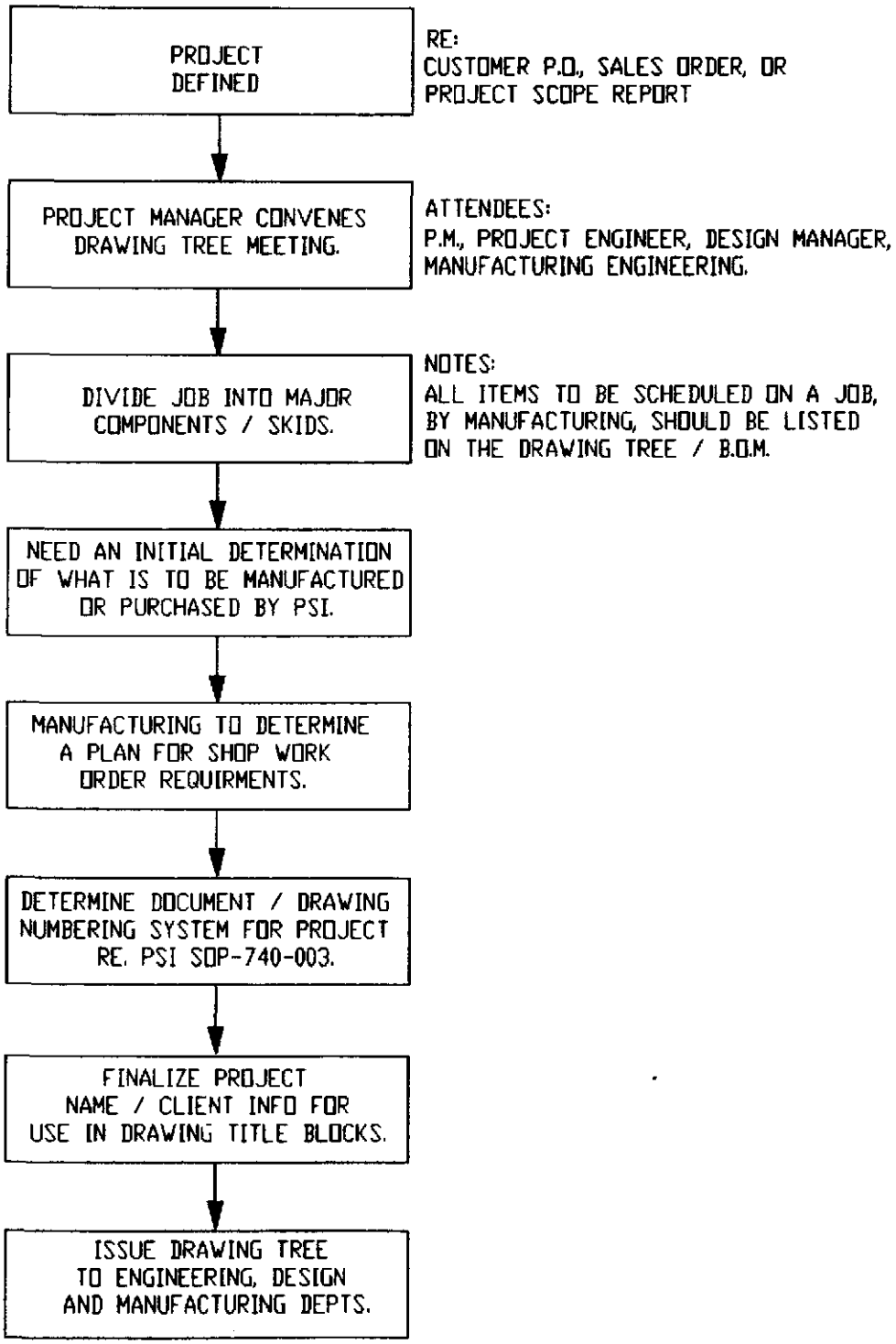
6.0 REFERENCES:

Procedure for Numbering Parts SOP-006-006 (formerly S-100/S-200).

Procedure for Loading Bills of Material SOP-006-007 (formerly STD. S-200).

Procedure for Assigning Engineering/Design Document Numbers SOP-006-003.

5.0 FLOW CHART
PSI DRAWING TREE / B.O.M. STRUCTURE PROCESS



CAD FILE:SOP60202

PROJECT DRAWING TREE EXAMPLE

USE THIS DWG. WITH PROCEDURE SDP-006-002
EXHIBIT "A"

ADVANCE ORDERED PARTS

ITEMS ON SPEC'S OR PURCHASE REQUISITION MUST BE ENTERED INTO EMS BEFORE BEING ISSUED TO PURCHASING. THESE SAME PARTS MUST BE LATER LISTED ON A B.O.M. TO LINK THEM TO THE PROJECT.

NOTE: T15077 = T077
(FIRST FOUR CHARACTERS OF THE ENGINEERING DOCUMENT NUMBER. REF. SDP-740-003)
LISTS/SHIPPING ORDERS FOR ITEMS SENT DIRECTLY TO SITE FROM VENDORS.

T15077
(PROJECT NO. OR ORDER NO.)
PROJECT PACKING LIST PT077-1-000

LEVEL 0
FINAL PRODUCT
QTY. 1

ITEMS NOT MANUFACTURED BY PSI
(PACKING LISTS)
- PT077-1-009 — EQUIPMENT & SPARE PARTS NOT ASSOC. WITH PSI SKIDS
- PT077-1-010 — PLATFORMS, LADDERS, STRUCTURES, ETC.
- PT077-1-011 — INSULATION, MISC. PARTS
- PT077-1-012 — PLOT PLANT, INTERCONNECTING PIPING GA'S, PIPING ISO'S, ETC.
- PT077-1-013 — OPER. MANUALS, FIELD INSTRUCTIONS, ETC.

LEVEL 0

ADVANCE ORDERED PARTS
TEMPORARY B.O.M.
T077-BULK1

SHOP JOB BOOK

REF. DOCUMENTATION NOT LISTED OR SCHEDULED IN EMS

- PFD'S PID'S PLOT PLAN T077-0-002, ETC.
- ENGINEERING LISTS LINE, VALVE, INSTR., ETC. T077-1-001, ETC.
- DOCUMENT LIST (ISSUED BY DOC. CTNL.)

ADDITIONAL SKIDS OR ASSEMBLIES

SKID 100

LEVEL 1
SKID 100 PACKING LIST PT077-1-100 — QTY. "X"

ITEMS SHIPPED LOOSE
- INTERFACE/OUTLINE T077-0-100
- VALVES, ACTUATORS, PIPE SPOOLS
- PENETRATION BOOT ASSY'S
- MOUNTING HARDWARE
- SKID BASE PLATES
- SPARE PARTS

LEVEL 2
GENERAL ASSEMBLY (3D OR OTHER) T077-5-101 — QTY. 1

LEVEL 3
- INSTRUMENT ASSEMBLY DWG. T077-3-150
  - LEVEL 4: ITEMS
- ELECTRICAL ASSEMBLY DWG. T077-3-100
  - LEVEL 4: T077-4-100 TOWERS, DRUMS, HEAT EXCHANGERS, EQUIPMENT MOUNTING HARDWARE
- SKID EQP. INSTALL./ MOUNTING ASSY. DWG. T077-5-101
  - LEVEL 4: STRUCTURAL ASSEMBLY T077-7-100 — SKID WELDMENT DETAILS
- (3D DWGS) SKID PIPING GEN. ASSEMBLY DWG. T077-5-150
  - LEVEL 4: PIPE SUPPORT INDEX T077-7-120 — PIPE SUPPORT DET. DWGS; PIPING SPOOL ASSEMBLY T077-6-100 — PIPING ISO'S

SKID 200

LEVEL 1
SKID 200 PACKING LIST PT077-1-200 — QTY. "X"

ITEMS SHIPPED LOOSE
- INTERFACE/OUTLINE T077-0-200
- VALVES, ACTUATORS, PIPE SPOOLS
- PENETRATION BOOT ASSY'S
- MOUNTING HARDWARE
- SKID BASE PLATES
- SPARE PARTS

LEVEL 2
GENERAL ASSEMBLY (3D OR OTHER) T077-5-200 — QTY. 1

LEVEL 3
- INSTRUMENT ASSEMBLY DWG. T077-3-250
  - LEVEL 4: ITEMS
- ELECTRICAL ASSEMBLY DWG. T077-3-200
  - LEVEL 4: T077-4-200 TOWERS, DRUMS, HEAT EXCHANGERS, EQUIPMENT MOUNTING HARDWARE
- SKID EQP. INSTALL./ MOUNTING ASSY. DWG. T077-5-200
  - LEVEL 4: STRUCTURAL ASSEMBLY T077-7-200 — SKID WELDMENT DETAILS
- (3D DWGS) SKID PIPING GEN. ASSEMBLY DWG. T077-5-202
  - LEVEL 4: PIPE SUPPORT INDEX T077-7-220 — PIPE SUPPORT DET. DWGS; PIPING SPOOL ASSEMBLY T077-6-200 — PIPING ISO'S

EQUIP. THIS DWG.

PROCESS SYSTEMS INTERNATIONAL INC.

PROJECT DRAWING TREE
SKID XXX / UNIT XXX
CLIENT XXX / PROJECT XXX
SITE OR CLIENT LOCATION

SDP60201	D	T077-0-001	0
NONE		1 OF 1	

COLD BOX ENG./DESIGN PROCESS

- ISSUE FOR DESIGN:
  P&ID'S,
  PIPING MAT'L. SPEC
- LOAD IN COMPUTER:
  PIPING MAT'L. SPEC
- DETERMINE:
  CLIENT'S REQUIREMENT OF FORMAL PLANS & GA'S OR PSI MANUFACTURING DRAWINGS

1, 2, 3, 5, 9

COLDBOX PROJECT KICKOFF MEETING

9

- ESTABLISH:
  SHIPPING SIZE,
  HYDRAULIC PROFILE,
  PRELIMINARY EQUIPMENT LOCATIONS,
  DRAWING TREE STRUCTURE
- OBTAIN VENDOR DRAWINGS
- START VESSEL DRAWINGS USING DATA SHEETS

1, 2, 4, 5, 7, 9, 14,

- DEVELOP:
  EQUIPMENT ARRANGEMENT,
  ELEC. EQUIPMENT PLACEMENT
- START 2 1/2D CAD MODEL
- DETERMINE:
  CLIENTS REQ. OF NORTH ARROW
- ESTABLISH:
  POINT OF ORIGIN FOR ALL 'X' REF'S.

2, 3, 4, 5, 7, 9

- DETERMINE:
  SHIPPING REQUIREMENTS,
  ROUGH C.B. CENTER OF GRAVITY,
  SHIPPING DOWN SIDE

2, 4, 5, 7, 9

- INTERNAL DESIGN REVIEW
- RELEASE VESSEL DRAWINGS FOR FABRICATION. NOZZLE LOCATIONS & SUPPORT LUGS ON HOLD
- CLIENT REQUIREMENTS,
  PROCESS/PROJECT CHECK LIST

1, 2, 3, 4, 5, 7, 9, 12, 14

- DETERMINE:
  GALLERY LOCATIONS
  PLATFORM & LADDER LOCATIONS

2, 5, 7

- DEVELOP:
  COLDBOX STRUCTURES
  COLDBOX SUPPORTS

3, 4, 5, 7, 14

- DEVELOP:
  EQUIPMENT LOCATION DRAWING

2, 5, 7

DOES STRESS ANALYSIS OF COLDBOX STRUCTURE PASS

4, 7

NO

REANALYSIS CONSIDERATIONS

- CHANGE STEEL SIZES
- ADD BRACING
- CHANGE BENT SPACING
- PLATFORMS USED AS REINFORCEMENT

YES

- FINALIZE:
  SUPPORT LOCATIONS FOR EQUIPMENT
- REMOVE:
  HOLDS ON NOZZLE LOCATIONS & SUPPORTS LUGS

2, 4, 5, 7

DOES PIPE PASS STRESS ANALYSIS

4, 5

NO

REANALYSIS CONSIDERATIONS:

- ADJUST PIPING LAYOUT AND/OR EQUIPMENT SUPPORT POINTS
- REQUEST HIGHER ALLOWABLE LOADS ON NOZZLES PER PIPE STRESS ANALYSIS RESULTS

4, 5, 14, 7

YES

IS MOST ECONOMICAL PIPE ROUTING USED ?

4, 5

NO

- REROUTE WITH LESS FITTINGS OR MORE DIRECT ROUTE

4, 5

IS IT ECONOMICALY FEASABLE TO REROUTE PIPE?

2, 5, 9,

NO

YES

YES

- FINALIZE:
  STRUCTURAL ARRANGEMENT DETAIL DRAWINGS

5, 7

- INTERNAL DESIGN REVIEW OF:
  2 1/2D PIPING ARRANGEMENT OF LARGE BORE PIPING,
- BEGIN:
  ELECTRICAL DESIGN

2, 4, 5, 6, 7, 9, 14

- CLIENT APPROVAL (IF REQUIRED)

2, 9

- ISSUE FOR FABRICATION:
  STRUCTURAL ARRANGEMENT & DETAILS, EQUIPMENT LOCATION
- GENERATE:
  3D PIPING ARRANGEMENT DRAWING, PIPING ISOMETRICS FROM MODEL

2, 4, 5, 7, 9

DROP BULK B.O.M. FROM 3D MODEL (IF REQUIRED)

- CHECK:
  PIPING ISOMETRICS
- GENERATE:
  EMS BILL OF MAT'L.

2, 5

- ISSUE FOR FABRICATION
  ISO'S
  3D PIPING ARRANGEMENTS
  BOX PENETRATIONS
  ALL MISC & STD. DETAILS
  ALL ELECECTRICAL & INSTRUMENT DRAWINGS

GROUP RESPONSIBILITIES

1.) PROCESS ENGINEER
2.) PROJECT ENGINEER
3.) I/E ENGINEER
4.) CIVIL ENGINEER
5.) MECHANICAL DESIGN
6.) I/E DESIGN
7.) STRUCTURAL DESIGNER
9.) PROJECT MANAGER
12.) Q.A.

PROCESS SYSTEMS INTERNATIONAL, INC.

WESTBOROUGH, MA.

DEPARTMENT PROCEDURE

FOR

THE DOCUMENT CONTROL DEPARTMENT

PROCESS SYSTEMS INTERNATIONAL – WESTBOROUGH, MA

REV	DATE	DESCRIPTION
1	5-4-95	Update DEO# 5022
0	9-15-94	RELEASE FOR USE DEO# 006-011

CERTIFIED FOR ISSUE

BY _____ DEPART.MGR. _____ V.P. _____

NO. SOP-006-011

SHEET 1 OF 18

DATE 9-15-94

Document Control Department Operating Procedures

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1.0 PURPOSE

The purpose of this procedure is to establish the responsibilities and define the any operations of the Document Control Department.

2.0 GENERAL

The Document Control Department (DCD) functions as the central point in managing and maintaining the electronic document data base, distribution, and archiving of electronic and hard copy controlled documents.

For the purpose of this document, Project Manager and Product Line Manager (PM) are synonymous.

3.0 RESPONSIBILITIES

The DCD is responsible for management, distribution, and archiving of the following documents:

A) PSI Engineering documents (electronic and hard copy)
B) Client documents, submittals, and transmittals
C) Vendor documents, submittals, and transmittals
D) Historical data base of all Projects and related Job Books
E) PSI Standard Operating Documents. These include Procedures (SOP), Work Instructions (WI), Work Standards (STD), Standard Drawings, etc.)

Any changes to this procedure must be approved by the Engineering Manager and the Vice President of Operations.

4.0 PROCEDURE

4.1 PSI ENGINEERING DOCUMENTS

4.1.1 DEO RELEASES

All PSI Engineering documents shall be released via a Design Engineering Order (DEO) as prescribed in **SOP-006-012**.

When a DEO Release is received in the DCD, the DCD shall perform the following:

A) Update the Document Control Data Base (DOCMAN) file
B) Copy and distribute according to the distribution provided by the Project Manager (PM) on the back of the DEO.
C) File the original copy of the released documents in the DCD for reference.

4.1.2 REQUESTS FOR CHANGE

A Request for Change (RFC) shall be submitted as prescribed in SOP-006-001.

Upon receiving an RFC the DCD shall:

A) Apply an RFC Number from the RFC Log Book (See WI-006-001)
B) Retain a copy of the RFC for the DCD RFC Pending File (The RFC Pending File is a hard copy "tickle" file of OPEN RFC's.)
C) Enter the RFC information in DOCMAN (the Document Management Program) with the description "OPEN"
D) Write a penciled note on the document being effected by the RFC noting the following:

    1) RFC Number
    2) "RFC Pending"
    3) Date

E) Forward the original copy of the RFC to the appropriate PM for disposition.

When a final disposition has been determined by the PM and the RFC has been returned to the DCD for distribution, the DCD will:

A) Update the DOCMAN file with the final disposition. Available dispositions are as follows:

    1) Approved
    2) Void
    3) DEO with DEO number

B) Correct the penciled note on the effected document indicating the RFC's final disposition (exception - DEO'd RFC's)
C) Copy and distribute the RFC according to the distribution list provided by the PM on the back of the RFC and shall include the originator of the RFC.
D) File the original copy of the RFC in the DCD Job File for reference.

See SOP-006-001 for complete details on issuing RFC's.

4.1.2 REQUESTS FOR CHANGE CONT.

The maximum number of RFC's on any document shall not exceed five (5). After five RFC's the accumulated changes shall be applied to the document by the Engineering/Design group and released via a DEO. RFC's can be "held for accumulation" and applied to the document at the end of the job as the Project Manager deems appropriate.

4.2 CLIENT DOCUMENTS

4.2.1 CLIENT SUBMITTALS

All Client submittals received in DCD will be given a document number in the "8" (or Vendor discipline) category unless otherwise directed by the PM. Client documents received in DCD will be logged in DOCMAN, copies forwarded according to the PM's direction, and the original filed in the appropriate DCD Job File.

All accompanying transmittal cover sheets will be 3-hole punched and kept in the Job Log Book for reference.

4.2.2 CLIENT TRANSMITTALS

All Client transmittals involving controlled documents will be processed through the DCD. DCD will:

A) Generate the transmittal using DOCMAN (see WI-006-002)
B) Complete the necessary shipping forms
C) Package the documents
D) Mail the documents according to the PM's instructions.
E) Retain a copy of the transmittal cover sheet in the Job Log Book for reference

4.3 VENDOR DOCUMENTS

4.3.1 VENDOR SUBMITTALS

All Vendor submittals received in DCD will be given a document number in the "8" (or Vendor discipline) category unless otherwise directed by the PM. Vendor documents received in DCD will be

4.3.1 VENDOR SUBMITTALS CONT.

logged in DOCMAN and the Review, Approval, and Status stamps applied (see ILL.1). These documents will be forwarded to the PM who will circulate them through the appropriate disciplines for review and approval.

All accompanying transmittal cover sheets will be 3-hole punched and kept in the Job Log Book for reference.

4.3.2 VENDOR TRANSMITTALS

When the Review and Approval process is complete the PM will apply his/her signature, check off the appropriate Vendor Approval Code, and return the documents to the DCD. The DCD will:

A) Make copies of the documents for the Project team according to the PMs instructions
B) Prepare a Vendor transmittal to accompany the copies being returned to the Vendor (See WI-006-002)
C) Complete the necessary shipping forms
D) Package the documents
E) Mail the documents according to the PM's instructions
F) File the original in the appropriate DCD Job File.
G) Retain a copy of the transmittal cover sheet in the Job Log Book for reference

4.4 HISTORICAL DATA

When a PSI Project, with the exception of Standard Cryogenic Systems (SCS), begins, the DCD forwards a New Project Information Package (see ILL.2) to the PM to obtain the necessary data to establish Job Log Books and Job Files for the new project.

The items included in the New Project Information Package are:

A) An explanation of the primary functions of the DCD
B) Information Checklist
C) Mail service summary
D) DCD transmittal information and cut-off times
E) Transmittal information sheet (to be completed by the PM)
F) Distribution form (to be completed by the PM)

4.4 HISTORICAL DATA CONT.

The Standard Cryogenic Systems (SCS) group differs from the Custom Project group in that the DCD perpetually maintains the SCS drawings, drawing Log Books, and related files. These products are standard equipment and sold as such with only minor modifications as specified by any given Customer. Special system configurations are documented using the standard SCS document numbering system.

4.4.1 CUSTOM PROJECT JOB LOG BOOKS AND FILES

The Custom Project Job Log Book is a 3-ring binder that contains the following Project information:

A) Discipline specific drawing/document logs
B) Computer generated drawing log from DOCMAN (see WI-006-002)
C) DEO Log
D) PSI transmittal cover sheets to Client
E) Client transmittal cover sheets to PSI
F) PSI transmittal cover sheets to Vendors
G) Vendor transmittal cover sheets to PSI

Project Job Books are not to be removed from the Document Control Department.

The Custom Project Job Files are kept in the DCD office area for reference as long as the Project is active. Job Files contain the following items:

A) Master copies of the Project's forms
B) Blank DEO forms for releases
C) Released DEOs
D) Approved RFCs
E) Bills of Material (BOMs)
F) Specifications
G) All "A" size (8 1/2" X 11") drawings and documents
H) Vendor related data

A separate flat file located in the DCD reproduction room will be labeled with the Custom Project Job number where all current B, C, D, and E size drawings will be held (see SOP-006-008 for archiving of previous revisions).

The PM notifies the DCD when a Project has been completed. At that

4.4.1 CUSTOM PROJECT JOB LOG BOOKS AND FILES CONT.

time all Job drawings, Job Log Books, and Job Files are transferred to the DCD locked storage area for archiving (see SOP-006-008).

4.4.2 STANDARD CRYOGENIC SYSTEMS DRAWING LOGS AND FILES

The SCS Drawing/Document Log Books contain only log sheets. These log sheets are organized in a specific four-digit base number system (see SOP-006-003 and 3545-2-001). Several base number logs can be contained in one Log Book; however, they must be separated by clearly marked tabs for easy reference. A separate DEO Log Book is maintained for all SCS releases.

4.4.2 SCS DRAWING LOGS AND FILES CONT.

The SCS Files are arranged in the same four-digit base number system with separate files for all SCS DEOs and RFCs. (SCS DEOs and RFCs are filed numerically from lowest to highest in front.)

Both SCS Drawing/Document Log Books and their related files are kept in the DCD office area for reference.

A separate flat file located in the DCD reproduction room will be labeled by base number where all current B, C, D, and E size drawings will be held (see SOP-006-008 for archiving of previous revisions).

4.5 OPERATING PROCEDURES AND STANDARDS (SOP)

4.5.1 SOP LOG BOOK

DCD maintains the Procedure and Standards Log Book and assigns numbers to these documents by utilizing this log book in the same manner as Engineering uses the drawing/document log for Custom projects.

The Procedure Log Book is divided into tabbed sections by Department. Each department has been assigned a permanent three-digit numeric

4.5.1 SOP LOG BOOK CONT.

indentification number. There are three document categories (denoted by their prefix below) as follows:

A) **SOP** = Standard Operating Procedures
B) **WI** = Work Instructions
C) **STD** = Standard Drawings and Guidelines

The DCD also maintains (and updates with each new entry into the Procedures Log Book) an Index listing all the pending and released procedures to date. The updated Index is distributed to all designated personnel who hold the SOP Binder for their individual department or group (see Section 4.5.3).

4.5.2 FILING AND STORAGE

The DCD maintains files for all current Procedures and Standards in the DCD office where they are kept for reference by all PSI personnel.

The SOP file contains:

A) SOP Distribution List (see ILL.3)
B) SOP Cover Sheets
    1) Company Procedures
    2) Department Procedures
C) Folders containing the original document. Folders are arranged by Department and document category (see Section 4.5.1)

4.5.3 DISTRIBUTION

The distribution of any Procedure or Standards document is determined by the Department Manager or Vice President of the department where the procedure is generated. Those personnel who are holders of SOP Binders for their department or group will receive copies of all released Procedures automatically. These persons are "flagged" on the SOP distribution list by an asterisk (see ILL.3).

4.6 OTHER DOCUMENT CONTROL FUNCTIONS

The DCD also provides the following services:

A) "Release of Original" to Engineering/Design for revisions
B) Reproduction of Job and Product Manuals
C) General copying

4.6 OTHER DOCUMENT CONTROL FUNCTIONS CONT.

D) Maintenance of Engineering Data Library
E) Archiving of documents (see SOP-006-008)
F) Generate reports from DCD data base (i.e Job Drawing Logs and RFC Aging report - see WI-006-002)

5.0 FLOWCHARTS

None

6.0 REFERENCES

None

7.0 EXHIBITS

ILL.1 Review, Approval, and Status Stamps
ILL.2 New Project Information Package
ILL.3 SOP Distribution List

REVIEW STAMP

PROCESS SYSTEMS INTERNATIONAL
DOCUMENT REVIEW CHECKLIST

PROJECT NAME: Lyondell-Citgo
PSI DOC. NO. M27004-8-499 0

CHK	BY / DATE
____ PROJECT ENG	
____ MECHANICAL	
____ STRESS	
____ ELECTRICAL	
____ PROCESS	
____ MFG. ENG.	
____ MANUF	
____ Q.A.	
____ DRAFTING	

7/29/94

APPROVAL STAMP

PROCESS SYSTEMS INTERNATIONAL
DOCUMENT APPROVAL CHECKLIST

PROJECT NAME: Lyondell-Citgo
PSI DOC. NO. M27004-8-499

NOTE: THIS REVIEW DOES NOT RELIEVE THE SELLER OR CONTRACTOR OF ANY OBLIGATIONS UNDER THE P.O. OR CONTRACT.

____ FA = FINAL APPROVAL
____ AS = APP'D AS NOTED - REVISE & RESUBMIT
____ AF = APPROVED FOR FABRICATION
____ NA = NOT APPROVED
____ RP = RELEASED FOR PROCUREMENT OF MATERIALS ONLY
____ RR = REVISE & RESUBMIT

BY _____ DATE _____

STATUS STAMP

REVIEWER	Valtek
REVISION NO	2
SUBMITTAL NO	3rd
STATUS	Review & Approval

ILL.1

PROCESS SYSTEMS INTERNATIONAL, INC. REV 2/95

NEW PROJECT INFORMATION/DATA PACKAGE

PROJECT MANAGER:

CONGRATULATIONS ON YOUR NEW PROJECT!

THE DOCUMENT CONTROL DEPARTMENT IS RESPONSIBLE FOR THE ORGANIZING AND MAINTENANCE OF PROJECT DOCUMENTS. AT THE BEGINNING OF EACH PROJECT DOCUMENT CONTROL CREATES SPECIFICATION AND DRAWING FILES, COMPUTER LOGS AND A PROJECT BOOK.

THE FOLLOWING PAGES REQUEST THE NECESSARY INFORMATION TO SET UP THESE RESOURCES. THE NEXT PAGE AFTER THIS COVER SHEET CONTAINS A CHECK LIST FOR YOUR CONVENIENCE. WHEN YOU HAVE COMPLETED THIS PACKAGE, PLEASE RETURN IT'S ENTIRE CONTENTS TO DOCUMENT CONTROL.

NOTE: IF DOCUMENT CONTROL DOESN'T RECEIVE THIS INFORMATION IN TIME FOR THE FIRST DOCUMENT RELEASES, PROCESSING MAY BE DELAYED!

IF YOU HAVE ANY QUESTIONS REGARDING THIS PACKAGE OR THE FORMS CONTAINED IN THESE PAGES, PLEASE DON'T HESITATE TO ASK.

SINCERELY,

THE DOCUMENT CONTROL DEPARTMENT

20 Walkup Drive • Westborough, Massachusetts 01581-5003 • 508/366-9111 • FAX 508/870-5930

NEW PROJECT INFO PACKAGE

CONTENTS

CHECK OFF WHEN DONE

____ 1) MAIL SERVICE SUMMARY (FOR YOUR REFERENCE)

____ 2) TRANSMITTAL CUT-OFF TIMES (FOR YOUR REFERENCE)

____ 3) TRANSMITTAL INFORMATION SHEET (PLEASE FILL IN APPROPRIATE INFO)

____ 4) BLANK DISTRIBUTION FORM WITH INSTRUCTIONS (PLEASE FILL IN APPROPRIATE INFO)

____ 5) SPECIAL INSTRUCTIONS AND REQUIREMENTS OF PROJECT (LIST BELOW)

_____

_____

_____

_____

_____

_____

_____

_____

_____

INFORMATION COMPLETED BY _____ DATE _____

MAIL SERVICE SUMMARY

EXPRESS MAIL: (DOMESTIC)

COST - MOST ECONOMICAL OF ALL METHODS AVAILABLE
DELIVERY - GUARANTEED TWO DAYS

FEDERAL EXPRESS: (DOMESTIC & INTERNATIONAL)

COST - RANGES BETWEEN HIGH TO ECONOMICAL DEPENDING ON REQUESTED DELIVERY
DELIVERY - PRIORITY OVERNIGHT: 10:30AM NEXT DAY
STANDARD OVERNIGHT: 3:00PM NEXT DAY
ECONOMY TWO-DAY: 4:30PM 2ND DAY
SATURDAY DELIVERY: 1:30PM SATURDAY

SPECIAL REQUIREMENTS: - ALL PACKAGES MUST HAVE A STREET ADDRESS. **NO P.O. BOXES ARE ACCEPTED!**

NOTE: FEDERAL EXPRESS PROVIDES AN EXCELLENT PACKAGE TRACKING SYSTEM THAT PROVIDES DATE THE PACKAGE WAS DELIVERED, TIME OF DELIVERY, AND NAME OF CONSIGNEE.

DHL WORLDWIDE: (USE ONLY IF REQUESTED BY CLIENT)

COST - RANGES BETWEEN HIGH TO MEDIUM DEPENDING ON REQUESTED DELIVERY
DELIVERY - AS INDICATED IN SERVICE MANUAL.

CLIENT/VENDOR TRANSMITTAL
CUT-OFF INFORMATION

IN ORDER TO PROCESS SAME DAY TRANSMITTALS, DOCUMENT CONTROL HAS THE FOLLOWING REQUIREMENTS:

RECEIVED IN DOCUMENT CONTROL		WILL SHIP
BEFORE	2:00PM	SAME DAY
AFTER	2:00PM	NEXT DAY

TRANSMITTALS CONTAINING **30 OR MORE** DRAWINGS, THAT REQUIRE REPRODUCTION COPIES, RECEIVED AFTER 12:00 NOON MIGHT NOT MAKE SAME DAY SHIPPING DUE TO PREP AND PROCESS TIME.

REMEMBER: THE EARLIER IN THE DAY THE DOCUMENT CONTROL DEPARTMENT RECEIVES THE TRANSMITTAL CONTENTS THE BETTER.

IF YOU ANTICIPATE A LARGE TRANSMITTAL, LET US KNOW AS SOON AS POSSIBLE SO WE CAN ORGANIZE OUR WORK LOAD ACCORDINGLY.

THANK YOU FOR YOUR COOPERATION.

TRANSMITTAL INFORMATION SHEET

PROJECT MANAGER: _____

PROJECT NUMBER: _____

NAME OF CLIENT: _____
STREET ADDRESS: _____
CITY/STATE/ZIP: _____

ATTN: _____

PREFERRED SHIPPING METHOD:

_____

_____

NUMBER OF PRINTS REQUIRED: _____ REGULAR PRINTS
_____ REPRODUCIBLES

OTHER EXTERNAL DISTRIB:

NAME: _____ # COPIES _____
NAME: _____ # COPIES _____
NAME: _____ # COPIES _____

ADDITIONAL INFORMATION: _____

_____

_____

_____

DISTRIBUTION FORM INSTRUCTIONS

THE PURPOSE OF THE DISTRIBUTION FORM IS TO AID IN THE INTERNAL AND EXTERNAL DISTRIBUTION OF DOCUMENTS FOR EACH PROJECT. (IT CAN ALSO BE USED AS A CHECK LIST FOR THE INTERNAL REVIEW OF DOCUMENTS BEFORE THEY ARE OFFICIALLY RELEASED ON A DEO.)

THE DISTRIBUTION LIST IS CONVENIENTLY PHOTOCOPIED ON THE REVERSE SIDE OF EACH DEO AND IS SPECIFIC TO EACH PROJECT. AFTER FILLING OUT THE FRONT OF EACH DEO WHEN RELEASING A DOCUMENT, YOU WILL NEED TO CIRCLE THE APPROPRIATE QUANTITIES FOR DISTRIBUTION ON THE BACK. THIS WILL PROVIDE DOCUMENT CONTROL WITH THE INFORMATION NEEDED TO DISTRIBUTE EACH DEO CORRECTLY.

THE DOCUMENT CONTROL DEPARTMENT WILL <u>NOT</u> TRY TO "SECOND GUESS" THE DISTRIBUTIONS YOU HAVE NOTED ON EACH DEO; THEREFORE, IT IS IMPORTANT THAT YOU FILL THIS INFORMATION OUT CORRECTLY.

IF, AT ANY TIME, YOU NEED TO MODIFY THE DISTRIBUTION LIST FOR ANY GIVEN PROJECT. PLEASE INFORM THE DOCUMENT CONTROL DEPART- MENT SO IT CAN BE CORRECTED PROMPTLY.

PLEASE FILL OUT THE FOLLOWING PAGE ACCORDING TO THE INSTRUCTIONS PROVIDED.

DISTRIBUTION FORM FOR:

PROJECT NAME: (1) _____

PROJECT NUMBER: (2) _____

IF COPIES OF THE ATTACHED DOCUMENTS ARE REQUIRED PLEASE CIRCLE THE QUANTITY IN THE APPROPRIATE COLUMN.

___CODE (3) ___NON CODE

DEO #_____	DWG	SPEC	DEO	RFQ	BOM	RFC
		(4)				

PURCHASING, QUALITY ASSURANCE, MAT'L PROCUREMENT (TO BE COMPLETED BY DOCUMENT CONTROL)

A BRADBROOK						
D BILODEAU			(5)			
B SCHRAMM						

NOTES (6)

EXTERNAL DISTRO		(7)				
TOTAL COPIES		(8)				

HOW TO FILL IN YOUR INITIAL DISTRIBUTION FORM

(1) FILL IN PROJECT NAME

(2) FILL IN PROJECT NUMBER

(3) CHECK OFF IS JOB IS "CODE" OR "NON-CODE" (i.e. PRESSURE VESSELS)

(4) FILL IN NAMES OF PSI STAFF AND THE QUANTITIES OF COPIES THEY WILL REQUIRE. BE SURE TO THINK OF ALL THE POSSIBLE DISTRO'S THIS JOB WILL HAVE TO BE SURE NO ONE WILL BE OMITTED.

(5) LEAVE THIS AREA BLANK. DOCUMENT CONTROL WILL FILL IN THESE TOTALS AS EACH DEO REQUIRES.

(6) LIST SPECIAL INSTRUCTIONS SUCH AS "EXTERNAL: 1 REPRO & 2 PRINTS".

(7) FILL IN THE NUMBER OF COPIES THE CUSTOMER HAS REQUESTED TO BE SENT TO THEM FOR INFO AND/OR APPROVAL.

(8) PLEASE LEAVE BOTTOM LINE BLANK. DOCUMENT CONTROL USES THIS AREA FOR PROCESSING YOUR RELEASES.

PLEASE FILL OUT DISTRO FORM PROVIDED ON THE NEXT PAGE ACCORDING TO THE INSTRUCTIONS GIVEN ABOVE.

DISTRIBUTION FORM FOR:

PROJECT NAME:_____

PROJECT NUMBER:_____

IF COPIES OF THE ATTACHED DOCUMENTS ARE REQUIRED PLEASE CIRCLE THE QUANTITY IN THE APPROPRIATE COLUMN.

____CODE ____NON CODE

DEO #_____	DWG	SPEC	DEO	RFQ	BOM	RFC

PURCHASING, QUALITY ASSURANCE, MAT'L PROCUREMENT (TO BE COMPLETED BY DOCUMENT CONTROL)

A BRADBROOK						
D BILODEAU						
B SCHRAMM						
NOTES						
EXTERNAL DISTRO						
TOTAL COPIES						

COMPANY PROCEDURE DISTRIBUTION LIST

4/95

GENERAL

* TOM ANKERMANN
* RICH BAGLEY
* BETH BARKLEY
DON BENERE
RON BENTO
TED BITOMSKI
* CHRIS CONNOR
DEBBIE COX
TED DESIRAKIAN
* DICK DERY
* DOUG DUCOTE
BOB ERIKSSON
MIKE FREEMAN
* KENT HIGGINS
KRIS HILLENBURG
* MAURICE KING
NORM MacKAY
MIKE MAGLIO
JOE McNAMARA
* BOB MOSELEY
BILL MURPHY
JOHN O'BRIEN
HERB PETERS
ELAINE PIGNATARO
BOB POWELL
TOM STARR
* PETER VanDUYNE
* KEN WEISMANTEL
B WOJNAROWSKI

PROC/PROJ ENG

* PAUL DOHERTY
LYNDA ENGSTROM
DICK ERIKSSON
BRETT FORLANO
JIM FRASER
JOHN FUCCI
M HENNESSEY
* DICK HOPEWELL
TED KOBEL
* D McWILLIAMS
AL MEISINGER
DAVE MOORE
STU MOTEW
MUSTAFIZ RAHMAN
KRIS ROBERTS
BILL ROCHELLE
L SYLVESTRE
ROBERTO THAN
STEVE TOTH
HANK VALCOUR

I/E ENG

FADI BARK
DICK BRAZER
STEVE CHIAVAROLI
RALPH GESE
MAX KOZYRCZAK
DAN PARENTI
GEORGE ROGERS
PETE SCHMIDT
LYNEL TRAVESI

CIVIL/STRUCT

JOHN ALMONTE
* FRED CORDELLA

I/E DESIGN

GLENN DAVIDSON
* ALAN GAGNON
BRUCE ROTH
RUSS WOOLEY
SHARON WILCOX
WELLS WHOOTEN
KARL YAO

MECH DESIGN

HARRY BASELICE
BILL BATES
BOB BATTISTA
MARK BROSS
* LEON COOK
* DICK CURTIS
LAURIE DAYTON
JOE GRANT
ED LAWS
ROCKY MAZO
LEO MITCHELL
GARY OWENS
RON PETERSON
KAARLO RINTARA
CONNIE SALVUCCI
PAUL VAUGHN
GARY WESLEY

Q/A

* A BRADBROOK
PAUL CLARKE
GENE SENECAL
STEVE SOKEL

NPS

LARRY BAILEY
ALAN HENRIKSON
LISA SIMARD
* JACK WALLER

PURCH/MAT'L

DIANE BILODEAU
PHIL FERLAND
BARRY SCHRAMM
DICK WEDGE
BOB VARIEUR

SHOP

M BROUWERS
GENE GAGNE
JOHN GESSNER
RON SULLIVAN

* = INDICATES HOLDER OF PROCEDURE BINDER FOR GROUP OR AREA. PLEASE SEND COPY OF EVERY RELEASE THREE HOLE PUNCHED FOR BOOK.

20 Binders

102

9 of 9

PROCESS SYSTEMS INTERNATIONAL, INC.

WESTBOROUGH, MA.

DEPARTMENT PROCEDURE

FOR

RELEASE OF CONTROLLED DOCUMENTS

PROCESS SYSTEMS INTERNATIONAL – WESTBOROUGH, MA

REV	DATE	DESCRIPTION
R0	2/2/95	RELEASE FOR USE DEO# S012

CERTIFIED FOR ISSUE

BY REB DEPART.MGR. REB V.P. D. DUCOTE/REB

NO. SOP- 006 - 012

SHEET 1 OF 9

DATE 2/2/95

TABLE OF CONTENTS

1.0 PURPOSE

2.0 GENERAL

3.0 RESPONSIBILITIES

4.0 PROCEDURE

- 4.1 General Document Release Procedure
- 4.2 ASME Code Vessels

5.0 FLOW CHART

6.0 REFERENCES

7.0 EXHIBITS

- A. Standard DEO
- B. *ASME Vessel DEO*
- C. Engineering Document Electronic File Structure

1.0 PURPOSE

The purpose of this procedure is to detail the process of releasing/revising all "controlled documents", including Specifications, Drawings, Bills of Material, Standard Operating Procedures, Work Instructions, SCS Sales Orders, etc.

2.0 GENERAL

Engineering documents must be prepared, released and archived in an efficient manner to promote cost-effective project execution. This procedure details the process for sign-off, distribution and archiving of engineering documents.

The release of PSI "Controlled Documents" is controlled via a Design/Engineering Order (DEO). The DEO is used to record document information, document changes from the last issue, routing for sign-off, internal and external distribution, etc.

A white DEO is used for general releases and a different blue DEO is used for ASME code vessel releases.

This procedure is applicable to all PSI product lines except for NPS Products. NPS is covered by its own procedures.

Glossary

BOM	Bill of Material
DEO	Design Engineering Order
RFC	Request for Change
EMS	PSI Material/Financial Management Computer System
CAD	Computer Aided Design
SCS	Standard Cryogenic Systems

3.0 RESPONSIBILITIES

Each product line manager is responsible for their product line complying with PSI procedures.

The Document Control Department is responsible for issuing and archiving all engineering documents.

The Vice President of Engineering is responsible for approving all revisions to this procedure.

4.0 PROCEDURE

The procedure for releasing engineering documents varies slightly depending on the product line and equipment type. The following sections detail the different requirements.

4.1 General Document Release Procedure

Preparer

For drawings, DEO is prepared by the responsible designer who developed the drawing or revision. For specification and other documents, the DEO is prepared by the responsible engineer who prepared the document or revised it.

Once the DEO is prepared, the preparer shall have the Project Manager fill in the sign-off routing (as required for each type of document) and hand-carry the document/DEO to the next reviewer.

If the document does not order material or call for PSI fabrication, entry into the EMS is not required. The Project Manager should put N/A in the EMS routing block.

Documents must be revised and acted on as soon as possible. The **maximum** delay in review time for a reviewer should be one day.

DEO/Document Sign-off

Preliminary issue revision (P1, P2, etc.) may be issued with only the project managers' sign-off (or their designee) on the DEO. The DEO number and reason for issue should be filled in on all preliminary drawing releases.

Draft copies of the documents to be released should always be circulated to the applicable project team members (including Manufacturing) prior to the document sign-off to minimize delays in releasing the document.

The following signatures are mandatory on DEO's releasing formal numbered issues (0, 1, 2, etc.)

For the Standard Cryogenic Systems (SCS) product line, the mandatory sign-offs for release are: The Preparer and the Engineering Supervisor. ASME Code Vessel releases shall comply with paragraph 4.2.

For the Custom/High Vacuum product lines, the mandatory sign-offs for release are: The Preparer, the Checker, Discipline Engineer of the type of drawing or specification being issued, and the Project Manager (or their designee). ASME Code Vessel releases shall comply with paragraph 4.2.

A data entry sign-off is required to issue or revise a Bill of Material (BOM). The DEO is signed off after the BOM is entered and "linked" to the project in the Paradox System. When a BOM is modified, an add/change/delete report shall be attached to the DEO and distributed.

Note: A RFC cannot be used to issue or revise a BOM.

A data entry sign-off is mandatory for all documents and BOM issued for PSI purchase or manufacture. The Project Manager shall note N/A in the EMS routing block if data entry into EMS is not required.

Note: The actual transfer of BOM data from the Paradox System to EMS is controlled by the Document Control Department. "System Nets" (add/change/delete information) are done twice daily and downloaded to EMS.

For CAD drawings, all sign-offs for the current issue shall be manual signatures or initials. The previous issue's sign-offs shall be electronically added to the document file during the revision process.

All documents and the DEO will continue to be signed off by all disciplines which have contributed to or reviewed the document.

For samples of the new DEO forms, see Exhibit II (used mainly for new releases) and Exhibit III (used mainly for releases of revised documents). Continuation pages are also available from the Document Control Department for each type DEO.

If the document also has a customer number, both numbers should be shown on the DEO so that the Document Control Department database can cross-reference the drawing numbers.

This sign-off procedure is applicable to all current and new PSI projects.

SCS Sales Orders

SCS sales are issued via a DEO. See "Controlling SCS Sales Orders", WI-010-003, for details.

DEO Numbering and Stickers

For Custom/High Vacuum projects, DEO's will be numbered consecutively starting from 001 for each project. DEO number stickers are provided for each project to avoid double numbering the DEO's.

For SCS projects, DEO's will continue to use the four-digit series. DEO numbers will be assigned by the Document Control Department and logged into the project book.

Projects that are in progress shall continue to use their current system.

Document Distribution

The Project Manager is responsible for setting up the project document distribution with the Document Control Department. A "New Project Information/Data" package is available from the Document Control Department for this purpose.

As each person reviews the document and signs off, they must also circle their required number of copies on the form on the back of the DEO. The Project Manager is responsible for document distribution to parties (Material Control, etc.) that have not reviewed the documents.

An add/change/delete report shall be distributed with the DEO when a BOM is revised.

Electronic Document Archiving

Note: This archiving procedure applies to all electronic documents except for 3-D models.

Unless otherwise noted herein, when an electronic document is ready for issue, the signed-off document and DEO form shall be delivered to the Document Control Department. If the document is not on the PSI network, a floppy copy of the document shall also be provided with the signed-off hardcopy. The Document Control Department will archive the document by moving it from the In-progress ("IN") subdirectory to the Issued ("IS") subdirectory. If the document is being transferred by floppy, a copy of the document should also be temporarily stored in the preparer's computer in case of loss or damage to the floppy. Once the preparer receives a copy of the released DEO, the backup copy should be erased.

If the document is available to the Document Control Department over the network, the preparer will leave the document to be issued in the In-progress ("IN") subdirectory so that the Document Control Department can electronically move the document into the ISSUED subdirectory. A copy of the issued document should also be temporarily stored in the preparer's computer in case of loss or damage to the file during archiving.

All subsequent revisions to documents shall be made using the Document Control Department copy of the file by copying the document from the "IS" subdirectory into the "IN" subdirectory. All superseded documents will be moved by the Document Control Department into the "SU" subdirectory for storage. The electronic file name of the old file will be modified to prevent accidental usage of the superseded file (see SOP-006-003 for details).

This electronic document file archiving system will be used for all projects as each document is released or revised.

A diagram of the Electronic File Structure is attached to this memo (Exhibit IV).

3-D Models

3-D models will be archived per WI-009-001.

Document and Electronic File Numbering

The PSI document and electronic file numbering system is generally based on a project number based system. Occasionally, a product family numbering system will be used for Custom Services/High Vacuum projects when generic components and sub-assemblies are used across a family of products. See SOP-006-003 titled, "Department Procedure for Assigning and Maintaining Engineering Document Numbers" for complete details.

SCS uses a separate system. For details, see "Document Numbering System for SCS", A3545-2-001.

Material Disposition

When previously purchased material is affected by a BOM change, material disposition information shall be added to the DEO by the Project Manager (or Engineering Supervisor).

Revisions to Document/Title Blocks

Back-circles, Revision Marks

For specifications and other documents, all changes shall be detailed on the DEO as well as noted with a revision mark in the page margin.

For Custom Services/High Vacuum projects, all drawing revisions (CAD and manual drawings) shall be detailed on the DEO in addition to being back-circled (with revision mark) on the drawing. Changes can also be detailed by reference to an RFC. Large revisions may be generally noted on the DEO, but all drawing and BOM changes must be identified on the documents or with an add/change/delete report.

For SCS product line, back-circles are not required.

Title Blocks

For Custom Services/High Vacuum projects, the DEO number and the reason for issue (preliminary, for design, etc.) should always be shown in the drawing revision block.

For SCS, the exact changes to the document should be filled in the revision block (up to a maximum of two lines) along with the DEO number.

Request for Change (RFC)

When a DEO issues a document incorporating changes requested by an RFC, the RFC number shall be shown on the DEO.

4.2 ASME Code Vessel Procedure

The system for releasing documentation for ASME coded vessels must meet the requirements of the ASME pressure vessel code. The procedure is fully documented in the PSI Section VIII ASME Q.A. manual. This special ASME code procedure covers only vessels that will be fabricated by PSI under their ASME Section VIII stamp. All outside vendor purchases of ASME vessels (or design only) shall use the normal DEO process.

Documents for PSI ASME code work use a different DEO form (color blue) and a modified release procedure.

The ASME code document procedure follow Section 4.1 procedures with the following exceptions:

1. DEO form is blue and has different sign-offs and distribution.

2. All releases must be approved and signed off by Preparer, Design Engineer, Manufacturing Engineer, Quality Assurance (Q.A.), Project Manager (or Engineering Supervisor) and EMS Data Entry.

3. Distribution:

   a) The bill of Material (BOM) and the add, change, delete reports are always issued with the drawing.

   b) Two (2) copies of the DEO are sent to the Material Control Department. One (1) copy is signed and returned to Document control confirming its receipt by Material Control.

5.0 FLOWCHART

See Exhibit I.

6.0 REFERENCES

WI-010-003 "Controlling SCS Sales Orders"

SOP-006-003 "Assigning Engineering Document Numbers"

A3534-2-001 "Document Numbering System for SCS"

7.0 EXHIBITS

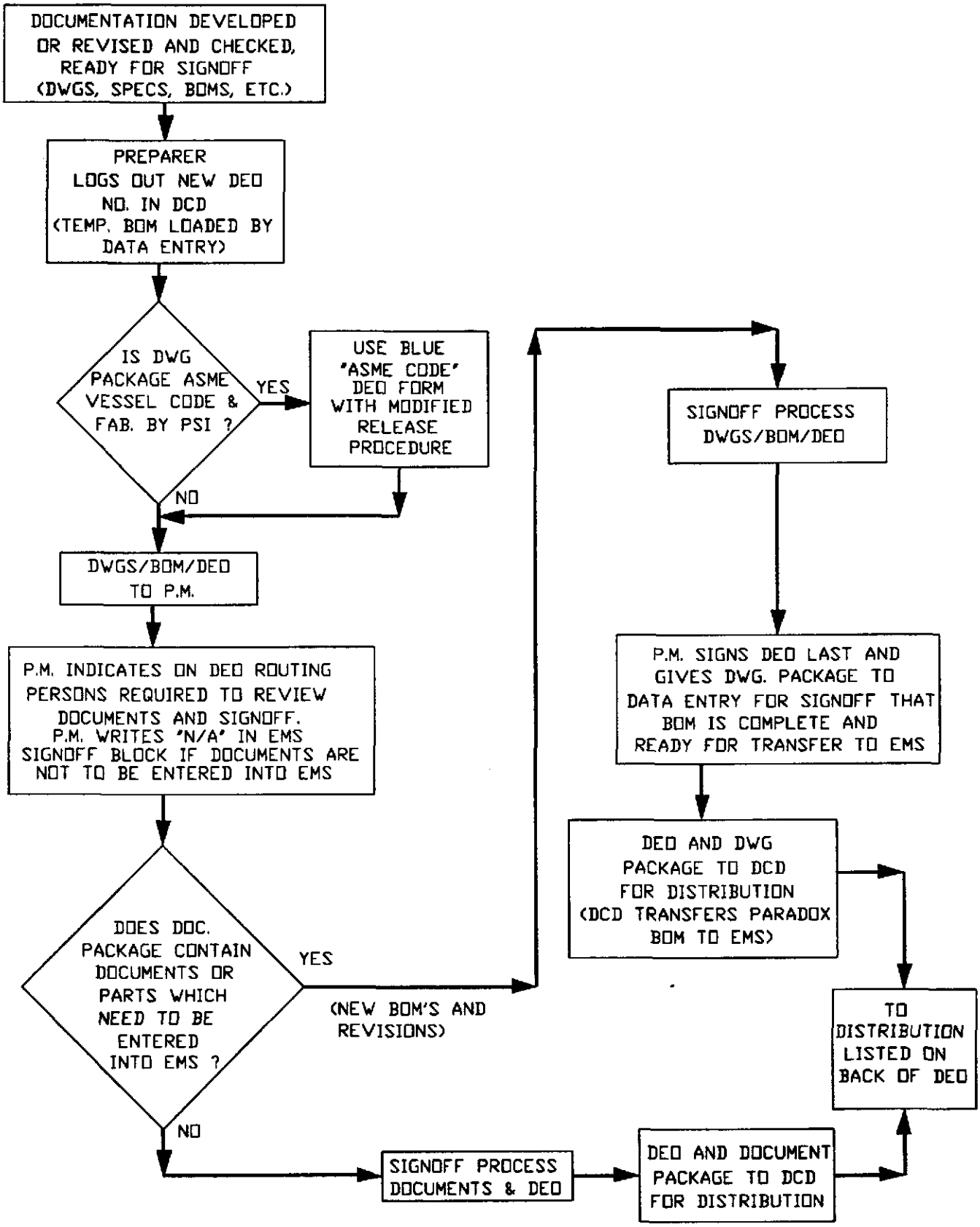
I. "DEO Process Flow Chart"

II. Sample DEO - Initial Release

III. Sample DEO - Revised Documents

IV. Archiving Electronic File Structure

EXHIBIT I



Feb 06, 1995 - 13:34:26

DEO PROCESS FLOW DIAGRAM

CAD# SOP06112

SOP-006-112

EXHIBIT II

DESIGN ENGINEERING ORDER			DEO NO.	
JOB NO.:			ELEC. FILES DIRECTORY	
CLIENT NAME:			DWG:	
PROJECT NAME:			SPEC:	
LOCATION:			OTHER:	
DOC. NO.	REV.	DESCRIPTION	FILE\DATE\TIME\BYTES	ARCH.

RFC NO.

DETAILED DESCRIPTION

MATERIAL DEPOSITION:			ACTION BY:	
DISTRIBUTION		ROUTING	SIGN-OFF	DATE:
EXTERNAL	INTERNAL		Prepared By:	
SUBMIT TO CLIENT FOR:	CHECK ONE:		App'd DESIGN	
			App'd I/E	
_____Approval	_____Quotation		App'd ELEC	
	_____P.O. Change		App'd CIV/STR	
_____Info Only	_____Resubmit to Vendor		App'd PROJECT	
	_____Purchase		App'd PROCESS	
_____Review/Comment	_____Mat'l Procurement		App'd QA	
	_____Fabrication		App'd EMS	
_____Distribution	_____Information		App'd MFG	
			App'd DISCIP MGR	
			App'd PROJECT MGR	

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MA SHEET 1 OF

EXHIBIT II

ASME CODE VESSEL

DESIGN ENGINEERING ORDER			DEO NO.	
JOB NO.:			ELEC. FILES DIRECTORY	
CLIENT NAME:			DWG:	
PROJECT NAME:			SPEC:	
LOCATION:			OTHER:	
DOC. NO.	REV.	DESCRIPTION	FILE\DATE\TIME\BYTES	ARCH.

RFC NO.

DETAILED DESCRIPTION

MATERIAL DEPOSITION:

ACTION BY:

DISTRIBUTION		ROUTING	SIGN–OFF	DATE:
EXTERNAL	INTERNAL		Prepared By:	
SUBMIT TO CLIENT FOR:	CHECK ONE:			
_____Approval _____Info Only _____Review/Comment _____Distribution	_____Quotation _____P.O. Change _____Resubmit to Vendor _____Purchase _____Mat'l Procurement _____Fabrication _____Information		App'd DESIGN ENG.:	
			App'd Q.A.:	
			App'd EMS:	
			App'd MFG ENG:	
			App'd PROJ. MGR.:	

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MA SHEET 1 OF

EXHIBIT II

DISTRIBUTION SLIP FOR:
LYONDELL PETROCHEMICAL CO.
M27004

IF COPY OF THIS DRAWING OR SPEC IS REQUIRED PLEASE CIRCLE THE QUANTITY IN THE APPROPRIATE COLUMN.

DEO #_____	DWG	SPEC	DEO	RFQ	BOM	RFC
H PETERS (DEO ONLY)						
A.MEISINGER						
J.FRASER						
B.FORLANO						
P SCHMIDT						
W.FOX						
F.BARK						
F.CORDELLA						
L.COOK (STICK FILE)						
D PARENTI						

THE FOLLOWING IS QUALITY ASSURANCE,MANFACTUR. AND PURCHASING.

	D.BILODEAU	B.SCHRAMM
QUOTATION	(4) + (1) PER VEN	(0)
P.O.CHANGE	(4) CONTROL	(0)
RESUBMIT TO VEN.	(4) CONTROL	(0)
PURCHASE	(4) CONTROL	(0)
MAT'L PROCUR.	(2)	(0)
FABRICATION	(2) CONTROL	(3) CONT.
INFORMATION	(2) CONTROL	(0)

External (R.NELSON)	2	2	1	0	0	0
NOTES						
TOTAL COPIES						

12/93

EXHIBIT III

DESIGN ENGINEERING ORDER			DEO NO.	
JOB NO.:			ELEC. FILES DIRECTORY	
CLIENT NAME:			DWG:	
PROJECT NAME:			SPEC:	
LOCATION:			OTHER:	
DOC. NO.	REV.	DESCRIPTION	FILE\DATE\TIME\BYTES	ARCH.
RFC NO.	DETAILED DESCRIPTION			
DOC. NO.	REV.	DESCRIPTION	FILE\DATE\TIME\BYTES	ARCH.
RFC NO.	DETAILED DESCRIPTION			
MATERIAL DEPOSITION:			ACTION BY:	

DISTRIBUTION		ROUTING	SIGN–OFF	DATE:
EXTERNAL	INTERNAL		Prepared By:	
SUBMIT TO CLIENT FOR:	CHECK ONE:		App'd DESIGN	
			App'd I/E	
_____Approval	_____Quotation		App'd ELEC	
	_____P.O. Change		App'd CIV/STR	
_____Info Only	_____Resubmit to Vendor		App'd PROJECT	
	_____Purchase		App'd PROCESS	
_____Review/Comment	_____Mat'l Procurement		App'd QA	
	_____Fabrication		App'd EMS	
_____Distribution	_____Information		App'd MFG	
			App'd DISCIP MGR	
			App'd PROJECT MGR	

PROCESS SYSTEMS INTERNATIONAL WESTBOROUGH, MA SHEET 1 OF

EXHIBIT IV

ATTACHMENT III

Engineering Document Electronic File Structure

I. Primary Directories:

a. Custom Services Projects ("CS")

Each custom project shall have a dedicated directory named for its PSI Project number (e.g. "T15077").

b. High Vacuum Projects ("HV")

Each high vacuum shall have a dedicated directory named for its PSI Project number (e.g. "V59014").

c. NPS Projects ("NP")

Each NPS project shall have a dedicated directory named for its PSI Project number (e.g. "N00581").

d. Standard Cryogenic Products ("SCS")

Each standard product shall have a dedicated directory named for its model number (e.g. "1400"). Special drawings modified for a project should be stored under the job number also.

e. Standards ("STD")

A directory named "STANDARD" shall contain all engineering standard documents.

f. Proposals ("PRO")

A directory named "PROPOSAL" shall contain all proposal documents with subdirectories for each product line and proposal number.

g. General ("GEN")

A directory named "GENERAL" shall contain all general documents.

II. ISSUED / INPROGRESS ("IS"/"IN") Subdirectories:

Each primary directory shall have two (2) subdirectories for issued documents and in-progress work. The "IS" subdirectory shall be "Read Only" for all network users except the Document Control Department. The in-progress directory shall have open access for all network stations.

EXHIBIT IV

III. **Discipline Subdirectories:**

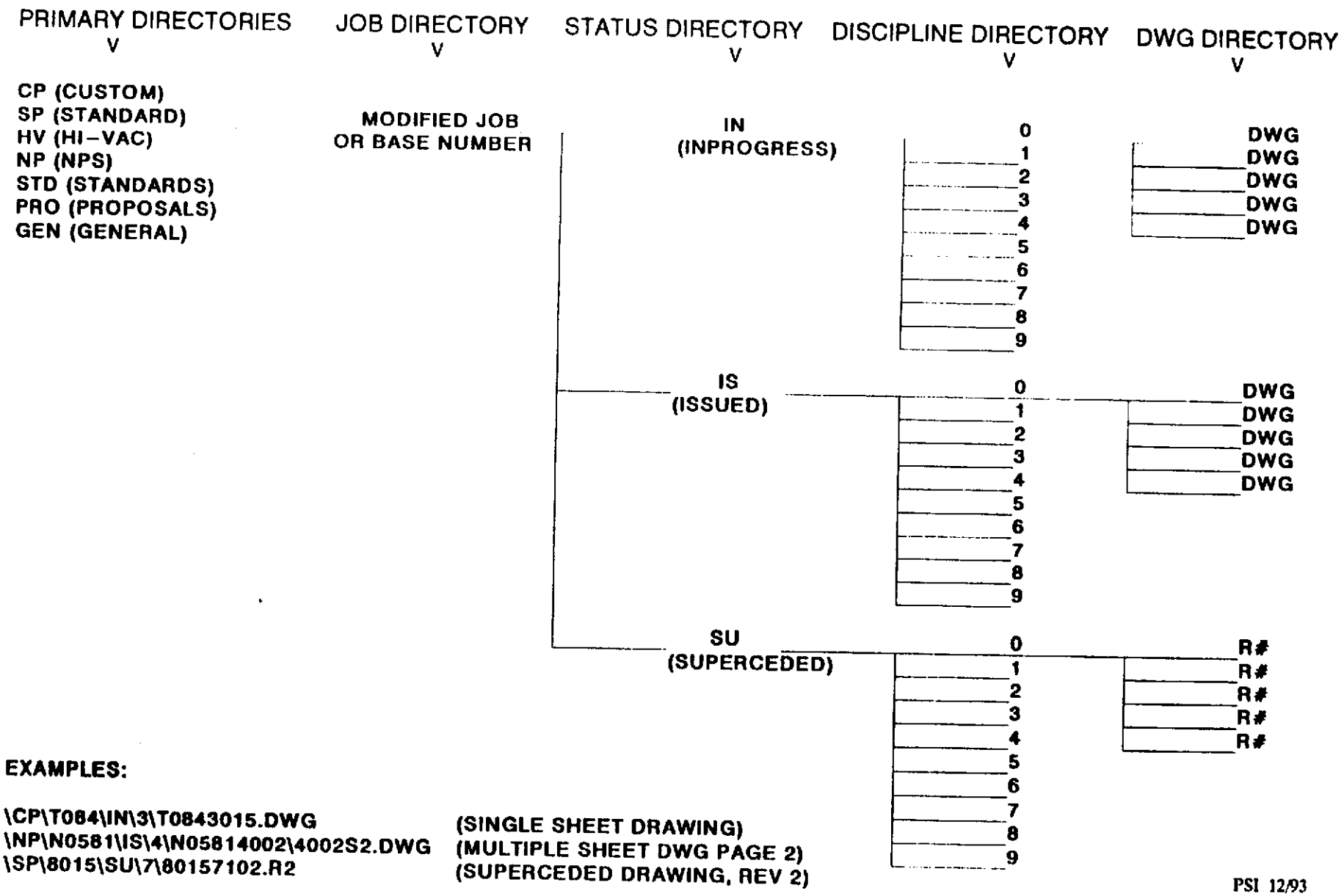
The "IS" and "IN" subdirectories shall contain the following subdirectories as needed:

"0" for PFD's and P&ID's
"1" for engineering lists
"2" for engineering specifications
"3" for I/E drawings
"4" for mechanical/equipment drawings
"5" for piping drawings
"6" for piping isometric drawings
"7" for structural drawings
"8" for vendor drawings
"9" for instrument loop drawings

"SU" for superseded issues of categories 0-9.

Superseded drawings will be periodically moved to tapes to save room on the network.

ELECTRONIC FILE STRUCTURE



EXAMPLES:

\CP\T084\IN\3\T0843015.DWG	(SINGLE SHEET DRAWING)
\NP\N0581\IS\4\N05814002\4002S2.DWG	(MULTIPLE SHEET DWG PAGE 2)
\SP\8015\SU\7\80157102.R2	(SUPERCEDED DRAWING, REV 2)

PSI 12/93

EXHIBIT IV

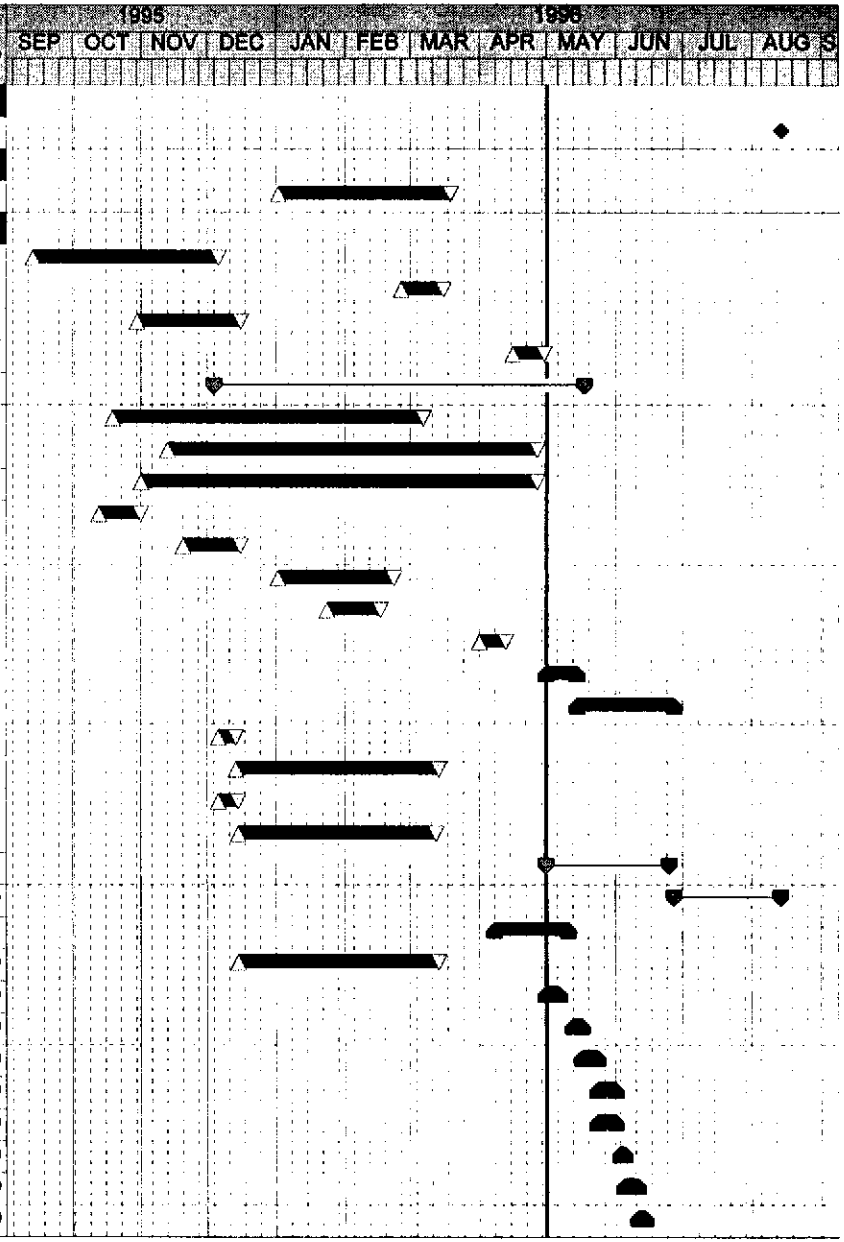
ATTACHMENT 2

DETAILED PROJECT SCHEDULE

PROTOTYPE BSC SCHEDULE

(Sorted by System / Activity ID)

Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
MILE - Contractual Schedule Milestones - Acticle II					
43	Final Prototype Vessel Design Review	0		13AUG96	0
SAME - Common Engineering / Design Activities					
107	Issue QA Plan for Vessels	10	02JAN96 A	18MAR96 A	100
VACE - Vacuum Envelope					
202	Design BSC Vessels	45	13SEP95 A	05DEC95 A	100
203	Design BSC chamber fab fixtures	15	26FEB96 A	15MAR96 A	100
214	Prepare a vessel fabrication specification	20	30OCT95 A	15DEC95 A	100
215	Prepare a final cleaning procedure	10	16APR96 A	29APR96 A	100
260	10" Benchscale Vessel Program	116 *	04DEC95 A	17MAY96	89
262	CO #13 - BSC internal floor loading requirements	20	19OCT95 A	06MAR96 A	100
273	Design short 80K cryopump vessel	50	13NOV95 A	26APR96 A	100
274	Design short 80K cryopump shroud	60	01NOV95 A	26APR96 A	100
279	Conduct a plasma welding investigation	10	13OCT95 A	31OCT95 A	100
280	Procure a plasma welding machine	20	20NOV95 A	15DEC95 A	100
281	Qualify Welding Procedure for Plasma Welding	10	02JAN96 A	22FEB96 A	100
284	Procure cleaning equipment	20	24JAN96 A	16FEB96 A	100
285	Conduct materials testing program	10	01APR96 A	12APR96 A	100
289	Short 80K Cryopump - Procure shroud mat'l (1)	10	01MAY96	14MAY96	0
290	Short 80K Cryopump - Fab shroud for prototype	30	15MAY96	26JUN96	0
291	Order Prototype BSC Flange Forgings	5	06DEC95 A	13DEC95 A	100
292	Fab and deliver Prototype BSC flange forgings	53	14DEC95 A	13MAR96 A	100
293	Order Prototype BSC shell, head, & nozzle mat'l	5	06DEC95 A	14DEC95 A	100
294	Fab & del Prototype BSC head, shell, nozzle matl	50	15DEC95 A	12MAR96 A	100
295	Fabricate Prototype BSC Vessel	38 *	01MAY96	24JUN96	0
296	Test program for Prototype vessel	33 *	27JUN96	13AUG96	0
297	Fabricate chamber fab fixtures	15	08APR96 A	10MAY96	47
298	Order mat'l for test/ship covers for prototype	40	15DEC95 A	13MAR96 A	100
295A	Prototype BSC Fab - Roll/weld shell (outside)	4	01MAY96	06MAY96	0
295B	Prototype BSC Fab - Weld on heads (outside)	4	13MAY96	16MAY96	0
295C	Prototype BSC Fab - Cut/weld nozzle necks	5	17MAY96	23MAY96	0
295D	Prototype BSC Fab - Machine flanges/blinds (out)	5	24MAY96	31MAY96	0
295E	Prototype BSC Fab - Stress relieve (outside)	5	24MAY96	31MAY96	0
295F	Prototype BSC Fab - Square off nozzles (outside)	2	03JUN96	04JUN96	0
295G	Prototype BSC Fab - Weld on flanges	4	05JUN96	10JUN96	0
295H	Prototype BSC Fab - Install welded attachments	3	11JUN96	13JUN96	0



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Start milestone point
Finish milestone point

Process Systems International, Inc.

LIGO Vacuum System Project

Prototype Schedule 1Aof3A

Data date 01MAY96

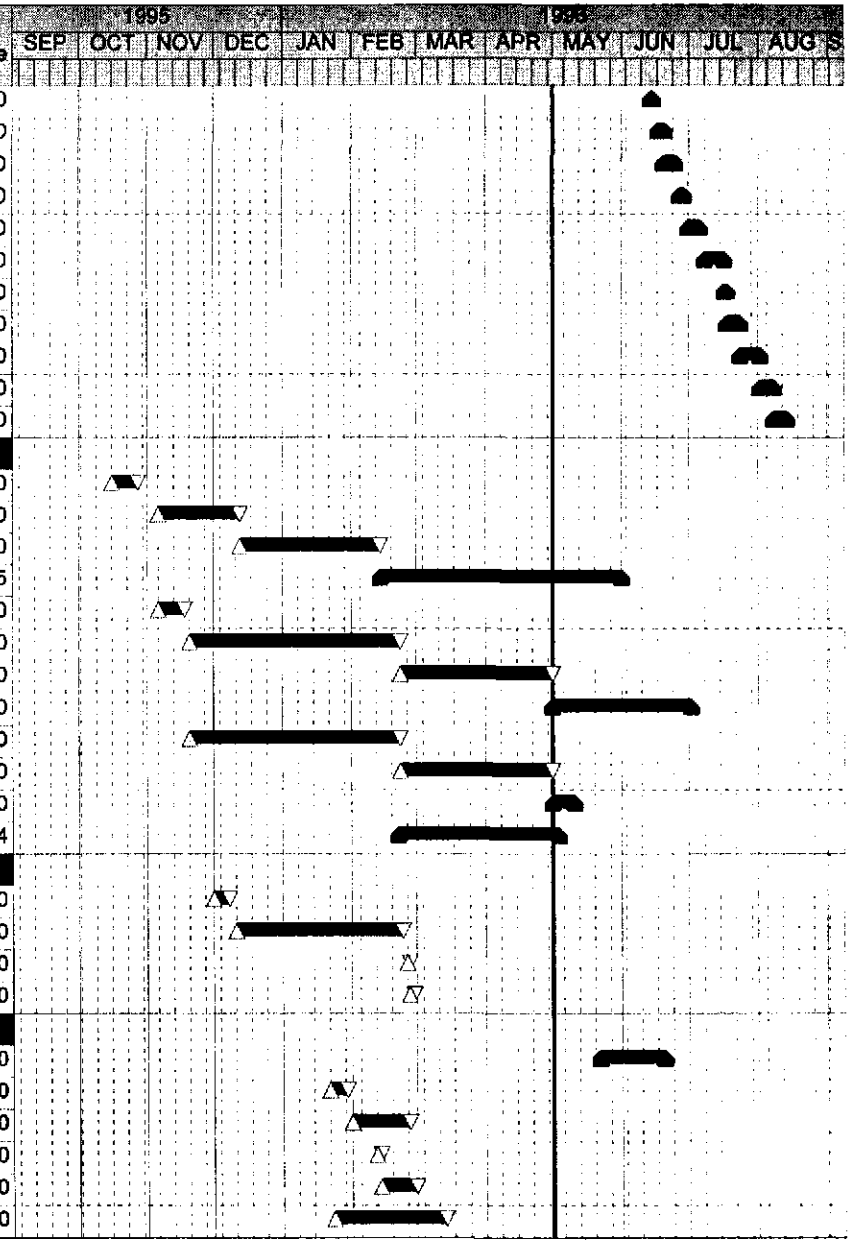
Run date 02MAY96

Filter Prototype Related Activities

Layout System

Date	Revision	Checked	Approved
02MAY96	Final Design Pkg	PFH	REB

Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
295I	Prototype BSC Fab - Install internal floor suppt	1	14JUN96	14JUN96	0
295J	Prototype BSC Fab - Install annulus tubing & pmp	3	17JUN96	19JUN96	0
295K	Prototype BSC Fab - Clean chamber to spec	3	20JUN96	24JUN96	0
296A	Start prototype testing program	2	27JUN96	28JUN96	0
296B	Prototype Test - Rough leak check	4	01JUL96	05JUL96	0
296C	Prototype Test - Bakeout	7	08JUL96	16JUL96	0
296D	Prototype Test - Perform dimensional check	1	17JUL96	17JUL96	0
296E	Prototype Test - Final leak check	4	18JUL96	23JUL96	0
296F	Prototype Test - Ultimate pressure test	7	24JUL96	01AUG96	0
296G	Prototype Test - Install cryopump shroud	4	02AUG96	07AUG96	0
296H	Prototype Test - Vibration/boiloff test	4	08AUG96	13AUG96	0
PUMP - Pumping System					
311	Main Turbo Pumps - Issue specification	10	16OCT95 A	27OCT95 A	100
312	Main Turbo Pumps - Finalize bid & purchase (10)	15	06NOV95 A	12DEC95 A	100
313	Main Turbo Pumps - Recieve/review v/dwgs	30	13DEC95 A	13FEB96 A	100
316	Main Turbo Pumps - Fab/deliver to Westboro (2)	40	14FEB96 A	31MAY96	45
327	All Ion Pumps - Issue specification	20	06NOV95 A	17NOV95 A	100
328	Main Ion Pumps - Bid and purchase (18)	7	20NOV95 A	22FEB96 A	100
329	Main Ion Pumps - Recieve/review v/dwgs	40	23FEB96 A	30APR96 A	100
330	Main Ion Pumps - Fab/deliver to Westboro (1)	43	01MAY96	01JUL96	0
333	Annuli Ion Pumps - Bid & purchase (43lg & 32sm)	4	20NOV95 A	22FEB96 A	100
334	Annuli Ion Pumps - Receive and review v/dwgs	40	23FEB96 A	30APR96 A	100
335	Annuli Ion Pumps - Fab/deliver to Westboro (2)	8	01MAY96	10MAY96	0
378	Prototype BSC Test Ion Pumps - Fab & deliver (2)	50	22FEB96 A	03MAY96	94
CTRL - Instrumentation and Controls					
522	Residual Gas Analyzer - Prepare specification	10	01DEC95 A	07DEC95 A	100
523	Residual Gas Analyzer - Bid & purchase (2)	30	11DEC95 A	23FEB96 A	100
524	Residual Gas Analyzer - Receive & review v/dwgs	10	26FEB96 A	26FEB96 A	100
525	RGA's - Fab/deliver to Westboro/Prototype (2)	20	27FEB96 A	28FEB96 A	100
BAKE - Bakeout Subsystem					
706	Bakeout Blankets - Fab/deliver to Westboro (6)	20	22MAY96	19JUN96	0
709	Bakeout System Controls - Issue specs	10	22JAN96 A	29JAN96 A	100
710	Bakeout System Controls - Bid and purchase	20	01FEB96 A	26FEB96 A	100
711	Bakeout System Controls - Receive/review v/dwgs	10	12FEB96 A	13FEB96 A	100
712	Bakeout System Controls - Fab/deliver to PSI	20	14FEB96 A	29FEB96 A	100
717	Design bakeout cart(s) - Preliminary design	5	24JAN96 A	13MAR96 A	100



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Process Systems International, Inc.

LIGO Vacuum System Project

Prototype Schedule 2Aof3A

Data date 01MAY96

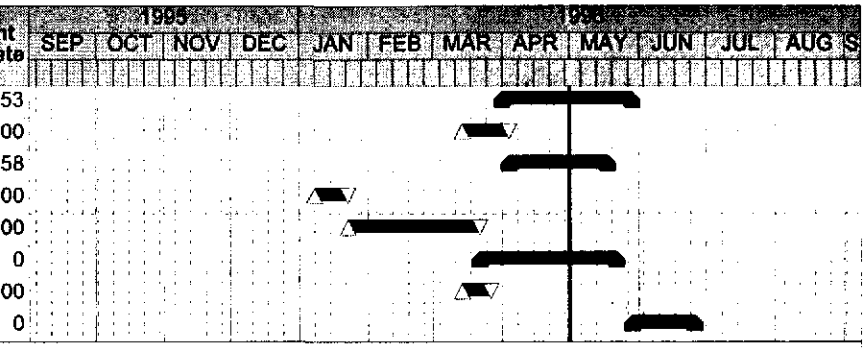
Run date 02MAY96

Filter Prototype Related Activities

Layout System

Date	Revision	Checked	Approved
02MAY96	Final Design Pkg	PFH	REB

Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
718	Program PLC's for bakeout system	40	01APR96 A	28MAY96	53
719	Bakeout Carts - Bid & award assembly of carts	15	14MAR96 A	03APR96 A	100
720	Bakeout Carts - Assemble 1st cart	31	04APR96 A	17MAY96	58
721	Prototype Bakeout Blankets - Issue specification	21	08JAN96 A	22JAN96 A	100
722	Prototype Bakeout Blankets - Bid & purchase (6)	20	23JAN96 A	21MAR96 A	100
723	Prototype Bakeout Blankets - Receive/rvw v/dwgs	15	22MAR96 A	21MAY96	0
726	Final design of bakeout carts	15	14MAR96 A	26MAR96 A	100
730	Bakeout Carts - Test 1st bakeout cart	20	29MAY96	25JUN96	0



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Process Systems International, Inc.

LIGO Vacuum System Project

Prototype Schedule 3Aof3A

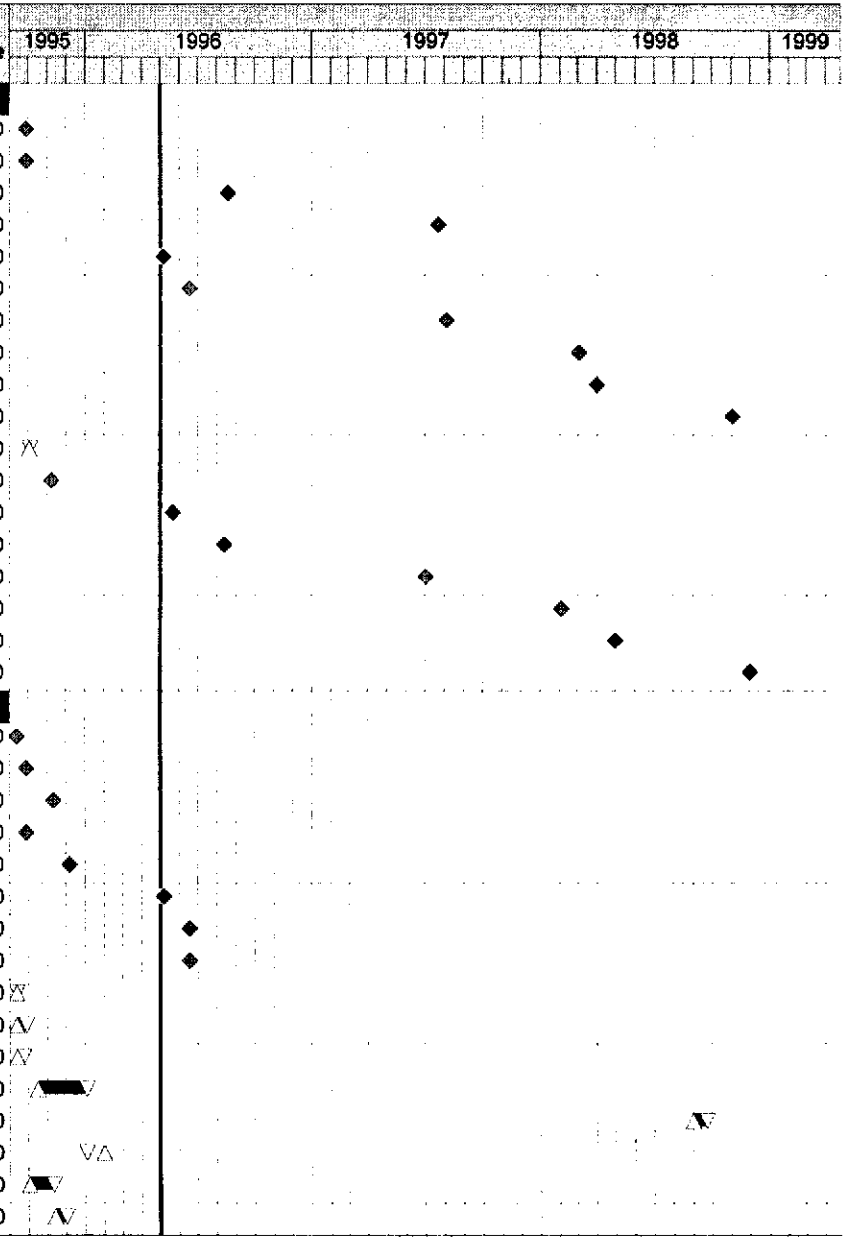
Data date 01MAY96
Run date 02MAY96
Filter Prototype Related Activities
Layout System

Date	Revision	Checked	Approved
02MAY96	Final Design Pkg	PFH	REB

DETAILED PROJECT SCHEDULE

(Sorted by System / Activity ID)

Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
MILE - Contractual Schedule Milestones - Acticle II					
30	Complete Updated Preliminary Design (Phase B)	0		27SEP95 A	100
31	Submit & Implement Updated Proj Mgmt Plan	0		27SEP95 A	100
32	Deliverables to the Beam Tube Contractor - WA	0		19AUG96	0
33	Deliverables to the Beam Tube Contractor - LA	0		21JUL97	0
34	Complete Final Design	0		06MAY96	0
35	Begin fabrication and procurement	0	18JUN96		0
36	Begin Installation - Washington Site	0	04AUG97		0
37	Begin Installation - Louisiana Site	0	03MAR98		0
38	Complete Acceptance Testing - Washington Site	0		31MAR98	0
39	Complete Acceptance Testing - Louisiana Site	0		02NOV98	0
40	Updated Preliminary Design Review	1	03OCT95 A	03OCT95 A	100
41	Deliverables to the Beam Tube Final Design Rvw	0		07NOV95 A	100
42	Final Design Review	0	22MAY96		0
43	Final Prototype Vessel Design Review	0		13AUG96	0
44	Installation Readiness Review - Washington	0		01JUL97	0
45	Installation Readiness Review - Louisiana	0		02FEB98	0
46	Acceptance Test Review - Washington	0		29APR98	0
47	Acceptance Test Review - Louisiana	0		01DEC98	0
SAME - Common Engineering / Design Activities					
1	Phase B Award	0		12SEP95 A	100
2	Submit Ph B Updated PDR for approval (CDRL 01)	0		27SEP95 A	100
3	Approval of Updated PDR (CDRL 01) by LIGO	0		10NOV95 A	100
4	Submit Proj Mgmt Plan for Approval (CDRL 02)	0		27SEP95 A	100
5	Approval of Proj Mgmt Plan by LIGO (CDRL 02)	0		06DEC95 A	100
6	Submit Final Design for Approval (CDRL 03)	0		06MAY96	0
7	Approval of Final Design by LIGO (CDRL 03)	0		17JUN96	0
8	Full Release for Fabrication and Procurement	0		17JUN96	0
000	Contract Award	1	12SEP95 A	12SEP95 A	100
100	Phase B Update of PDR & Proj Mgmt Plan	1	12SEP95 A	27SEP95 A	100
101	P&ID's - Initial Issue	10	13SEP95 A	22SEP95 A	100
102	P&ID's - Issue for Design	30	16OCT95 A	03JAN96 A	100
103	P&ID's - Issue As-Built	15	01SEP98 *	22SEP98	0
104	PFD's - Issue for Design	10	01FEB96 A	03JAN96 A	100
105	Receive LIGO comments on updated prelim design	10	03OCT95 A	10NOV95 A	100
106	Final issue of Ph B update of prelim design pkg	30	13NOV95 A	01DEC95 A	100



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Finish milestone point

Process Systems International, Inc.

LIGO Vacuum System Project

Project Schedule

1Aof18A

Data date 01MAY96

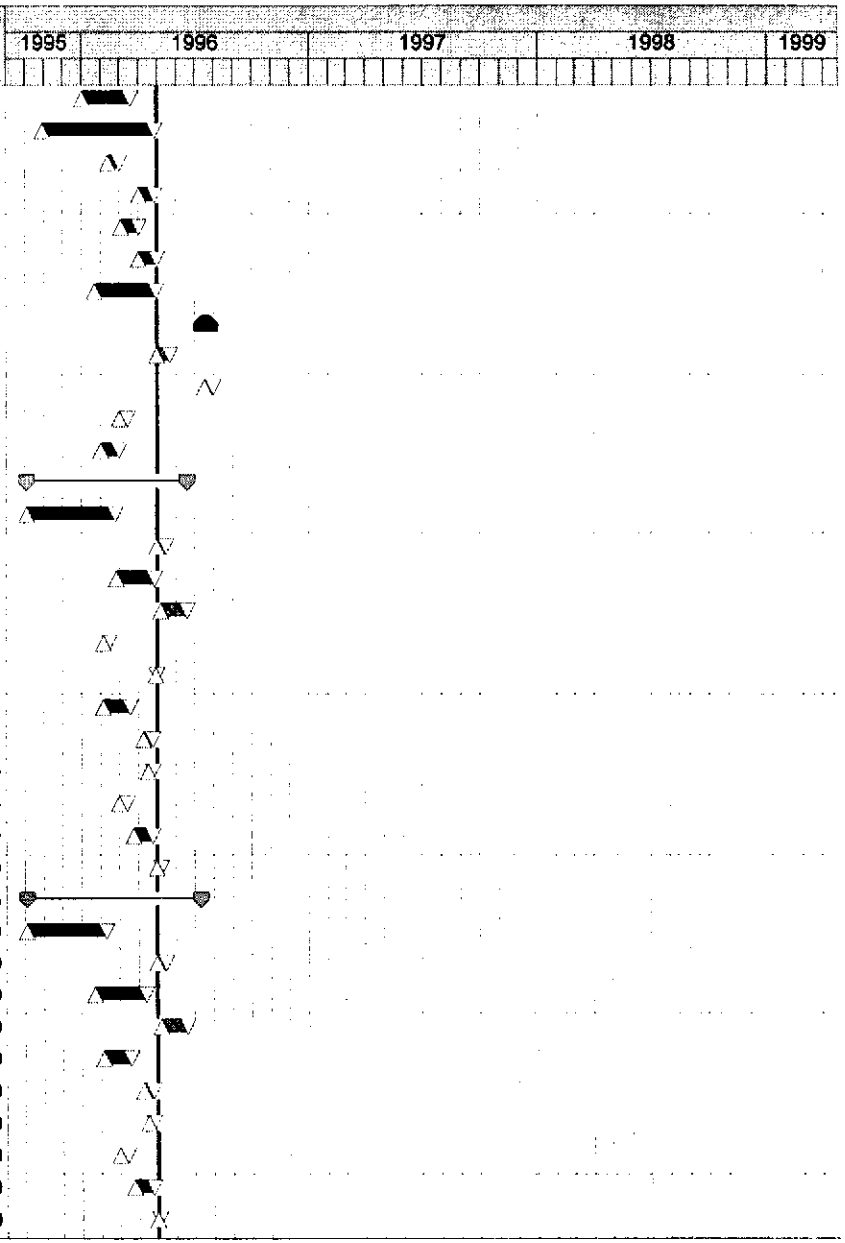
Run date 03MAY96

Filter All Activities

Layout System

Date	Revision	Checked	Approved
03MAY96	Final Design Pkg	PFH	REB

Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
107	Issue QA Plan for Vessels	10	02JAN96 A	18MAR96 A	100
108	Prep shock, vibration, & noise model (CAA)	90	30OCT95 A	26APR96 A	100
109	Develop power calculations/requirements	10	12FEB96 A	01MAR96 A	100
110	Failure mode and effect analysis	9	02APR96 A	26APR96 A	100
111	Hazard analysis	20	04MAR96 A	01APR96 A	100
112	Prepare an installation spec and procedures	15	01APR96 A	30APR96 A	100
113	Prepare commissioning and testing plans	20	22JAN96 A	29APR96 A	100
114	Prepare packing lists	10	12JUL96	25JUL96	0
115	Prep Vacuum Eqt Maintenance Requirements	15	01MAY96	21MAY96	0
116	CAA finalize model & design requirements	10	17JUL96	30JUL96	0
117	Preparation of a drawing tree	15	01MAR96 A	14MAR96 A	100
118	Bldg/utility interface definitions (PSI to LIGO)	20	01FEB96 A	29FEB96 A	100
119	Washington Corner Station Overall Design	177 *	04OCT95 A	18JUN96	81
120	WACS - LVEA equipment arrangement dwgs	102	04OCT95 A	23FEB96 A	100
121	WACS - Anchor bolt design	10	01MAY96	14MAY96	0
122	WACS - Piping general arrangement design	40	26FEB96 A	26APR96 A	100
123	WACS - Piping isometrics & cut sheets	30	07MAY96	18JUN96	0
124	WACS - Pump support design	10	05FEB96 A	13FEB96 A	100
125	WACS - Pipe & misc structural supports	2	29APR96 A	30APR96 A	100
126	WACS - Cable tray layout & power plan	30	05FEB96 A	18MAR96 A	100
127	WACS - Instr/controls plan	5	09APR96 A	24APR96 A	100
128	WACS - Instr/elect details	4	17APR96 A	24APR96 A	100
129	WACS - Interface wiring design	15	01MAR96 A	13MAR96 A	100
130	WACS - Ion pump controller cabinet layout	10	25MAR96 A	24APR96 A	100
131	WACS - Instr/elect cable schedules	5	01MAY96	07MAY96	0
132	Washington Mid-Station Overall Design	192 *	04OCT95 A	10JUL96	75
133	WAMS Right - LVEA equipment arrangement dwgs	102	04OCT95 A	09FEB96 A	100
134	WAMS - Anchor bolt design	10	01MAY96	14MAY96	0
135	WAMS Right - Piping general arrangement dwgs	40	22JAN96 A	12APR96 A	100
136	WAMS Right - Piping isometrics & cut sheets	30	07MAY96	18JUN96	0
137	WAMS - Cable tray layout & power plan	30	05FEB96 A	18MAR96 A	100
138	WAMS - Instr/controls plan	5	09APR96 A	24APR96 A	100
139	WAMS - Instr/elect details	4	17APR96 A	24APR96 A	100
140	WAMS - Interface wiring design	11	01MAR96 A	13MAR96 A	100
141	WAMS - Ion pump controller cabinet layout	10	25MAR96 A	24APR96 A	100
142	WAMS - Instr/elect cable schedules	3	01MAY96	03MAY96	0



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Process Systems International, Inc.

LIGO Vacuum System Project

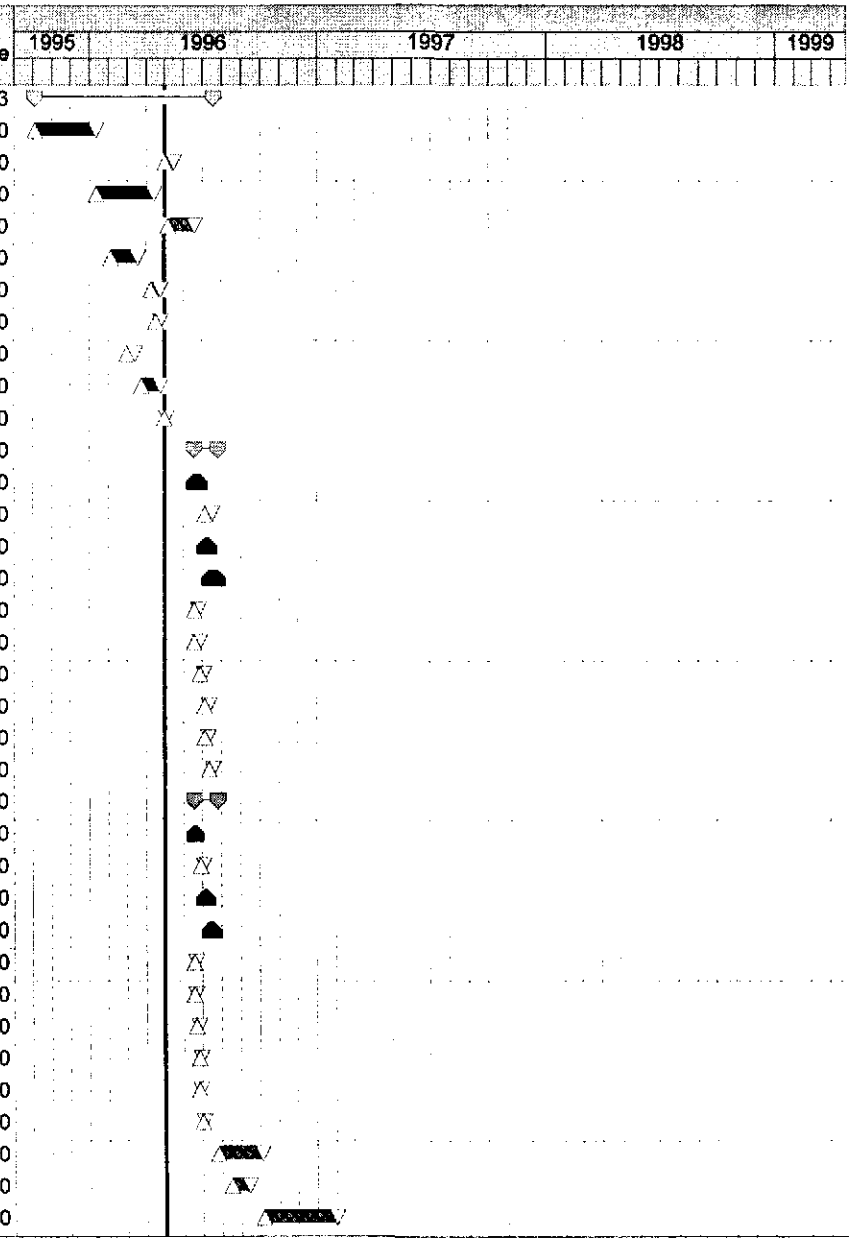
Project Schedule

2Aof18A

Data date 01MAY96
Run date 03MAY96
Filter All Activities
Layout System

Date	Revision	Checked	Approved
03MAY96	Final Design Pkg	PFH	REB

Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
143	Washington End Station Overall Design	197 *	04OCT95 A	17JUL96	73
144	WAES Right - LVEA equipment arrangement dwgs	81	04OCT95 A	10JAN96 A	100
145	WAES - Anchor bolt design	10	01MAY96	14MAY96	0
146	WAES Right - Piping general arrangement dwgs	30	11JAN96 A	12APR96 A	100
147	WAES Right - Piping isometrics & cut sheets	30	07MAY96	18JUN96	0
148	WAES - Cable tray layout & power plan	30	05FEB96 A	18MAR96 A	100
149	WAES - Instr/controls plan	5	09APR96 A	24APR96 A	100
150	WAES - Instr/elect details	4	17APR96 A	24APR96 A	100
151	WAES - Interface wiring design	11	01MAR96 A	13MAR96 A	100
152	WAES - Ion pump controller cabinet layout	10	25MAR96 A	24APR96 A	100
153	WAES - Instr/elect cable schedules	3	01MAY96	03MAY96	0
154	Louisiana Corner Station Overall Design	27 *	18JUN96	25JUL96	0
155	LACS - LVEA equipment arrangement dwgs	7	18JUN96	26JUN96	0
156	LACS - Anchor bolt design	8	05JUL96	16JUL96	0
157	LACS - Piping general arrangement design	5	05JUL96	11JUL96	0
158	LACS - Piping isometrics	10	12JUL96	25JUL96	0
159	LACS - Cable tray layout & power plan	5	18JUN96	24JUN96	0
160	LACS - Instr/controls plan	7	18JUN96	26JUN96	0
161	LACS - Instr/elect details	5	27JUN96	03JUL96	0
162	LACS - Interface wiring design	5	05JUL96	11JUL96	0
163	LACS - Ion pump controller cabinet layout	4	05JUL96	10JUL96	0
164	LACS - Instr/elect cable schedules	4	12JUL96	17JUL96	0
165	Louisiana End Station Overall Design	27 *	18JUN96	25JUL96	0
166	LAES Right - LVEA equipment arrangement dwgs	3	18JUN96	20JUN96	0
167	LAES - Anchor bolt design	3	28JUN96	02JUL96	0
168	LAES Right - Piping general arrangement dwgs	3	03JUL96	08JUL96	0
169	LAES Right - Piping isometrics & cut sheets	5	12JUL96	18JUL96	0
170	LAES - Cable tray layout & power plan	3	18JUN96	20JUN96	0
171	LAES - Instr/controls plan	3	18JUN96	20JUN96	0
172	LAES - Instr/elect details	3	21JUN96	25JUN96	0
173	LAES - Interface wiring design	3	26JUN96	28JUN96	0
174	LAES - Ion pump controller cabinet layout	2	26JUN96	27JUN96	0
175	LAES - Instr/elect cable schedules	2	01JUL96	02JUL96	0
180	Procure piping materials	50	26JUL96	04OCT96	0
181	Prepare cut sheets from piping isometrics	20	16AUG96	13SEP96	0
182	Fab/deliver WA pipe spools	80	07OCT96	31JAN97	0



PSI

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Process Systems International, Inc.

LIGO Vacuum System Project

Project Schedule

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Data date 01MAY96

Run date 03MAY96

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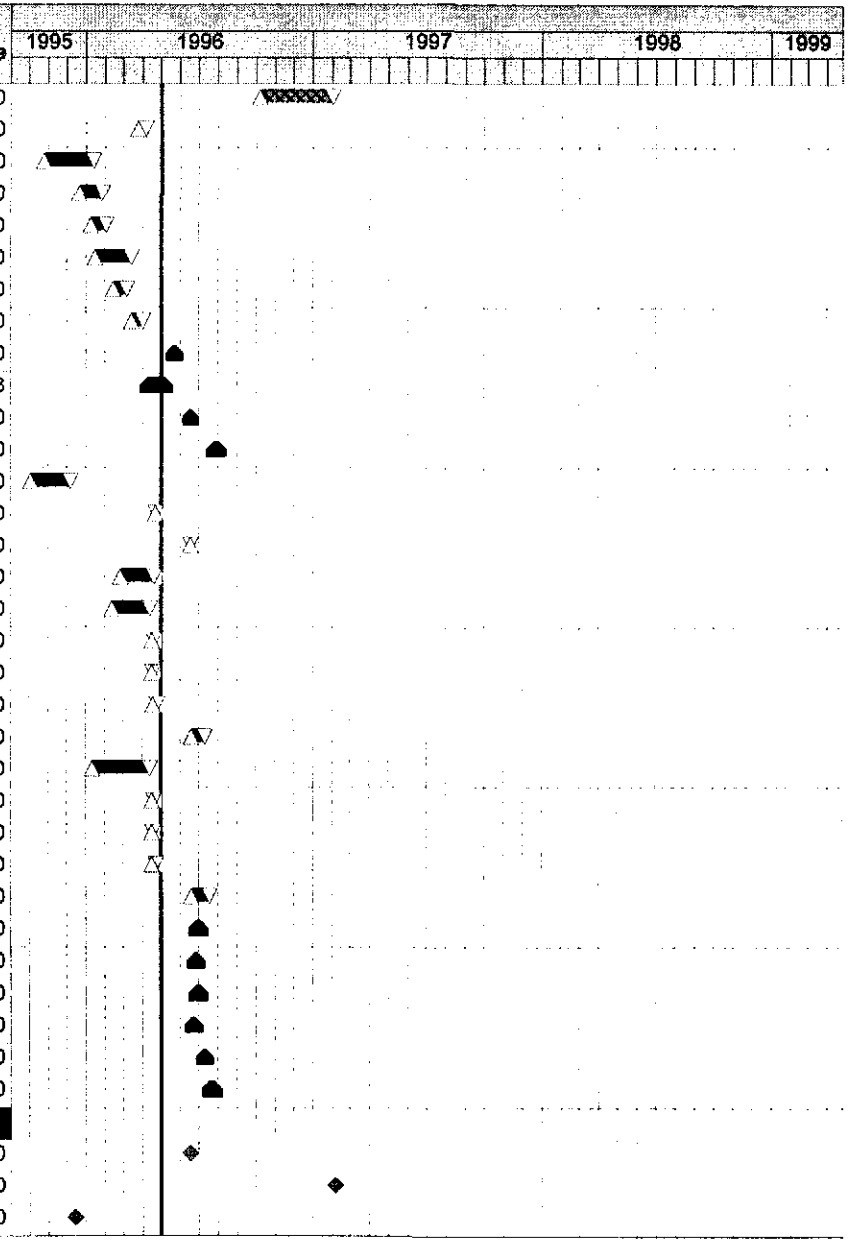
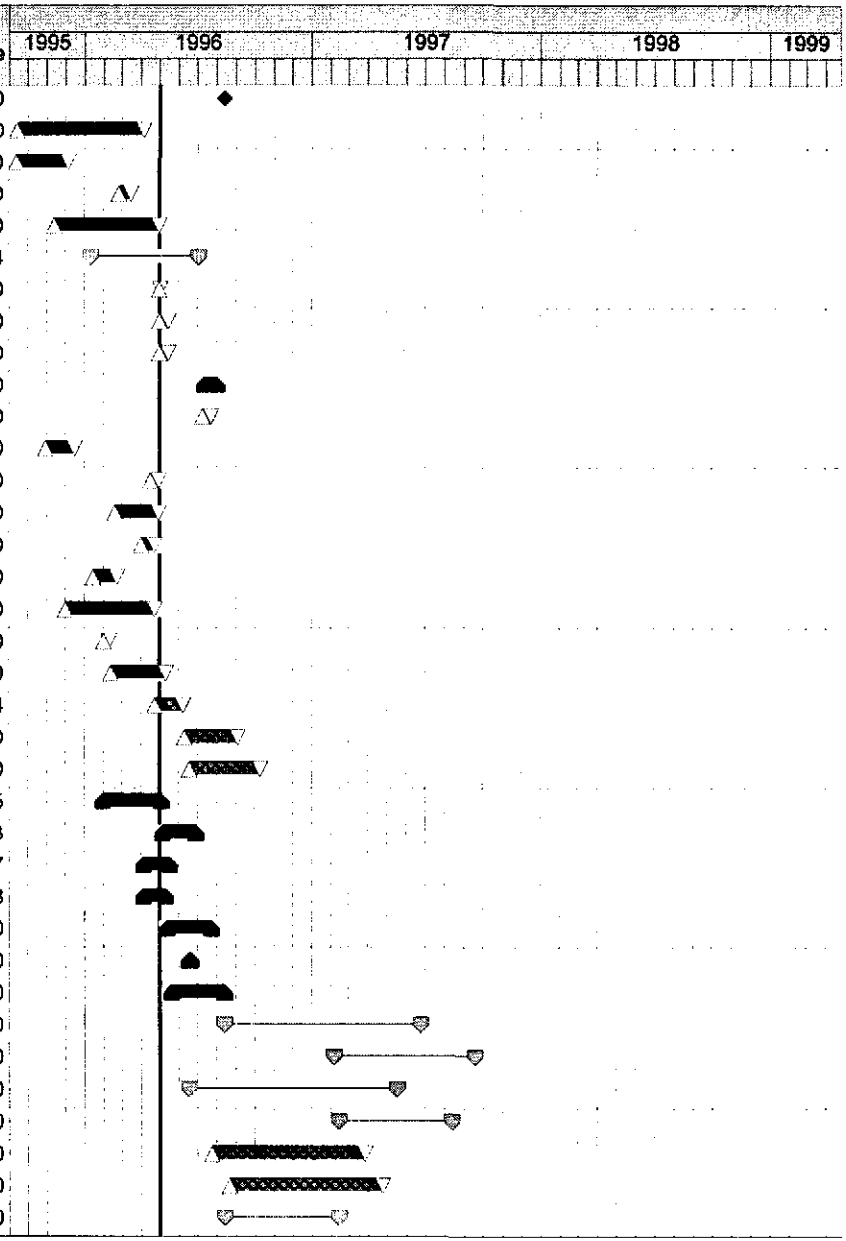
Layout System

Date	Revision	Checked	Approved
03MAY96	Final Design Pkg	PFH	REB

Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
183	Fab/deliver LA pipe spools	80	07OCT96	31JAN97	0
184	Update the 3D model	10	25MAR96 A	05APR96 A	100
185	C.O. #5 - Add cw supply to roots & turbo pumps	20	24OCT95 A	12JAN96 A	100
186	CO #11 - WACS beam manifold spool changes	25	21DEC95 A	26JAN96 A	100
188	CO #14 - LVEA changes to mid/end mech rooms	1	09JAN96 A	02FEB96 A	100
190	CO #16 - BSC removable spools due to space limit	15	16JAN96 A	14MAR96 A	100
192	CO #18 - Reduce annulus pumping speed	15	14FEB96 A	06MAR96 A	100
194	CO #19 - 30" Mode Cleaner Tube Changes	15	14MAR96 A	01APR96 A	100
196	Conduct final design review with LIGO	2	22MAY96 *	23MAY96	0
197	Prepare & Issue Final Design Package Draft	15	10APR96 A	06MAY96	73
198	Receive LIGO Approval of Final Design Package	1	17JUN96	17JUN96	0
199	Final Issue of Final Design Package	5	26JUL96	01AUG96	0
105A	LIGO approval of the Project Mgmt Plan	15	03OCT95 A	06DEC95 A	100
118A	PSI to receive revised WA bldg dwgs for comments	1	22APR96 A	22APR96 A	100
118B	PSI to receive LA bldg dwgs for comments	1	17JUN96 *	17JUN96	0
120D	WACS - Equipment detail dwgs	40	26FEB96 A	19APR96 A	100
133D	WAMS Right - Equipment detail dwgs	40	12FEB96 A	12APR96 A	100
133DL	WAMS Left - Equipment detail dwgs	3	16APR96 A	18APR96 A	100
133L	WAMS Left - LVEA equipment arrangement dwg	2	16APR96 A	17APR96 A	100
135L	WAMS Left - Piping general arrangement dwgs	5	18APR96 A	24APR96 A	100
136L	WAMS Left - Piping isometrics & cut sheets	15	19JUN96	10JUL96	0
144D	WAES Right - Equipment detail dwgs	27	11JAN96 A	12APR96 A	100
144DL	WAES Left - Equipment detail dwgs	3	16APR96 A	18APR96 A	100
144L	WAES Left - LVEA equipment arrangement dwg	2	16APR96 A	17APR96 A	100
146L	WAES Left - Piping general arrangement dwgs	5	16APR96 A	22APR96 A	100
147L	WAES Left - Piping isometrics & cut sheets	20	19JUN96	17JUL96	0
155D	LACS - Equipment detail dwgs	5	27JUN96	03JUL96	0
166D	LAES Right - Equipment detail dwgs	3	25JUN96	27JUN96	0
166DL	LAES Left - Equipment detail dwgs	3	28JUN96	02JUL96	0
166L	LAES Left - LVEA equipment arrangement dwgs	2	21JUN96	24JUN96	0
168L	LAES Left - Piping general arrangement dwgs	3	09JUL96	11JUL96	0
169L	LAES Left - Piping isometrics & cut sheets	5	19JUL96	25JUL96	0
VACE - Vacuum Envelope					
10	Begin Vessel Fabrication - Washington	0	18JUN96		0
11	Begin Vessel Fabrication - Louisiana	0	06FEB97		0
16	Order First Article Material	0		14DEC95 A	100



Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
19	Complete Prototype Vessel Tests	0		13AUG96	0
201	Design HAM Vessels	96	13SEP95 A	04APR96 A	100
202	Design BSC Vessels	45	13SEP95 A	05DEC95 A	100
203	Design BSC chamber fab fixtures	15	26FEB96 A	15MAR96 A	100
204	Design long 80K cryopump vessels	30	13NOV95 A	30APR96 A	100
205	Design adapters and spool pieces	121 *	11JAN96 A	02JUL96	64
206	WACS - Prepare skid/pre-assy details	20	01MAY96	01MAY96	100
207	WAMS - Prepare skid/pre-assy details	10	01MAY96	14MAY96	0
208	WAES - Prepare skid/pre-assy details	10	01MAY96	14MAY96	0
209	LACS - Prepare skid/pre-assy details	15	12JUL96	01AUG96	0
210	LAES - Prepare skid/pre-assy details	10	09JUL96	22JUL96	0
214	Prepare a vessel fabrication specification	20	30OCT95 A	15DEC95 A	100
215	Prepare a final cleaning procedure	10	16APR96 A	29APR96 A	100
217	Develop a leak test procedure	20	19FEB96 A	29APR96 A	100
219	Develop a bakeout procedure	15	01APR96 A	22APR96 A	100
222	Develop welding procedures	10	15JAN96 A	22FEB96 A	100
223	Design and specify test/shipping covers	25	01DEC95 A	22APR96 A	100
224	Bellows expansion joints - Prepare Purchase Spec	10	01FEB96 A	09FEB96 A	100
225	Bellows expansion joints - Bid/Purchase 69 items	20	12FEB96 A	10MAY96	60
226	Bellows expansion joints - receive/review v/dwgs	25	23APR96 A	07JUN96	24
227	Bellows expansion joints - Fab & ship 69 items	60	10JUN96	03SEP96	0
229	Order mat'l & fab test/shipping covers	80	18JUN96	09OCT96	0
235	SS Vessel Mat'l - Bid & purchase total quantity	20	31JAN96 A	03MAY96	85
237	SS Vessel Mat'l - Fab & deliver 1st shipment	40	06MAY96	28JUN96	3
239	Vessel Heads - Bid & purchase total quantity	30	05APR96 A	17MAY96	57
240	Flange Forgings - Bid & purchase total quantity	25	05APR96 A	10MAY96	68
241	Flange Forgings - Fab & deliver 1st shipment	50	13MAY96	23JUL96	0
242	Release vessel material for shipment	3	18JUN96	20JUN96	0
243	Vessel Heads - Fab & deliver 1st shipment	60	20MAY96	13AUG96	0
244	BSC's - Fab and test WA vessels (10)	218 *	14AUG96	24JUN97	0
245	BSC's - Fab and test LA vessels (5)	158 *	06FEB97	18SEP97	0
246	HAM's - Fab and test WA vessels (12)	232 *	18JUN96	16MAY97	0
247	HAM's - Fab and test LA vessels (6)	127 *	13FEB97	12AUG97	0
248	WA Beam Tube Manifolds / Spools / Adapters - Fab	170	24JUL96	26MAR97	0
249	WA BTM/Spools/Adapters - Clean/test/prep to ship	170	21AUG96	23APR97	0
250	Long 80K Cryopumps - Fab & test WA pumps (2)	125 *	14AUG96	12FEB97	0



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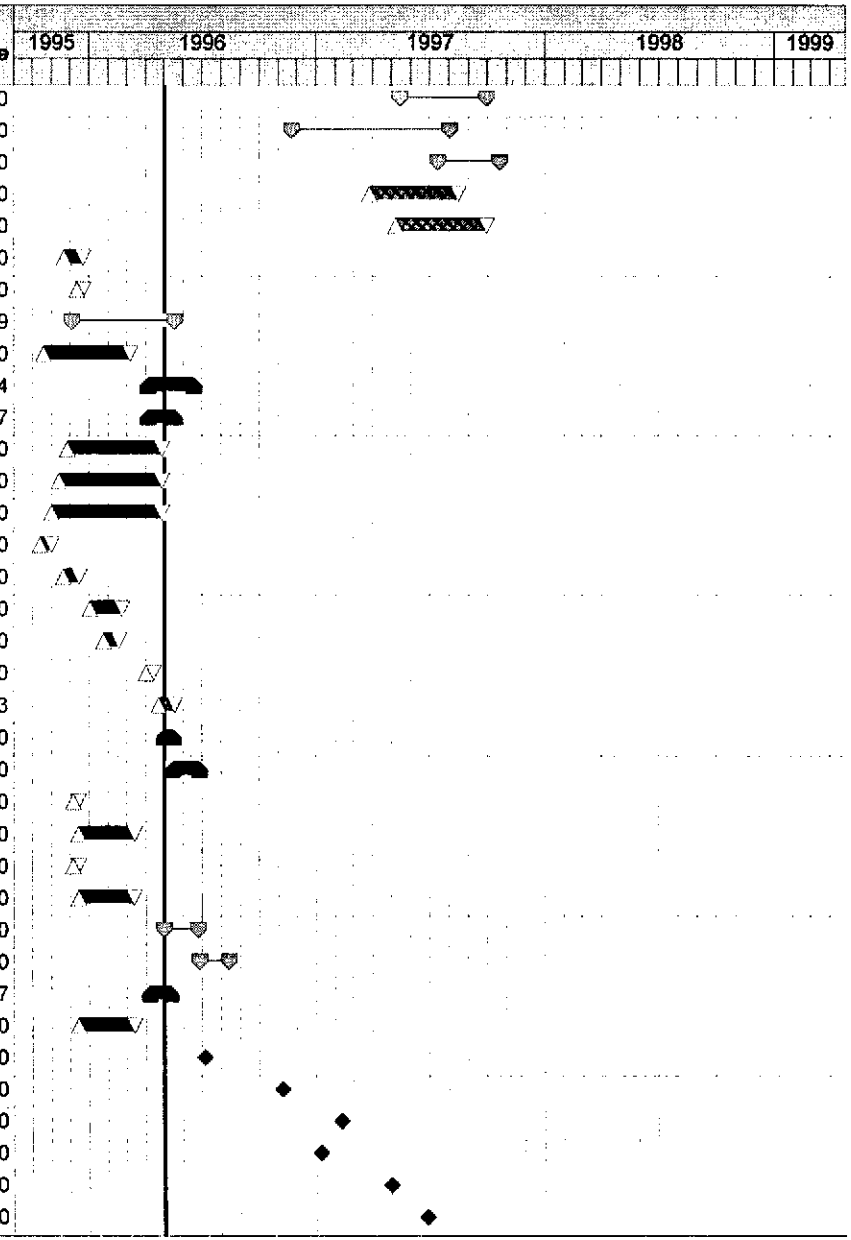
Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
251	Long 80K Cryopumps - Fab & test LA pumps (2)	95 *	15MAY97	29SEP97	0
252	Short 80K Cryopumps - Fab & test WA pumps (6)	175 *	22NOV96	01AUG97	0
253	Short 80K Cryopumps - Fab & test LA pumps (2)	70 *	14JUL97	20OCT97	0
254	LA Beam Tube Manifolds / Spools / Adapters - Fab	100	27MAR97	15AUG97	0
255	LA BTM/Spools/Adapters - Clean/test/prep to ship	100	08MAY97	29SEP97	0
257	CO # 6 - Additional bracing on BSC chamber	15	21NOV95 A	21DEC95 A	100
258	CO #10 -Increase pumping surface clear aperature	9	12DEC95 A	21DEC95 A	100
260	10" Benchscale Vessel Program	116 *	04DEC95 A	17MAY96	89
262	CO #13 - BSC internal floor loading requirements	20	19OCT95 A	06MAR96 A	100
265	1st Article HAM - Procure fab materials	50	05APR96 A	17JUN96	34
266	1st Article HAM - Bid & award fabrication	30	05APR96 A	17MAY96	57
272	Design long 80K cryopump shroud	20	27NOV95 A	26APR96 A	100
273	Design short 80K cryopump vessel	50	13NOV95 A	26APR96 A	100
274	Design short 80K cryopump shroud	60	01NOV95 A	26APR96 A	100
279	Conduct a plasma welding investigation	10	13OCT95 A	31OCT95 A	100
280	Procure a plasma welding machine	20	20NOV95 A	15DEC95 A	100
281	Qualify Welding Procedure for Plasma Welding	10	02JAN96 A	22FEB96 A	100
284	Procure cleaning equipment	20	24JAN96 A	16FEB96 A	100
285	Conduct materials testing program	10	01APR96 A	12APR96 A	100
286	Conduct a viton investigation	15	22APR96 A	17MAY96	13
289	Short 80K Cryopump - Procure shroud mat'l (1)	10	01MAY96	14MAY96	0
290	Short 80K Cryopump - Fab shroud for prototype	30	15MAY96	26JUN96	0
291	Order Prototype BSC Flange Forgings	5	06DEC95 A	13DEC95 A	100
292	Fab and deliver Prototype BSC flange forgings	53	14DEC95 A	13MAR96 A	100
293	Order Prototype BSC shell, head, & nozzle mat'l	5	06DEC95 A	14DEC95 A	100
294	Fab & del Prototype BSC head, shell, nozzle matl	50	15DEC95 A	12MAR96 A	100
295	Fabricate Prototype BSC Vessel	38 *	01MAY96	24JUN96	0
296	Test program for Prototype vessel	33 *	27JUN96	13AUG96	0
297	Fabricate chamber fab fixtures	15	08APR96 A	10MAY96	47
298	Order mat'l for test/ship covers for prototype	40	15DEC95 A	13MAR96 A	100
12A	Receipt of 1/3 of SS vessel material	0		05JUL96	0
12B	Receipt of 2/3 of SS vessel material	0		07NOV96	0
12C	Receipt of All SS vessel material	0		10FEB97	0
13A	Complete fab on 1/3 of WA vessels	0		08JAN97	0
13B	Complete fab on 2/3 of WA vessels	0		30APR97	0
13C	Complete fab of all WA vessels	0		26JUN97	0



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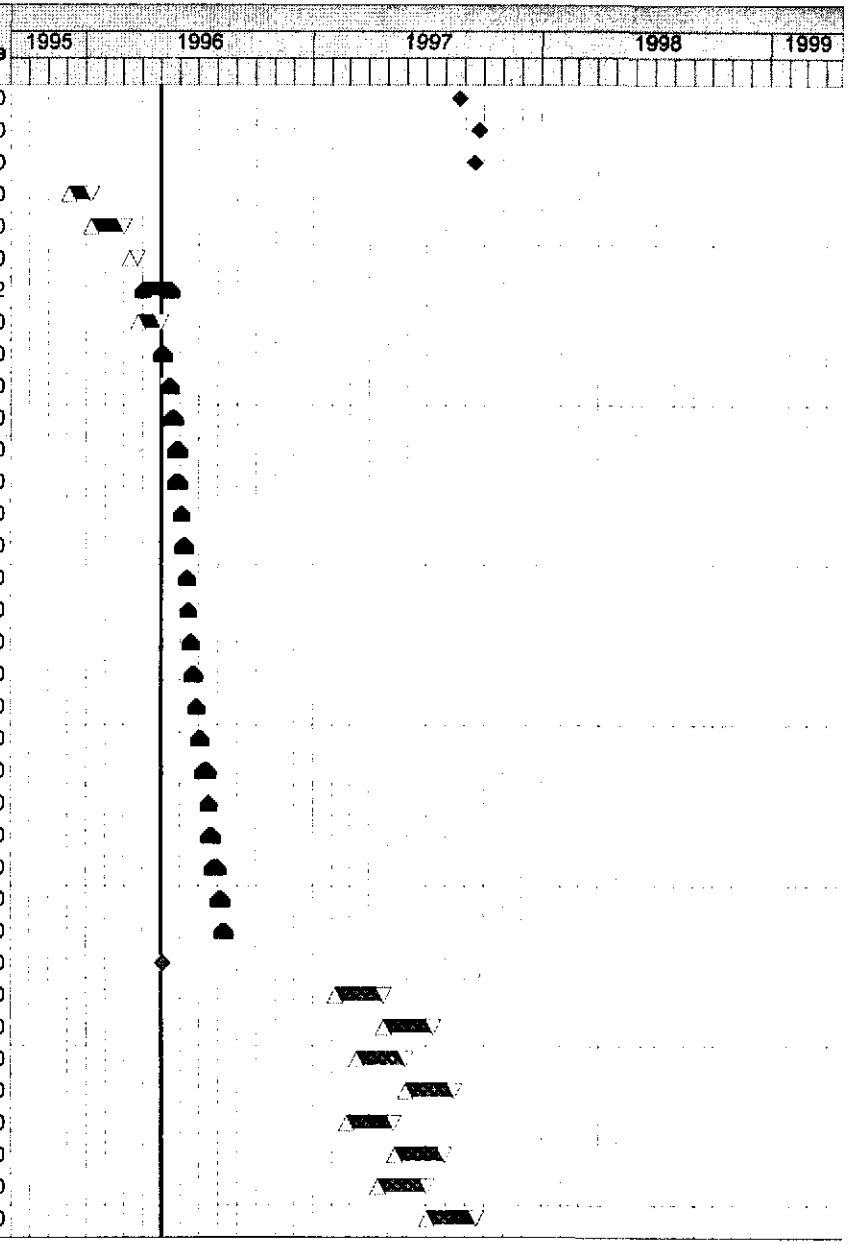
Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
14A	Complete fab on 1/3 of LA vessels	0		22AUG97	0
14B	Complete fab on 2/3 of LA vessels	0		22SEP97	0
14C	Complete fab of all LA vessels	0		15SEP97	0
260A	10" Benchscale Vessel - System Engineering	20	04DEC95 A	08JAN96 A	100
260B	10" Benchscale Vessel - Procure materials	30	09JAN96 A	01MAR96 A	100
260C	10" Benchscale Vessel - Fabricate vessel	10	11MAR96 A	22MAR96 A	100
260D	10" Benchscale Vessel - Conduct test program	34	01APR96 A	17MAY96	62
260E	10" Benchscale Vessel - Order matl/fab new sectn	15	25MAR96 A	30APR96 A	100
295A	Prototype BSC Fab - Roll/weld shell (outside)	4	01MAY96	06MAY96	0
295B	Prototype BSC Fab - Weld on heads (outside)	4	13MAY96	16MAY96	0
295C	Prototype BSC Fab - Cut/weld nozzle necks	5	17MAY96	23MAY96	0
295D	Prototype BSC Fab - Machine flanges/blinds (out)	5	24MAY96	31MAY96	0
295E	Prototype BSC Fab - Stress relieve (outside)	5	24MAY96	31MAY96	0
295F	Prototype BSC Fab - Square off nozzles (outside)	2	03JUN96	04JUN96	0
295G	Prototype BSC Fab - Weld on flanges	4	05JUN96	10JUN96	0
295H	Prototype BSC Fab - Install welded attachments	3	11JUN96	13JUN96	0
295I	Prototype BSC Fab - Install internal floor suppt	1	14JUN96	14JUN96	0
295J	Prototype BSC Fab - Install annulus tubing & pmp	3	17JUN96	19JUN96	0
295K	Prototype BSC Fab - Clean chamber to spec	3	20JUN96	24JUN96	0
296A	Start prototype testing program	2	27JUN96	28JUN96	0
296B	Prototype Test - Rough leak check	4	01JUL96	05JUL96	0
296C	Prototype Test - Bakeout	7	08JUL96	16JUL96	0
296D	Prototype Test - Perform dimensional check	1	17JUL96	17JUL96	0
296E	Prototype Test - Final leak check	4	18JUL96	23JUL96	0
296F	Prototype Test - Ultimate pressure test	7	24JUL96	01AUG96	0
296G	Prototype Test - Install cryopump shroud	4	02AUG96	07AUG96	0
296H	Prototype Test - Vibration/boiloff test	4	08AUG96	13AUG96	0
9C	Place PO for SS vessel material (main release)	0		03MAY96	0
LBSC01F	LBSC1 - Outside fabrication	55	06FEB97	23APR97	0
LBSC01T	LBSC1 - Final fab/clean/test/prep for ship	55	24APR97	11JUL97	0
LBSC02F	LBSC2 - Outside fabrication	55	12MAR97	28MAY97	0
LBSC02T	LBSC2 - Final fab/clean/test/prep for ship	55	29MAY97	14AUG97	0
LBSC03F	LBSC3 - Outside fabrication	55	24FEB97	09MAY97	0
LBSC03T	LBSC3 - Final fab/clean/test/prep for ship	55	12MAY97	29JUL97	0
LBSC04F	LBSC4 - Outside fabrication	55	15APR97	01JUL97	0
LBSC04T	LBSC4 - Final fab/clean/test/prep for ship	55	02JUL97	18SEP97	0



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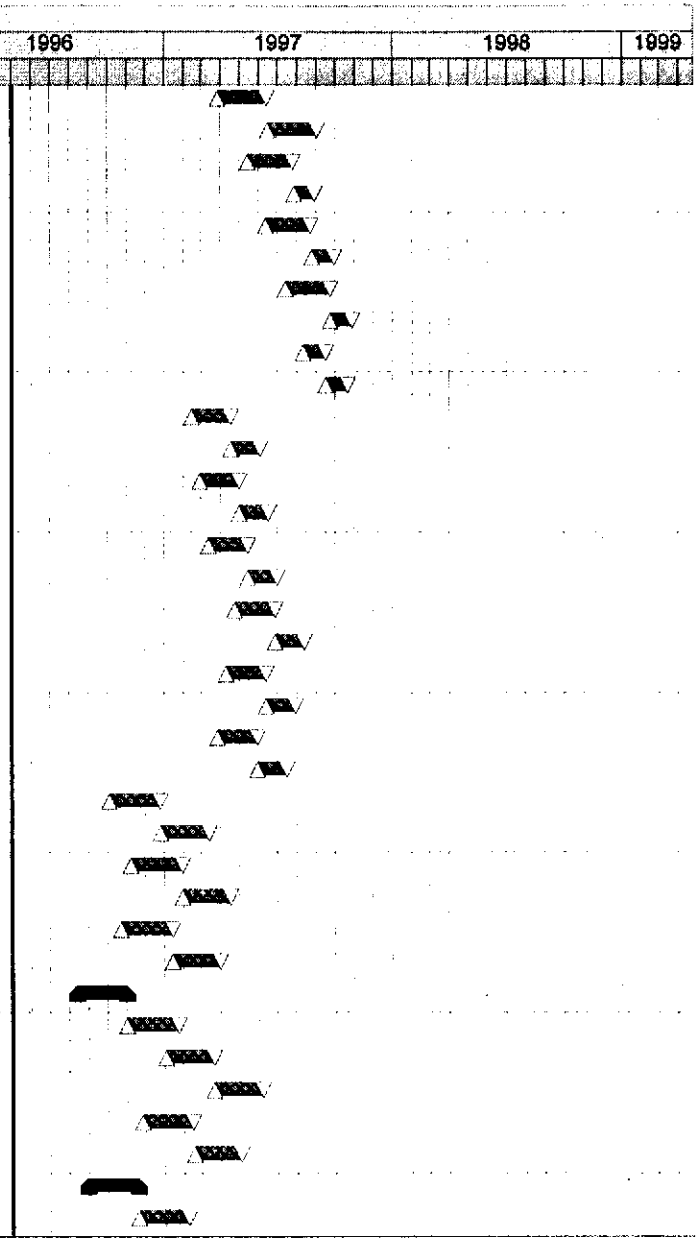
LBSC05F	LBSC5 - Outside fabrication	55	28MAR97	13JUN97	0
LBSC05T	LBSC5 - Final fab/clean/test/prep for ship	55	16JUN97	02SEP97	0
LCP1F	LCP1 - Fabricate long 80K cryopump	50	15MAY97	25JUL97	0
LCP1T	LCP1 - Final clean/test/prep to ship long pump	25	28JUL97	29AUG97	0
LCP2F	LCP2 - Fabricate long 80K cryopump	50	13JUN97	22AUG97	0
LCP2T	LCP2 - Final clean/test/prep to ship long pump	25	25AUG97	29SEP97	0
LCP3F	LCP3 - Fabricate short 80K cryopump	50	14JUL97	22SEP97	0
LCP3T	LCP3 - Final clean/test/prep to ship short pump	25	23SEP97	27OCT97	0
LCP4F	LCP4 - Fabricate short 80K cryopump	25	11AUG97	15SEP97	0
LCP4T	LCP4 - Final clean/test/prep to ship short pump	25	16SEP97	20OCT97	0
LHAM01F	LHAM1 - Outside fabrication	45	13FEB97	16APR97	0
LHAM01T	LHAM1 - Final fab/clean/test/prep for ship	32	17APR97	02JUN97	0
LHAM02F	LHAM2 - Outside fabrication	45	27FEB97	30APR97	0
LHAM02T	LHAM2 - Final fab/clean/test/prep for ship	32	01MAY97	16JUN97	0
LHAM03F	LHAM3 - Outside fabrication	45	13MAR97	14MAY97	0
LHAM03T	LHAM3 - Final fab/clean/test/prep for ship	32	15MAY97	30JUN97	0
LHAM04F	LHAM4 - Outside fabrication	45	24APR97	26JUN97	0
LHAM04T	LHAM4 - Final fab/clean/test/prep for ship	32	27JUN97	12AUG97	0
LHAM05F	LHAM5 - Outside fabrication	45	10APR97	12JUN97	0
LHAM05T	LHAM5 - Final fab/clean/test/prep for ship	32	13JUN97	29JUL97	0
LHAM06F	LHAM6 - Outside fabrication	45	27MAR97	29MAY97	0
LHAM06T	LHAM6 - Final fab/clean/test/prep for ship	32	30MAY97	15JUL97	0
WBSC01F	WBSC1 - Outside fabrication	55	04OCT96	24DEC96	0
WBSC01T	WBSC1 - Final fab/clean/test/prep for ship	55	26DEC96	13MAR97	0
WBSC02F	WBSC2 - Outside fabrication	55	08NOV96	29JAN97	0
WBSC02T	WBSC2 - Final fab/clean/test/prep for ship	55	30JAN97	16APR97	0
WBSC03F	WBSC3 - Outside fabrication	55	23OCT96	13JAN97	0
WBSC03T	WBSC3 - Final fab/clean/test/prep for ship	55	14JAN97	31MAR97	0
WBSC04F	WBSC4 - Outside fabrication	55	14AUG96	31OCT96	0
WBSC04T	WBSC4 - Final fab/clean/test/prep for ship	55	01NOV96	22JAN97	0
WBSC05F	WBSC5 - Outside fabrication	55	03JAN97	20MAR97	0
WBSC05T	WBSC5 - Final fab/clean/test/prep for ship	55	21MAR97	06JUN97	0
WBSC06F	WBSC6 - Outside fabrication	55	26NOV96	14FEB97	0
WBSC06T	WBSC6 - Final fab/clean/test/prep for ship	55	17FEB97	02MAY97	0
WBSC07F	WBSC7 - Outside fabrication	55	30AUG96	18NOV96	0
WBSC07T	WBSC7 - Final fab/clean/test/prep for ship	55	19NOV96	07FEB97	0



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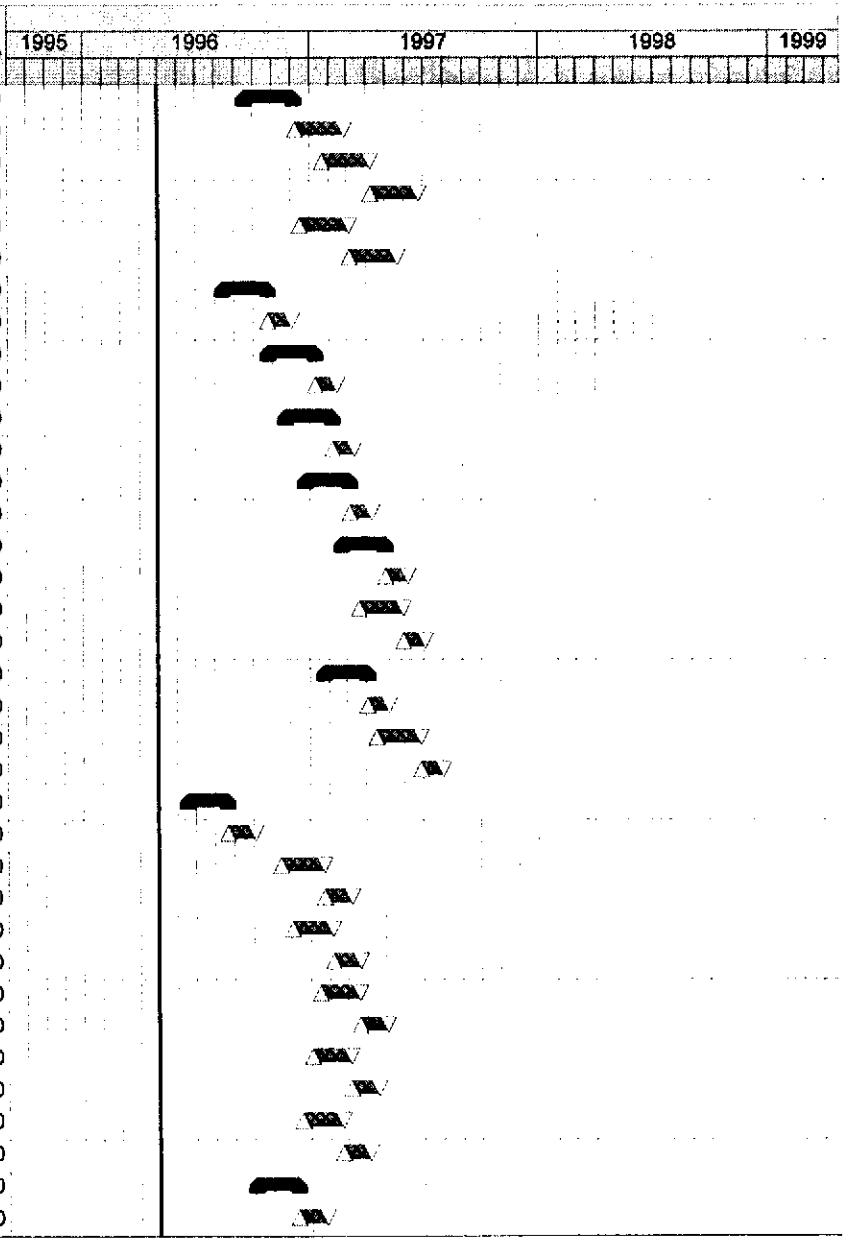
WBSC08F	WBSC8 - Outside fabrication	55	18SEP96	06DEC96	0
WBSC08T	WBSC8 - Final fab/clean/test/prep for ship	55	09DEC96	25FEB97	0
WBSC09F	WBSC9 - Outside fabrication	55	21JAN97	07APR97	0
WBSC09T	WBSC9 - Final fab/clean/test/prep for ship	55	08APR97	24JUN97	0
WBSC10F	WBSC10 - Outside fabrication	55	16DEC96	04MAR97	0
WBSC10T	WBSC10 - Final fab/clean/test/prep for ship	55	05MAR97	20MAY97	0
WCP1F	WCP1 - Fabricate long 80k cryopump	50	14AUG96	24OCT96	0
WCP1T	WCP1 - Final clean/test/prep for ship long pump	25	25OCT96	02DEC96	0
WCP2F	WCP2 - Fabricate long 80K cryopump	50	25OCT96	08JAN97	0
WCP2T	WCP2 - Final clean/test/prep to ship long pump	25	09JAN97	12FEB97	0
WCP3F	WCP3F - Fabricate short 80K cryopump	50	22NOV96	05FEB97	0
WCP3T	WCP3 - Final clean/test/prep to ship short pump	25	06FEB97	12MAR97	0
WCP4F	WCP4 - Fabricate short 80K cryopump	50	24DEC96	05MAR97	0
WCP4T	WCP4 - Final clean/test/prep to ship short pump	25	06MAR97	09APR97	0
WCP5F	WCP5 - Fabricate short 80K cryopump	50	20FEB97	30APR97	0
WCP5T	WCP5 - Final clean/test/prep to ship short pump	25	01MAY97	05JUN97	0
WCP6F	WCP6 - Fabricate short 80K cryopump	50	20MAR97	29MAY97	0
WCP6T	WCP6 - Final clean/test/prep to ship short pump	25	30MAY97	03JUL97	0
WCP7F	WCP7 - Fabricate short 80K cryopump	50	23JAN97	02APR97	0
WCP7T	WCP7 - Final clean/test/prep to ship short pump	25	03APR97	07MAY97	0
WCP8F	WCP8 - Fabricate short 80K cryopump	50	17APR97	26JUN97	0
WCP8T	WCP8 - Final clean/test/prep to ship short pump	25	27JUN97	01AUG97	0
WHAM01F	WHAM1 - Outside fabrication	45	18JUN96	20AUG96	0
WHAM01T	WHAM01 - Final fab/clean/test/prep for ship	32	21AUG96	04OCT96	0
WHAM02F	WHAM2 - Outside fabrication	45	15NOV96	22JAN97	0
WHAM02T	WHAM2 - Final fab/clean/test/prep for ship	32	23JAN97	07MAR97	0
WHAM03F	WHAM3 - Outside fabrication	45	03DEC96	05FEB97	0
WHAM03T	WHAM3 - Final fab/clean/test/prep for ship	32	06FEB97	21MAR97	0
WHAM04F	WHAM4 - Outside fabrication	45	16JAN97	19MAR97	0
WHAM04T	WHAM4 - Final fab/clean/test/prep for ship	32	20MAR97	02MAY97	0
WHAM05F	WHAM5 - Outside fabrication	45	02JAN97	05MAR97	0
WHAM05T	WHAM5 - Final fab/clean/test/prep for ship	32	06MAR97	18APR97	0
WHAM06F	WHAM6 - Outside fabrication	45	17DEC96	19FEB97	0
WHAM06T	WHAM6 - Final fab/clean/test/prep for ship	32	20FEB97	04APR97	0
WHAM07F	WHAM7 - Outside fabrication	45	03OCT96	09DEC96	0
WHAM07T	WHAM7 - Final fab/clean/test/prep for ship	32	10DEC96	24JAN97	0



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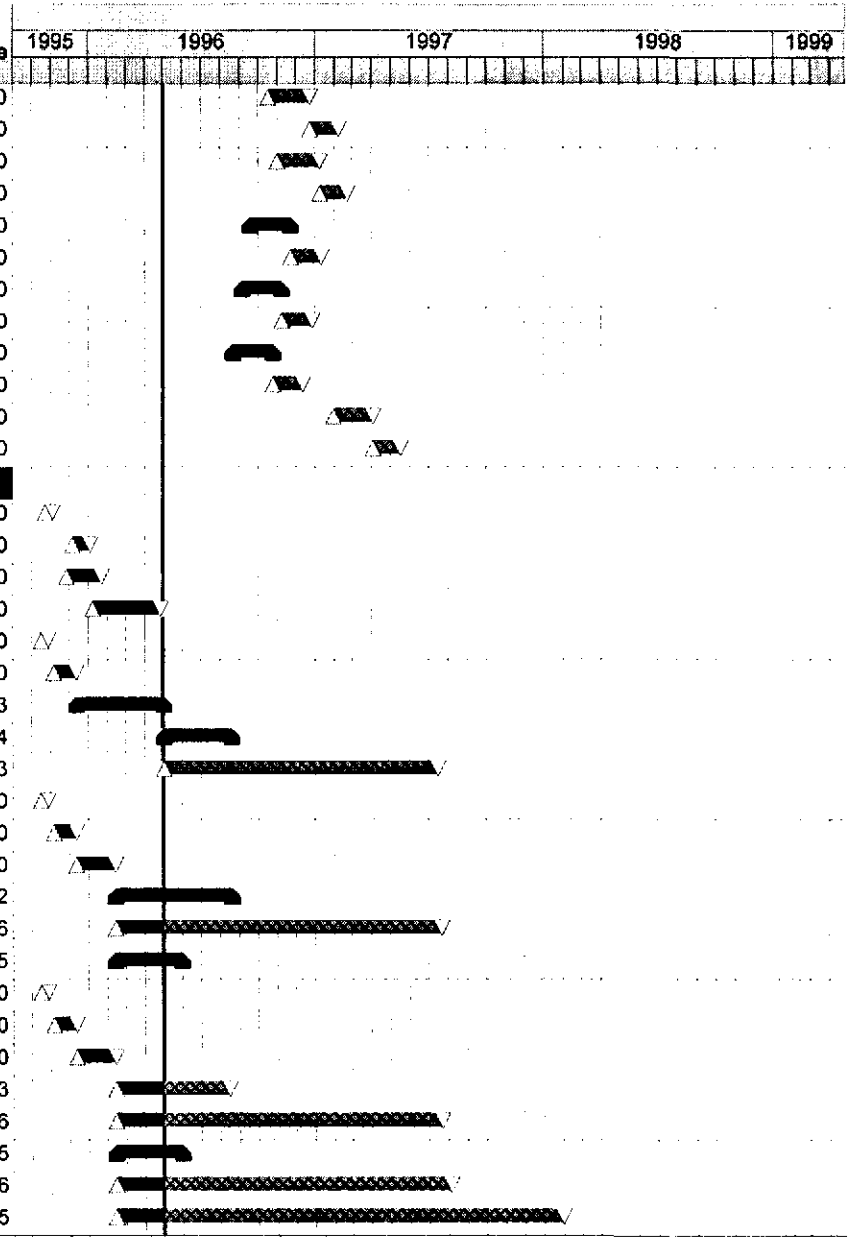
Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
WHAM08F	WHAM8 - Outside fabrication	45	18OCT96	23DEC96	0
WHAM08T	WHAM8 - Final fab/clean/test/prep for ship	32	24DEC96	07FEB97	0
WHAM09F	WHAM9 - Outside fabrication	45	01NOV96	08JAN97	0
WHAM09T	WHAM9 - Final fab/clean/test/prep for ship	32	09JAN97	21FEB97	0
WHAM10F	WHAM10 - Outside fabrication	45	19SEP96	21NOV96	0
WHAM10T	WHAM10 - Final fab/clean/test/prep for ship	32	22NOV96	10JAN97	0
WHAM11F	WHAM11 - Outside fabrication	45	05SEP96	07NOV96	0
WHAM11T	WHAM11 - Final fab/clean/test/prep for ship	32	08NOV96	26DEC96	0
WHAM12F	WHAM12 - Outside fabrication	45	21AUG96	24OCT96	0
WHAM12T	WHAM12 - Final fab/clean/test/prep for ship	32	25OCT96	11DEC96	0
WHAM13F	WHAM13 - Outside fabrication	45	30JAN97	02APR97	0
WHAM13T	WHAM13 - Final fab/clean/test/prep for ship	32	03APR97	16MAY97	0
PUMP - Pumping System					
301	Perform vacuum/backfill calculations	10	23OCT95 A	03NOV95 A	100
302	Develop line list and line sizing	30	06DEC95 A	03JAN96 A	100
303	Develop piping specifications	13	27NOV95 A	22JAN96 A	100
305	Prepare special material specifications	20	08JAN96 A	26APR96 A	100
306	Main Roughing Pump - Issue specification	10	16OCT95 A	27OCT95 A	100
307	Main Roughing Pumps - Finalize bid & purchase (4	15	06NOV95 A	12DEC95 A	100
308	Main Roughing Pumps - Receive/review v/dwgs	30	13DEC95 A	02MAY96	93
309	Main Roughing Pumps - Fab/deliver to WA BTC (2)	75	03MAY96	19AUG96	14
310	Main Roughing Pumps - Fab/deliver to LA BTC (2)	311	03MAY96	15JUL97	3
311	Main Turbo Pumps - Issue specification	10	16OCT95 A	27OCT95 A	100
312	Main Turbo Pumps - Finalize bid & purchase (10)	15	06NOV95 A	12DEC95 A	100
313	Main Turbo Pumps - Recieve/review v/dwgs	30	13DEC95 A	13FEB96 A	100
314	Main Turbo Pumps - Fab/deliver to WA BTC (4)	95	14FEB96 A	19AUG96	22
315	Main Turbo Pumps - Fab/deliver to LA BTC (4)	330	14FEB96 A	21JUL97	6
316	Main Turbo Pumps - Fab/deliver to Westboro (2)	40	14FEB96 A	31MAY96	45
318	Aux Turbo Pumps - Issue specifications	5	16OCT95 A	27OCT95 A	100
319	Aux Turbo Pumps - Finalize bid & purchase (10)	15	06NOV95 A	12DEC95 A	100
320	Aux Turbo Pumps - Receive/review v/dwgs	30	13DEC95 A	13FEB96 A	100
321	Aux Turbo Pumps - Fab/deliver to WA BTC (2)	110	14FEB96 A	14AUG96	33
322	Aux Turbo Pumps - Fab/deliver to LA BTC (2)	330	14FEB96 A	21JUL97	6
323	Aux Turbo Pumps - Fab/deliver to Westboro (2)	40	14FEB96 A	31MAY96	45
325	Aux Turbo Pumps - Fab/deliver to WA site (3)	340	14FEB96 A	04AUG97	6
326	Aux Turbo Pumps - Fab/deliver to LA site (1)	465	14FEB96 A	30JAN98	5



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Layout System

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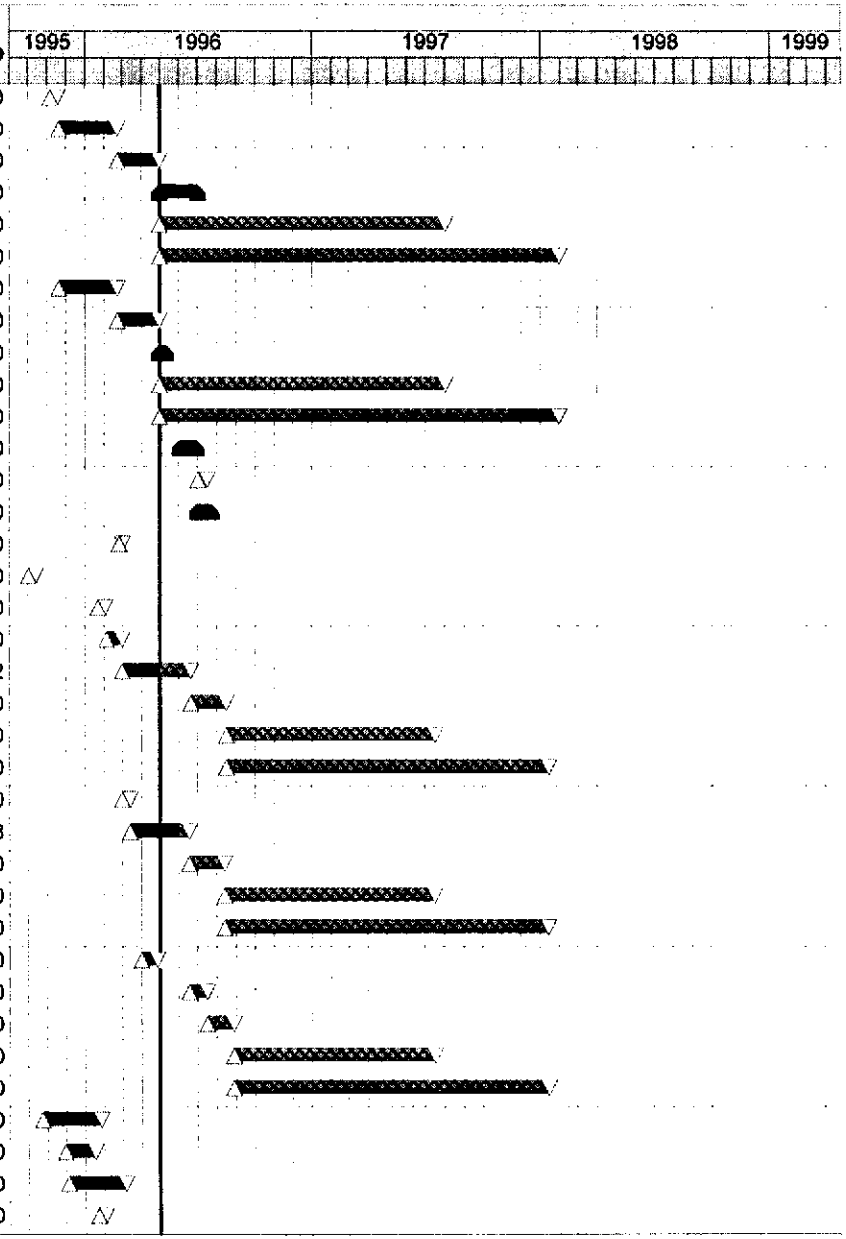
Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
327	All Ion Pumps - Issue specification	20	06NOV95 A	17NOV95 A	100
328	Main Ion Pumps - Bid and purchase (18)	7	20NOV95 A	22FEB96 A	100
329	Main Ion Pumps - Recieve/review v/dwgs	40	23FEB96 A	30APR96 A	100
330	Main Ion Pumps - Fab/deliver to Westboro (1)	43	01MAY96	01JUL96	0
331	Main Ion Pumps - Fab/deliver to WA site (12)	318	01MAY96	01AUG97	0
332	Main Ion Pumps - Fab/deliver to LA site (5)	445	01MAY96	30JAN98	0
333	Annuli Ion Pumps - Bid & purchase (43lg & 32sm)	4	20NOV95 A	22FEB96 A	100
334	Annuli Ion Pumps - Receive and review v/dwgs	40	23FEB96 A	30APR96 A	100
335	Annuli Ion Pumps - Fab/deliver to Westboro (2)	8	01MAY96	10MAY96	0
336	Annuli Ion Pumps - Fab/deliver to WA site (48)	318	01MAY96	01AUG97	0
337	Annuli Ion Pumps - Fab/deliver to LA site (25)	444	01MAY96	30JAN98	0
338	Gather turbomolecular pump vibration data (CAA)	20	03JUN96	28JUN96	0
339	Gather Main Ion Pmp controls vibration data (CAA	10	02JUL96	16JUL96	0
340	Design main turbo pump cart vib dampeners	15	01JUL96	22JUL96	0
341	Design Main Ion Pump supports	20	26FEB96 A	01MAR96 A	100
342	Perform cryopump process calculations	10	02OCT95 A	13OCT95 A	100
343	LN2 System - Perform detail design	25	22JAN96 A	02FEB96 A	100
344	LN2 System Components - Issue specifications	10	05FEB96 A	29FEB96 A	100
345	LN2 System Components - Bid and purchase	60	01MAR96 A	19JUN96	42
346	LN2 System Components - Rec/rvw v/dwgs	40	20JUN96	15AUG96	0
347	LN2 System Components - Fab/deliver to WA site	231	16AUG96	16JUL97	0
348	LN2 System Components - Fab/deliver to LA site	357	16AUG96	14JAN98	0
350	LN2 Dewars - Prepare specification	5	01MAR96 A	13MAR96 A	100
351	LN2 Dewars - Bid and purchase (12)	40	14MAR96 A	17JUN96	68
352	LN2 Dewars - Receive & review vendor drawings	40	18JUN96	13AUG96	0
353	LN2 Dewars - Fab/deliver to WA site (8)	233	14AUG96	16JUL97	0
354	LN2 Dewars - Fab/deliver to LA site (4)	359	14AUG96	14JAN98	0
355	VJ Lines - Prepare specification	10	01APR96 A	26APR96 A	100
356	VJ Lines - Assemble isos, bid, and purchase	20	18JUN96	16JUL96	0
357	VJ Lines - Receive and review vendor drawings	30	17JUL96	27AUG96	0
358	VJ Lines - Fab/deliver WA site lines (8 sets)	223	28AUG96	16JUL97	0
359	VJ Lines - Fab/deliver LA site lines (4 sets)	349	28AUG96	14JAN98	0
362	C.O. #3 - Design/fab/install CS pipe bridge	20	24OCT95 A	26JAN96 A	100
364	C.O. #8 - Foundation design for LN2 dewars	11	30NOV95 A	16JAN96 A	100
366	CO #12 - Add freon cooling sys to BTD pump carts	25	05DEC95 A	06MAR96 A	100
368	CO #15 - Add 8" port to main ion pumps (future)	5	23JAN96 A	02FEB96 A	100



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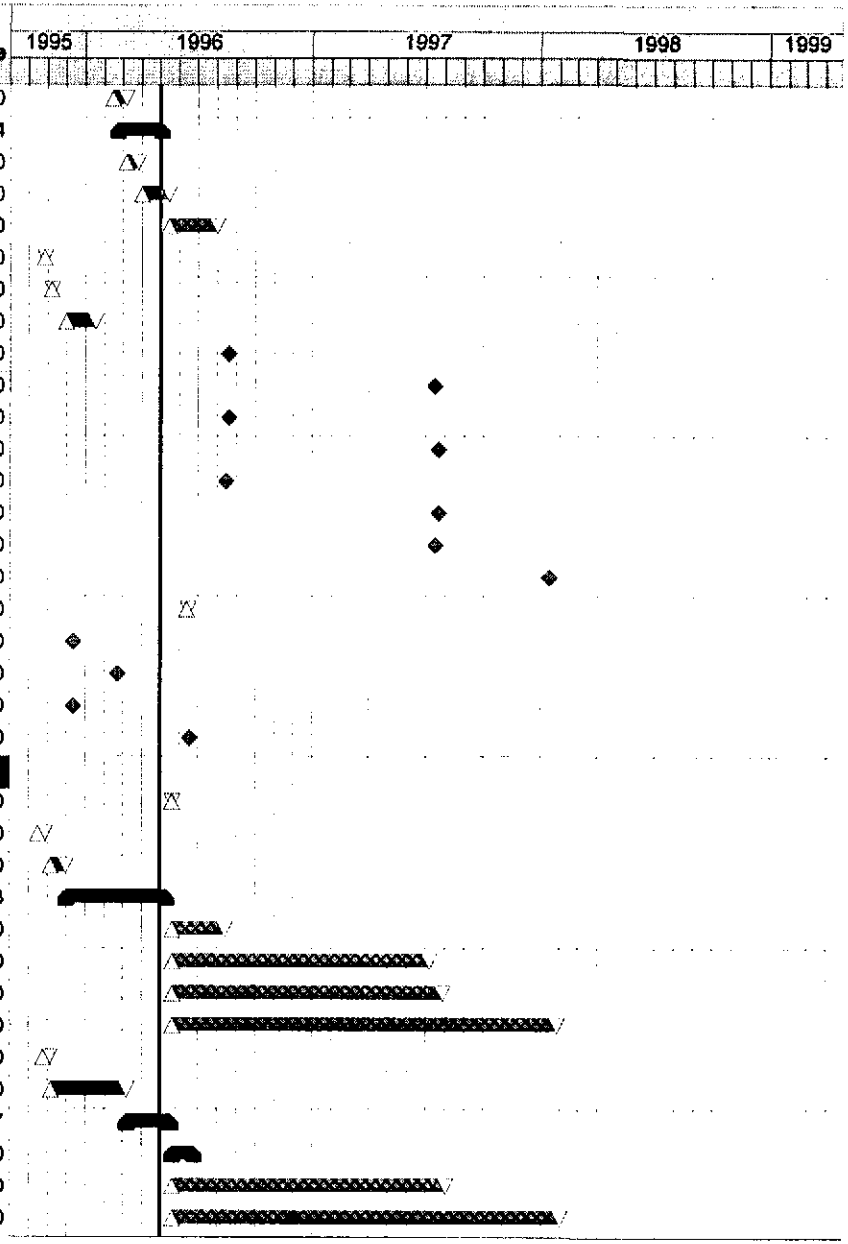
Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
370	CO #17 - Vacuum pump cart modifications	15	14FEB96 A	06MAR96 A	100
378	Prototype BSC Test Ion Pumps - Fab & deliver (2)	50	22FEB96 A	03MAY96	94
380	Freon Cooling Systems - Bid & purchase (6)	1	07MAR96 A	25MAR96 A	100
381	Freon Cooling Systems - Receive & review v/dwgs	20	01APR96 A	14MAY96	50
382	Freon Cooling Systems - Fab/deliver to WA (6)	54	15MAY96	31JUL96	0
398	Prep/iss draft Beam Tube deliverable pkg to LIGO	3	27OCT95 A	27OCT95 A	100
399	Review Beam Tube Deliverable documents with LIGO	1	07NOV95 A	07NOV95 A	100
400	Issue final Beam Tube deliverable pkg to LIGO	20	01DEC95 A	16JAN96 A	100
15A	WA BTC Main Roughing Pumps At Site	0		19AUG96	0
15B	LA BTC Main Roughing Pumps At Site	0		15JUL97	0
15C	WA BTC Turbo Molecular Pumps At Site	0		19AUG96	0
15D	LA BTC Turbo Molecular Pumps At Site	0		21JUL97	0
15E	WA BTC Auxiliary Turbo Carts At Site	0		14AUG96	0
15F	LA BTC Auxiliary Turbo Pumps At Site	0		21JUL97	0
17F	WA LN2 Dewars Delivery At Site	0		16JUL97	0
17G	LA LN2 Dewars Delivery At Site	0		14JAN98	0
330T	Main Ion Pumps - Performance test for 1st pump	2	13JUN96	14JUN96	0
9A	Place PO for Turbomolecular Pumps	0		12DEC95 A	100
9E	Place PO for Ion Pumps	0		22FEB96 A	100
9F	Place PO for Roughing Pumps	0		12DEC95 A	100
9H	Place PO for LN2 Dewars	0		17JUN96	0
VALV - Valve Subsystem					
401	Gather large gate valve shock data (CAA)	1	20MAY96 *	20MAY96	0
402	Large Gate Valves - Issue specification	8	16OCT95 A	27OCT95 A	100
403	Large Gate Valves - Finalize bid & purchase (32)	20	06NOV95 A	30NOV95 A	100
404	Large Gate Valves - Receive & review v/dwgs	30	01DEC95 A	10MAY96	73
405	Large Gate Valves - Fab/deliver to WA BTC (8)	59	21MAY96	13AUG96	0
406	Large Gate Valves - Fab/deliver to LA BTC (6)	285	21MAY96	07JUL97	0
407	Large Gate Valves - Fab/deliver to WA site (12)	300	21MAY96	28JUL97	0
408	Large Gate Valves - Fab/deliver to LA site (6)	426	21MAY96	26JAN98	0
409	6/10/14" Gate Valves - Issue specification	8	25OCT95 A	03NOV95 A	100
410	6/10/14" Gate Valves - Final bid & purchase (37)	20	06NOV95 A	07MAR96 A	100
411	6/10/14" Gate Valves - Receive & review v/dwgs	30	08MAR96 A	17MAY96	57
412	6/10/14" Gate Valves - Fab/deliver to Wbro (5)	25	20MAY96	24JUN96	0
413	6/10/14" Gate Valves - Fab/deliver WA site (27)	305	20MAY96	01AUG97	0
414	6/10/14" Gate Valves - Fab/deliver LA site (18)	431	20MAY96	30JAN98	0



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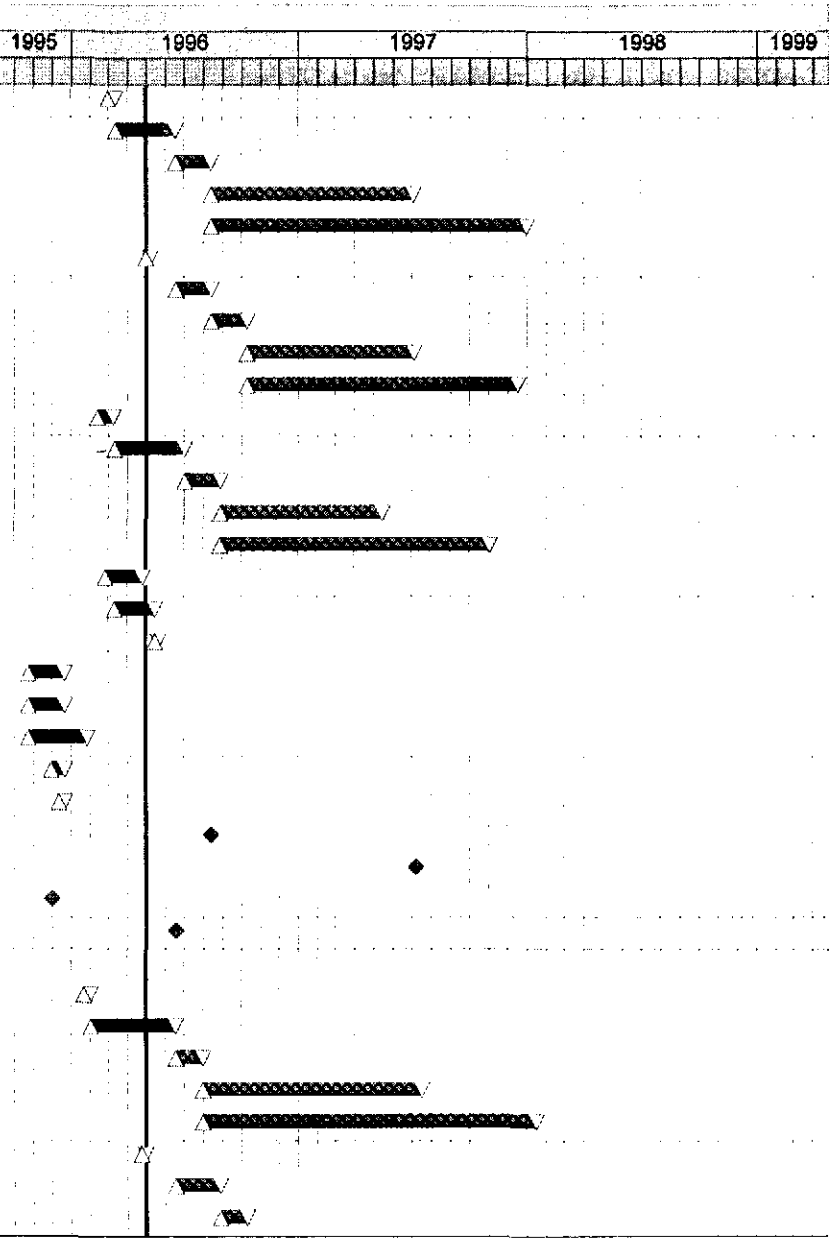
Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
415	Control Valves - Issue specifications	8	01MAR96 A	12MAR96 A	100
416	Control Valves - Bid & purchase	40	13MAR96 A	17JUN96	63
417	Control Valves - Receive & review vendor dwgs	40	18JUN96	13AUG96	0
418	Control Valves - Fab/deliver to WA site	225	14AUG96	03JUL97	0
419	Control Valves - Fab/deliver to LA site	350	14AUG96	31DEC97	0
421	Relief Valves - Issue specification	5	01MAY96	07MAY96	0
422	Relief Valves - Bid & purchase	40	18JUN96	13AUG96	0
423	Relief Valves - Receive & review vendor dwgs	40	14AUG96	09OCT96	0
424	Relief Valves - Fab/deliver to WA site	185	10OCT96	03JUL97	0
425	Relief Valves - Fab/deliver to LA site	300	10OCT96	16DEC97	0
427	Small Valves - Issue specifications	30	12FEB96 A	08MAR96 A	100
428	Small Valves - Bid and purchase	50	11MAR96 A	01JUL96	80
429	Small Valves - Receive & review vendor dwgs	40	02JUL96	27AUG96	0
430	Small Valves - Fab/deliver to WA site	180	28AUG96	14MAY97	0
431	Small Valves - Fab/deliver to LA site	300	28AUG96	03NOV97	0
433	Design supports for gate valves	20	26FEB96 A	25APR96 A	100
434	Large Gate Valves - Fab prototype large valve	25	12MAR96 A	15MAY96	88
435	Large Gate Valves - Cycle/shock test prototype	3	16MAY96	20MAY96	0
450	C.O. #1 - Change lg gate valve actuation	20	24OCT95 A	21DEC95 A	100
452	C.O. #2 -Change LA midpoint valves from 48 to 44	20	24OCT95 A	21DEC95 A	100
454	C.O. #4 - Add fail safe gates to roughing pumps	20	24OCT95 A	26JAN96 A	100
456	C.O. #7 - 304L weld stubs for lg gate valves	1	30NOV95 A	21DEC95 A	100
458	C.O. No. 9 - Change all lg gates to 48" electric	10	12DEC95 A	21DEC95 A	100
15G	WA BTC Large Gate Valves At Site	0		13AUG96	0
15H	LA BTC Large Gate Valves At Site	0		07JUL97	0
9B	Place PO for Beam Tube Large Gate Valves	0		30NOV95 A	100
9D	Release for Remaining Large Gate Valves (Main)	0		17JUN96	0
CTRL - Instrumentation and Controls					
501	Vacuum Gauges/Tees - Issue specification	5	22JAN96 A	01FEB96 A	100
502	Vacuum Gauges/Tees - Bid & purchase (43)	40	02FEB96 A	17JUN96	88
503	Vacuum Gauges/Tees- Receive/ review vendor dwgs	30	18JUN96	30JUL96	0
504	Vacuum Gauges - Fab/deliver to WA site (28)	243	31JUL96	16JUL97	0
505	Vacuum Gauges - Fab/deliver to LA site (15)	370	31JUL96	15JAN98	0
506	Misc Instrumentation - Issue specifications	3	24APR96 A	30APR96 A	100
507	Misc Instrumentation - Bid & purchase	50	18JUN96	27AUG96	0
508	Misc Instrumentation - Receive & review v/dwgs	30	28AUG96	09OCT96	0



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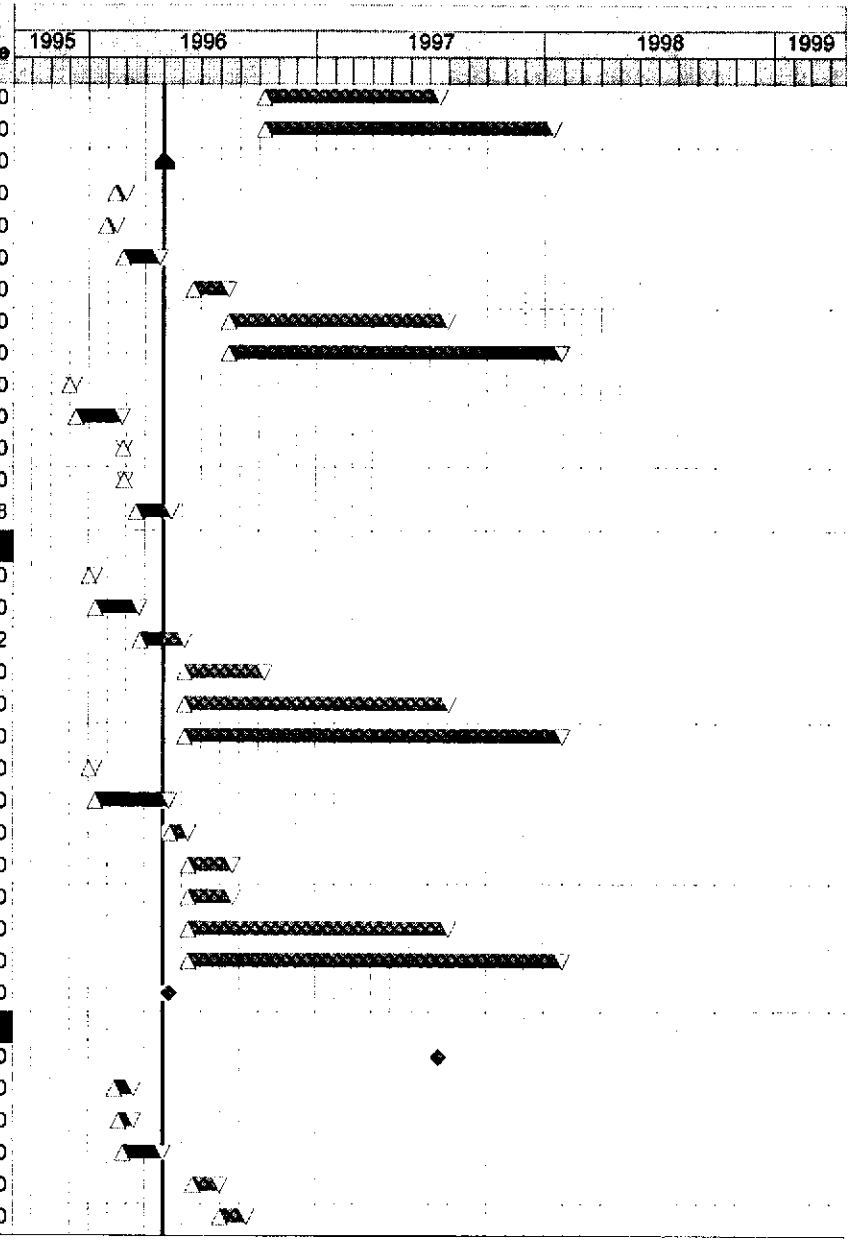
509	Misc Instrumentation - Fab/deliver to WA site	193	10OCT96	16JUL97	0
510	Misc Instrumentation - Fab/deliver to LA site	319	10OCT96	14JAN98	0
511	Develop logic lists	5	29APR96 A	03MAY96	40
512	Establish control interface definitions	5	12FEB96 A	29FEB96 A	100
513	I/E Cabinets - Determine size reqmts	10	29JAN96 A	14FEB96 A	100
515	Ion Pump Controller Cabinets - Size and specify	20	26FEB96 A	24APR96 A	100
519	Cabinets/Racks - Bid and purchase	40	18JUN96	13AUG96	0
520	Cabinets/Racks - Fab/deliver to WA site	242	14AUG96	29JUL97	0
521	Cabinets/Racks - Fab/deliver to LA site	368	14AUG96	27JAN98	0
522	Residual Gas Analyzer - Prepare specification	10	01DEC95 A	07DEC95 A	100
523	Residual Gas Analyzer - Bid & purchase (2)	30	11DEC95 A	23FEB96 A	100
524	Residual Gas Analyzer - Receive & review v/dwgs	10	26FEB96 A	26FEB96 A	100
525	RGA's - Fab/deliver to Westboro/Prototype (2)	20	27FEB96 A	28FEB96 A	100
599	LIGO Test Eqt & Cleanroom Training	40	18MAR96 A	13MAY96	78
VENT - Vent and Purge Subsystem					
601	Air Supply Skids - Issue specification	12	02JAN96 A	10JAN96 A	100
602	Air Supply Skids - Bid and purchase (8)	30	12JAN96 A	22MAR96 A	100
603	Air Supply Skids - Receive & review vendor dwgs	50	25MAR96 A	04JUN96	52
604	Air Supply Skids - Fab/deliver to Westboro (2)	90	05JUN96	10OCT96	0
605	Air Supply Skids - Fab/deliver to WA site (5)	294	05JUN96	01AUG97	0
606	Air Supply Skids - Fab/deliver to LA site (1)	420	05JUN96	30JAN98	0
608	Portable Cleanrooms - Issue specification	18	02JAN96 A	10JAN96 A	100
609	Portable Cleanrooms - Bid and purchase	20	12JAN96 A	10MAY96	60
610	Portable Cleanrooms - Receive & review v/dwgs	20	13MAY96	10JUN96	0
611	Portable Cleanroom - Fab/deliver to Westboro (2)	50	11JUN96	20AUG96	0
612	Portable Cleanrooms - Fab/deliver to Wstboro (2)	50	11JUN96	20AUG96	0
613	Portable Cleanrooms - Fab/deliver to WA site (6)	290	11JUN96	01AUG97	0
614	Portable Cleanrooms - Fab/deliver to LA site (4)	416	11JUN96	30JAN98	0
9G	Place PO for Clean Rooms	0		10MAY96	0
BAKE - Bakeout Subsystem					
18	Delivery of Bakeout System to WA Site	0		16JUL97	0
701	Prepare a bakeout system schematic	15	12FEB96 A	13MAR96 A	100
702	Perform bakeout system calculations	30	19FEB96 A	13MAR96 A	100
703	Bakeout Blankets - Issue specification	20	26FEB96 A	30APR96 A	100
704	Bakeout Blankets - Bid and purchase system	30	18JUN96	30JUL96	0
705	Bakeout Blankets - Receive & review vendor dwgs	30	31JUL96	11SEP96	0



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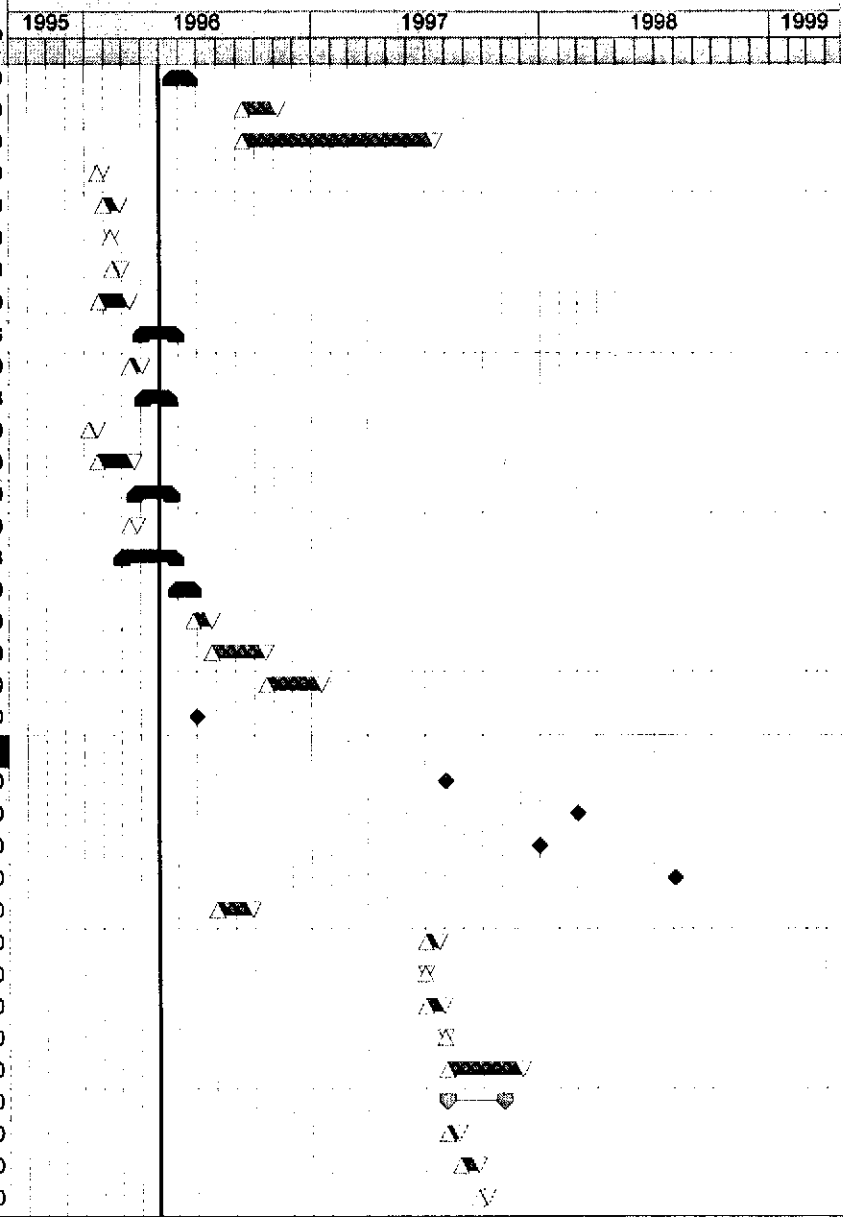
706	Bakeout Blankets - Fab/deliver to Westboro (6)	20	22MAY96	19JUN96	0
707	Bakeout Blankets - Fab/deliver to Westboro (20)	40	12SEP96	07NOV96	0
708	Bakeout Blankets - Fab/deliver to WA site (30)	213	12SEP96	16JUL97	0
709	Bakeout System Controls - Issue specs	10	22JAN96 A	29JAN96 A	100
710	Bakeout System Controls - Bid and purchase	20	01FEB96 A	26FEB96 A	100
711	Bakeout System Controls - Receive/review v/dwgs	10	12FEB96 A	13FEB96 A	100
712	Bakeout System Controls - Fab/deliver to PSI	20	14FEB96 A	29FEB96 A	100
717	Design bakeout cart(s) - Preliminary design	5	24JAN96 A	13MAR96 A	100
718	Program PLC's for bakeout system	40	01APR96 A	28MAY96	53
719	Bakeout Carts - Bid & award assembly of carts	15	14MAR96 A	03APR96 A	100
720	Bakeout Carts - Assemble 1st cart	31	04APR96 A	17MAY96	58
721	Prototype Bakeout Blankets - Issue specification	21	08JAN96 A	22JAN96 A	100
722	Prototype Bakeout Blankets - Bid & purchase (6)	20	23JAN96 A	21MAR96 A	100
723	Prototype Bakeout Blankets - Receive/rvw v/dwgs	15	22MAR96 A	21MAY96	0
726	Final design of bakeout carts	15	14MAR96 A	26MAR96 A	100
727	Program PC's for Bakeout System	70	01MAR96 A	28MAY96	73
730	Bakeout Carts - Test 1st bakeout cart	20	29MAY96	25JUN96	0
731	Bakeout Carts - Procure materials for 5 carts	20	26JUN96	24JUL96	0
732	Bakeout Carts - Assemble 5 carts	60	25JUL96	18OCT96	0
733	Bakeout Carts - Test 5 carts	60	21OCT96	16JAN97	0
91	Place PO for Bakeout System/Blankets	0		01JUL96	0
BILD - Systems Installation					
20	Begin Installation At Washington Site	0	04AUG97		0
21	Begin Installation At Louisiana Site	0	03MAR98		0
22	Mechanical Completion At Washington Site	0		31DEC97	0
23	Mechanical Completion At Louisiana Site	0		03AUG98	0
798	Bid & award Washington installation subcontract	40	02AUG96	27SEP96	0
799	WA Site - Installation subcontractor mobilize	15	02JUL97	23JUL97	0
801	Conduct installation readiness review - WA site	1	01JUL97 *	01JUL97	0
802	Verify interfaces & as-built site conditions -WA	20	02JUL97	30JUL97	0
803	Joint occupancy of WA site	1	01AUG97 *	01AUG97	0
804	WA Site - Receive/store/set eqt in all stations	85	04AUG97	02DEC97	0
810	WACS installation	65 *	04AUG97	03NOV97	0
811	WACS - Offload, clean, & position all components	15	04AUG97	22AUG97	0
812	WACS - Install vertex components	20	25AUG97	22SEP97	0
814	WACS - Install right beam manifold components	10	23SEP97	06OCT97	0



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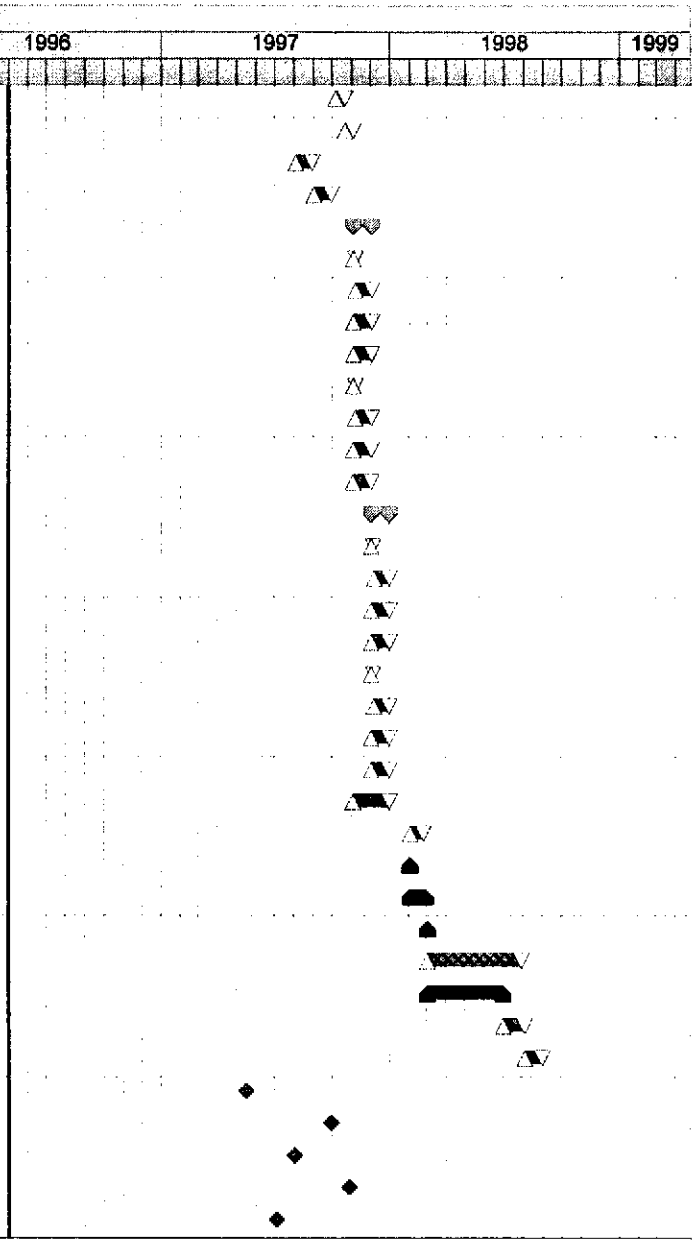
816	WACS - Install diagonal components	10	07OCT97	20OCT97	0
817	WACS - Install left beam manifold components	10	21OCT97	03NOV97	0
818	WACS - Install mechancial room eqt/piping/wiring	20	04AUG97	29AUG97	0
819	WACS - LN2 supply systems installation	20	02SEP97	29SEP97	0
820	WA Arm 1 (left) - Install mid/end station eqt	20 *	04NOV97	02DEC97	0
821	Left WAMS - Offload, clean, position components	3	04NOV97	06NOV97	0
822	Left WAMS - Install components	17	07NOV97	02DEC97	0
824	Left WAMS - Install mechanical room eqt/wiring	20	04NOV97	02DEC97	0
825	Left WAMS - LN2 supply systems installation	20	04NOV97	02DEC97	0
826	Left WAES - Offload, clean, position components	3	04NOV97	06NOV97	0
827	Left WAES - Install components	17	07NOV97	02DEC97	0
828	Left WAES - Install mechanical room eqt/wiring	20	04NOV97	02DEC97	0
829	Left WAES - LN2 supply system installation	20	04NOV97	02DEC97	0
830	WA Arm 2 (right) - Install mid/end station eqt	20 *	03DEC97	31DEC97	0
831	Right WAMS - Offload, clean, position components	3	03DEC97	05DEC97	0
832	Right WAMS - Install components	17	08DEC97	31DEC97	0
834	Right WAMS - Install mechanical room eqt/wiring	20	03DEC97	31DEC97	0
835	Right WAMS - LN2 supply systems installation	20	03DEC97	31DEC97	0
836	Right WAES - Offload, clean, position components	3	03DEC97	05DEC97	0
837	Right WAES - Install components	17	08DEC97	31DEC97	0
838	Right WAES - Install mechanical room eqt/wiring	20	03DEC97	31DEC97	0
839	Right WAES - LN2 supply system installation	20	03DEC97	31DEC97	0
848	Bid & award Louisiana installation subcontract	40	04NOV97	31DEC97	0
849	LA Site - Installation subcontractor mobilize	15	03FEB98	23FEB98	0
851	Conduct installation readiness review - LA site	1	02FEB98 *	02FEB98	0
852	Verify interfaces & as-built site conditions -LA	19	03FEB98	27FEB98	0
853	Joint occupancy of LA site	1	02MAR98	02MAR98	0
854	LA Site - Receive/store/set eqt in all stations	105	03MAR98	29JUL98	0
860	LACS installation	85	03MAR98	30JUN98	0
870	LA Arm 3 (left) - Install end station eqt	23	01JUL98	03AUG98	0
872	LA Arm 4 (right) - Install end station eqt	20	04AUG98	31AUG98	0
17A	WA Corner Station Major Vessel Delivery	0		16MAY97	0
17B	LA Corner Station Major Vessel Delivery	0		29SEP97	0
17C	WA End Station Major Vessel Delivery	0		01AUG97	0
17D	LA End Station Major Vessel Delivery	0		27OCT97	0
17E	WA Mid Station Major Vessel Delivery	0		03JUL97	0



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LIGO Vacuum System Project

Project Schedule 16Aof18A

Data date 01MAY96

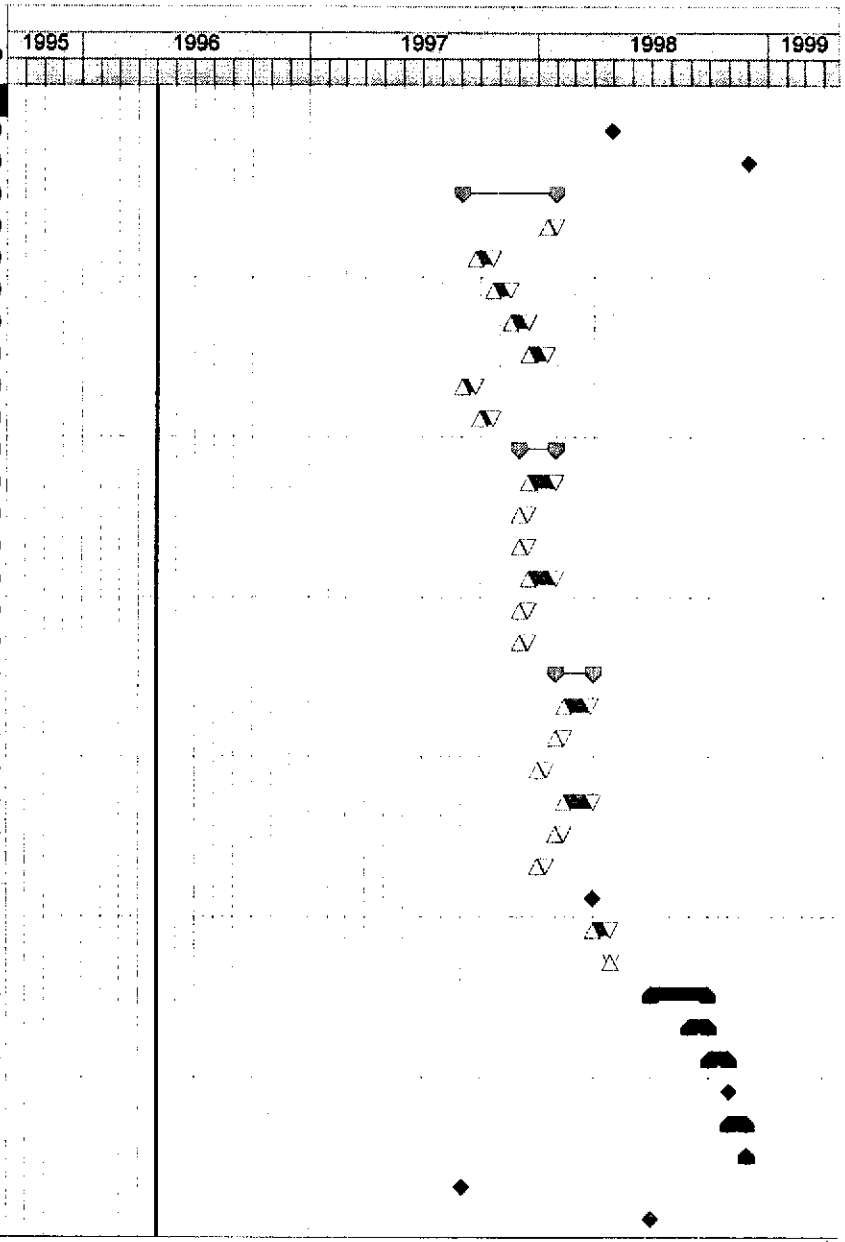
Run date 03MAY96

Filter All Activities

Layout System

Date	Revision	Checked	Approved
03MAY96	Final Design Pkg	PFH	REB

Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
CACT - Commissioning and Acceptance Testing					
25	Complete WA Acceptance Test Review Package	0		28APR98	0
26	Complete LA Acceptance Test Review	0		30NOV98	0
910	WACS - Test/commission station	105 *	02SEP97	29JAN98	0
911	WACS - Complete station commissioning	10	16JAN98	29JAN98	0
912	WACS - Test/commission vertex section	20	23SEP97	20OCT97	0
914	WACS - Test/commission right beam manifold	20	21OCT97	17NOV97	0
916	WACS - Test/commission diagonal section	20	18NOV97	16DEC97	0
917	WACS - Test/commission left beam manifold	20	17DEC97	15JAN98	0
918	WACS - Test/commission mechanical room equipment	15	02SEP97	22SEP97	0
919	WACS - Test/commission LN2 supply systems	15	30SEP97	20OCT97	0
920	WA Arm 1 (left) - Test/commission mid/end sta's	40 *	03DEC97	29JAN98	0
922	Left WAMS - Test/commission station components	30	17DEC97	29JAN98	0
924	Left WAMS - Test/commission mechanical room eqt	10	03DEC97	16DEC97	0
925	Left WAMS - Test/commission LN2 supply systems	10	03DEC97	16DEC97	0
927	Left WAES - Test/commission station components	30	17DEC97	29JAN98	0
928	Left WAES - Test/commission mechanical room eqt	10	03DEC97	16DEC97	0
929	Left WAES - Test/commission LN2 supply system	10	03DEC97	16DEC97	0
930	WA Arm 2 (right) - Test/commission mid/end sta's	43 *	30JAN98	31MAR98	0
932	Right WAMS - Test/commission station components	30	13FEB98	26MAR98	0
934	Right WAMS - Test/commission mechanical room eqt	10	30JAN98	12FEB98	0
935	Right WAMS - Test/commission LN2 supply systems	10	02JAN98	15JAN98	0
937	Right WAES - Test/commission station components	33	13FEB98	31MAR98	0
938	Right WAES - Test/commission mechanical room eqt	10	30JAN98	12FEB98	0
939	Right WAES - Test/commission LN2 supply system	10	02JAN98	15JAN98	0
940	Complete acceptance testing - WA site	0		31MAR98	0
945	Prepare acceptance test report for WA site	20	01APR98	28APR98	0
946	Conduct acceptance review meeting - WA site	1	29APR98	29APR98	0
960	LACS - Test/commission station	64	01JUL98	30SEP98	0
970	LA Arm 3 (left) - Test/commission end station	22	01SEP98	01OCT98	0
972	LA Arm 4 (right) - Test/commission end station	22	02OCT98	02NOV98	0
980	Complete acceptance testing - LA site	0		02NOV98	0
985	Prepare acceptance test report for LA site	19	03NOV98	30NOV98	0
986	Conduct acceptance review meeting - LA site	1	01DEC98	01DEC98	0
24A	Start Acceptance Testing At Washington Site	0	02SEP97		0
24B	Start Acceptance Testing At Louisiana Site	0	01JUL98		0



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LIGO Vacuum System Project

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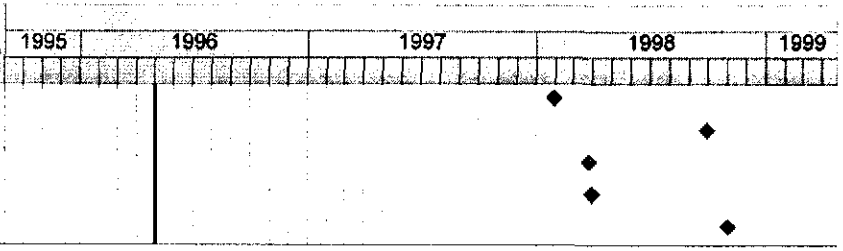
Act ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
24C	Complete Acceptance Test - WA Corner Station	0		29JAN98	0
24D	Complete Acceptance Test - LA Corner Station	0		30SEP98	0
24E	Complete Acceptance Test - WA Mid Stations	0		26MAR98	0
24F	Complete Acceptance Test - WA End Stations	0		31MAR98	0
24G	Complete Acceptance Test - LA End Stations	0		02NOV98	0



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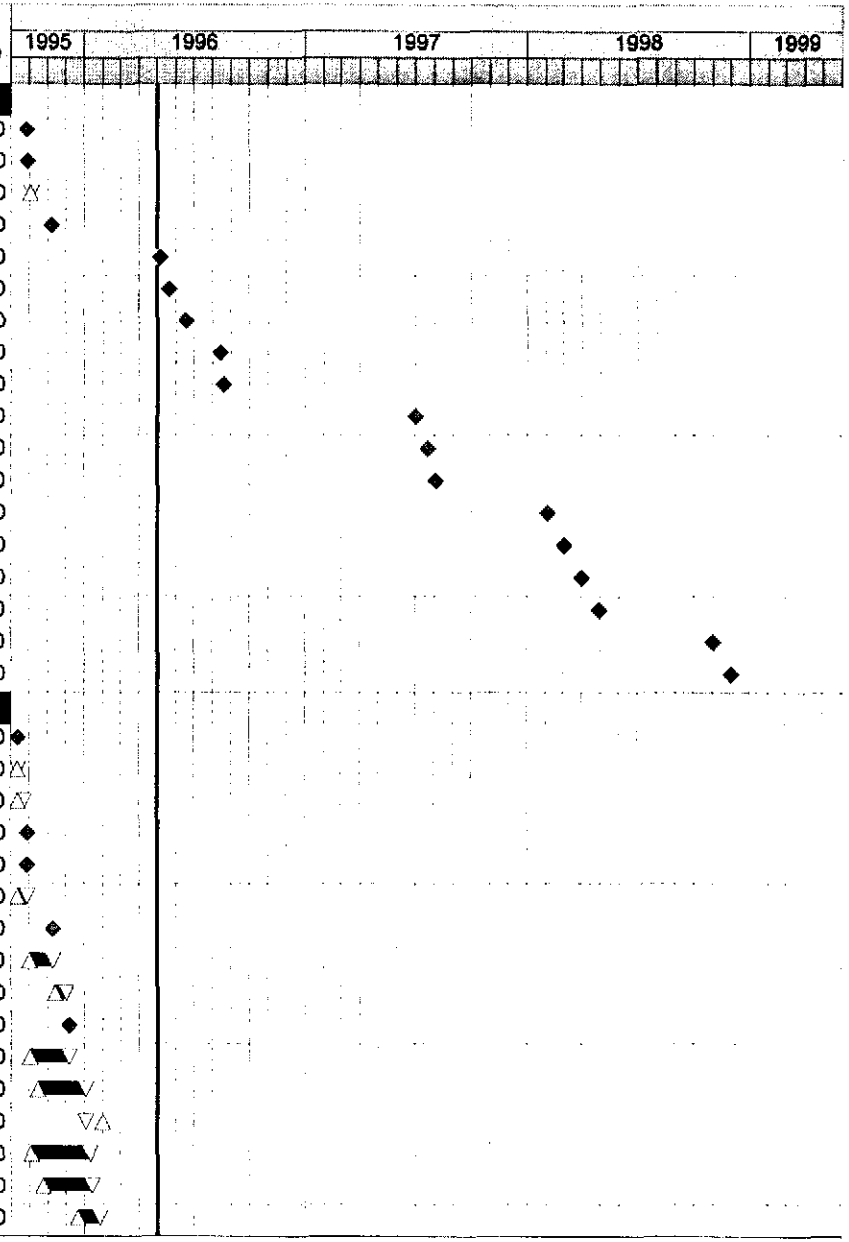
03MAY96	Final Design Pkg	PFH	REB

DETAILED PROJECT SCHEDULE

(Sorted by System / Early Finish)

Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
MILE - Contractual Schedule Milestones - Acticle II					
30	Complete Updated Preliminary Design (Phase B)	0		27SEP95 A	100
31	Submit & Implement Updated Proj Mgmt Plan	0		27SEP95 A	100
40	Updated Preliminary Design Review	1	03OCT95 A	03OCT95 A	100
41	Deliverables to the Beam Tube Final Design Rvw	0		07NOV95 A	100
34	Complete Final Design	0		06MAY96	0
42	Final Design Review	0	22MAY96		0
35	Begin fabrication and procurement	0	18JUN96		0
43	Final Prototype Vessel Design Review	0		13AUG96	0
32	Deliverables to the Beam Tube Contractor - WA	0		19AUG96	0
44	Installation Readiness Review - Washington	0		01JUL97	0
33	Deliverables to the Beam Tube Contractor - LA	0		21JUL97	0
36	Begin Installation - Washington Site	0	04AUG97		0
45	Installation Readiness Review - Louisiana	0		02FEB98	0
37	Begin Installation - Louisiana Site	0	03MAR98		0
38	Complete Acceptance Testing - Washington Site	0		31MAR98	0
46	Acceptance Test Review - Washington	0		29APR98	0
39	Complete Acceptance Testing - Louisiana Site	0		02NOV98	0
47	Acceptance Test Review - Louisiana	0		01DEC98	0
SAME - Common Engineering / Design Activities					
1	Phase B Award	0		12SEP95 A	100
000	Contract Award	1	12SEP95 A	12SEP95 A	100
101	P&ID's - Initial Issue	10	13SEP95 A	22SEP95 A	100
2	Submit Ph B Updated PDR for approval (CDRL 01)	0		27SEP95 A	100
4	Submit Proj Mgmt Plan for Approval (CDRL 02)	0		27SEP95 A	100
100	Phase B Update of PDR & Proj Mgmt Plan	1	12SEP95 A	27SEP95 A	100
3	Approval of Updated PDR (CDRL 01) by LIGO	0		10NOV95 A	100
105	Receive LIGO comments on updated prelim design	10	03OCT95 A	10NOV95 A	100
106	Final issue of Ph B update of prelim design pkg	30	13NOV95 A	01DEC95 A	100
5	Approval of Proj Mgmt Plan by LIGO (CDRL 02)	0		06DEC95 A	100
105A	LIGO approval of the Project Mgmt Plan	15	03OCT95 A	06DEC95 A	100
102	P&ID's - Issue for Design	30	16OCT95 A	03JAN96 A	100
104	PFD's - Issue for Design	10	01FEB96 A	03JAN96 A	100
144	WAES Right - LVEA equipment arrangement dwgs	81	04OCT95 A	10JAN96 A	100
185	C.O. #5 - Add cw supply to roots & turbo pumps	20	24OCT95 A	12JAN96 A	100
186	CO #11 - WACS beam manifold spool changes	25	21DEC95 A	26JAN96 A	100



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LIGO Vacuum System Project

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Data date 01MAY96

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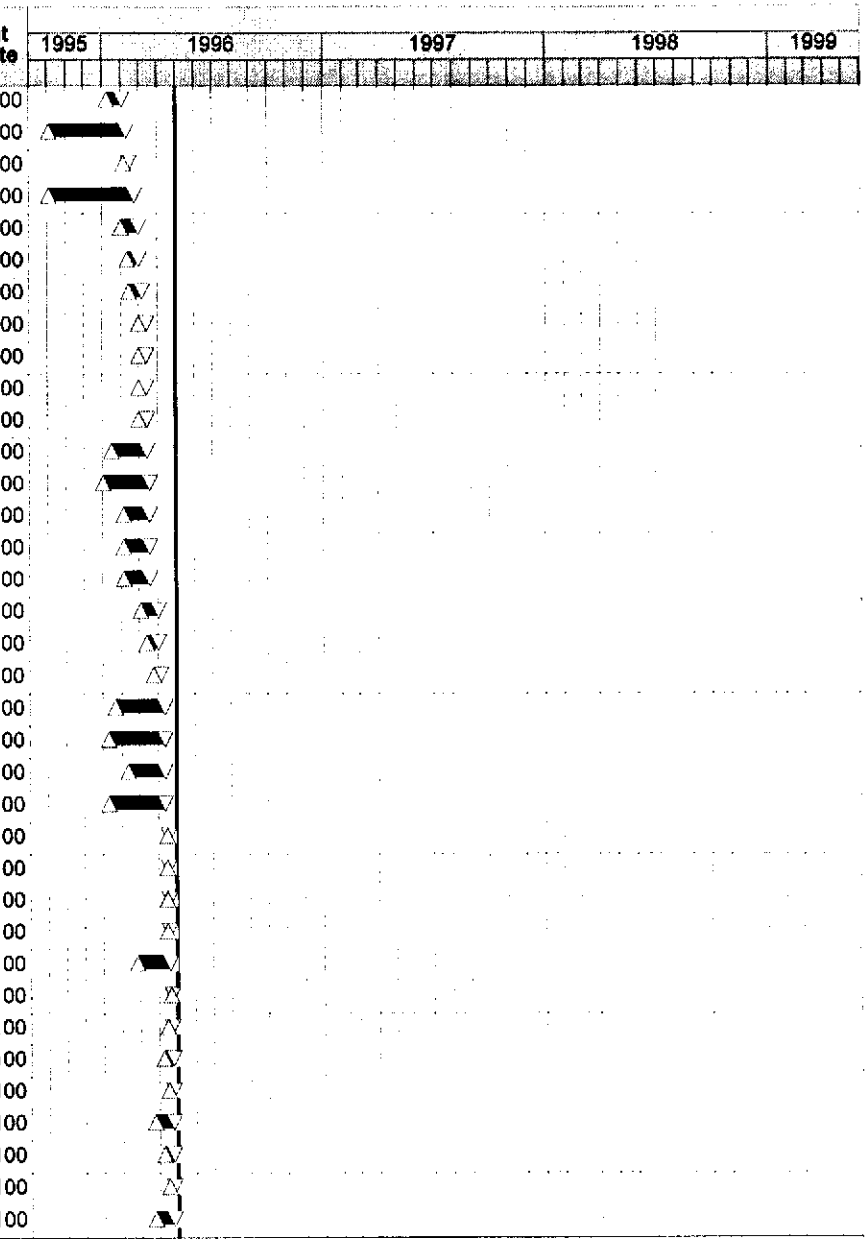
Filter All Activities

Layout Early finish sort

Date	Revision	Checked	Approved
03MAY96	Final Design Pkg	PFH	REB

Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
188	CO #14 - LVEA changes to mid/end mech rooms	1	09JAN96 A	02FEB96 A	100
133	WAMS Right - LVEA equipment arrangement dwgs	102	04OCT95 A	09FEB96 A	100
124	WACS - Pump support design	10	05FEB96 A	13FEB96 A	100
120	WACS - LVEA equipment arrangement dwgs	102	04OCT95 A	23FEB96 A	100
118	Bldg/utility interface definitions (PSI to LIGO)	20	01FEB96 A	29FEB96 A	100
109	Develop power calculations/requirements	10	12FEB96 A	01MAR96 A	100
192	CO #18 - Reduce annulus pumping speed	15	14FEB96 A	06MAR96 A	100
129	WACS - Interface wiring design	15	01MAR96 A	13MAR96 A	100
140	WAMS - Interface wiring design	11	01MAR96 A	13MAR96 A	100
151	WAES - Interface wiring design	11	01MAR96 A	13MAR96 A	100
117	Preparation of a drawing tree	15	01MAR96 A	14MAR96 A	100
190	CO #16 - BSC removable spools due to space limit	15	16JAN96 A	14MAR96 A	100
107	Issue QA Plan for Vessels	10	02JAN96 A	18MAR96 A	100
126	WACS - Cable tray layout & power plan	30	05FEB96 A	18MAR96 A	100
137	WAMS - Cable tray layout & power plan	30	05FEB96 A	18MAR96 A	100
148	WAES - Cable tray layout & power plan	30	05FEB96 A	18MAR96 A	100
111	Hazard analysis	20	04MAR96 A	01APR96 A	100
194	CO #19 - 30" Mode Cleaner Tube Changes	15	14MAR96 A	01APR96 A	100
184	Update the 3D model	10	25MAR96 A	05APR96 A	100
135	WAMS Right - Piping general arrangement dwgs	40	22JAN96 A	12APR96 A	100
146	WAES Right - Piping general arrangement dwgs	30	11JAN96 A	12APR96 A	100
133D	WAMS Right - Equipment detail dwgs	40	12FEB96 A	12APR96 A	100
144D	WAES Right - Equipment detail dwgs	27	11JAN96 A	12APR96 A	100
133L	WAMS Left - LVEA equipment arrangement dwg	2	16APR96 A	17APR96 A	100
144L	WAES Left - LVEA equipment arrangement dwg	2	16APR96 A	17APR96 A	100
133DL	WAMS Left - Equipment detail dwgs	3	16APR96 A	18APR96 A	100
144DL	WAES Left - Equipment detail dwgs	3	16APR96 A	18APR96 A	100
120D	WACS - Equipment detail dwgs	40	26FEB96 A	19APR96 A	100
118A	PSI to receive revised WA bldg dwgs for comments	1	22APR96 A	22APR96 A	100
146L	WAES Left - Piping general arrangement dwgs	5	16APR96 A	22APR96 A	100
127	WACS - Instr/controls plan	5	09APR96 A	24APR96 A	100
128	WACS - Instr/elect details	4	17APR96 A	24APR96 A	100
130	WACS - Ion pump controller cabinet layout	10	25MAR96 A	24APR96 A	100
138	WAMS - Instr/controls plan	5	09APR96 A	24APR96 A	100
139	WAMS - Instr/elect details	4	17APR96 A	24APR96 A	100
141	WAMS - Ion pump controller cabinet layout	10	25MAR96 A	24APR96 A	100



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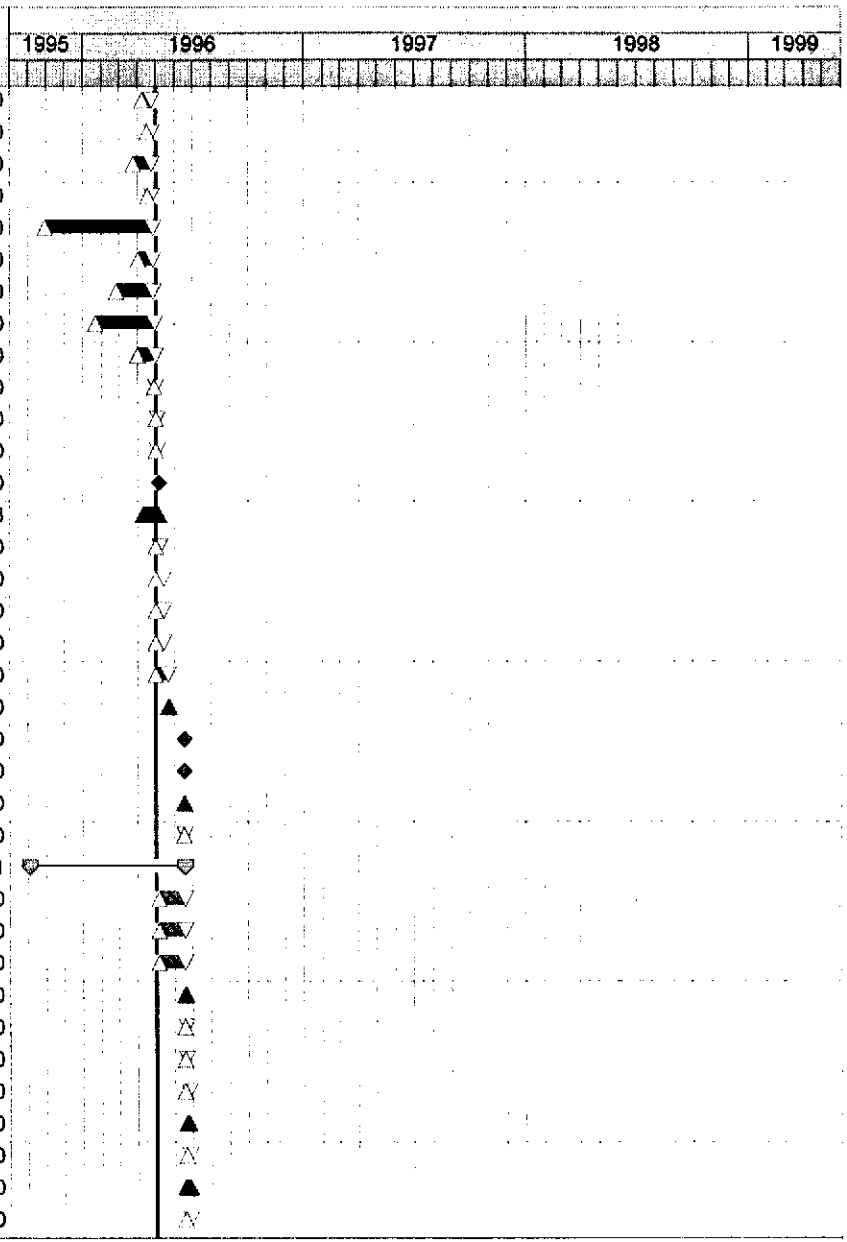
Layout Early finish sort

Date	Revision	Checked	Approved
03MAY96	Final Design Pkg	PFH	REB

Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
149	WAES - Instr/controls plan	5	09APR96 A	24APR96 A	100
150	WAES - Instr/elect details	4	17APR96 A	24APR96 A	100
152	WAES - Ion pump controller cabinet layout	10	25MAR96 A	24APR96 A	100
135L	WAMS Left - Piping general arrangement dwgs	5	18APR96 A	24APR96 A	100
108	Prep shock, vibration, & noise model (CAA)	90	30OCT95 A	26APR96 A	100
110	Failure mode and effect analysis	9	02APR96 A	26APR96 A	100
122	WACS - Piping general arrangement design	40	26FEB96 A	26APR96 A	100
113	Prepare commissioning and testing plans	20	22JAN96 A	29APR96 A	100
112	Prepare an installation spec and procedures	15	01APR96 A	30APR96 A	100
125	WACS - Pipe & misc structural supports	2	29APR96 A	30APR96 A	100
142	WAMS - Instr/elect cable schedules	3	01MAY96	03MAY96	0
153	WAES - Instr/elect cable schedules	3	01MAY96	03MAY96	0
6	Submit Final Design for Approval (CDRL 03)	0		06MAY96	0
197	Prepare & Issue Final Design Package Draft	15	10APR96 A	06MAY96	73
131	WACS - Instr/elect cable schedules	5	01MAY96	07MAY96	0
121	WACS - Anchor bolt design	10	01MAY96	14MAY96	0
134	WAMS - Anchor bolt design	10	01MAY96	14MAY96	0
145	WAES - Anchor bolt design	10	01MAY96	14MAY96	0
115	Prep Vacuum Eqt Maintenance Requirements	15	01MAY96	21MAY96	0
196	Conduct final design review with LIGO	2	22MAY96 *	23MAY96	0
7	Approval of Final Design by LIGO (CDRL 03)	0		17JUN96	0
8	Full Release for Fabrication and Procurement	0		17JUN96	0
198	Receive LIGO Approval of Final Design Package	1	17JUN96	17JUN96	0
118B	PSI to receive LA bldg dwgs for comments	1	17JUN96 *	17JUN96	0
119	Washington Corner Station Overall Design	177 *	04OCT95 A	18JUN96	81
123	WACS - Piping isometrics & cut sheets	30	07MAY96	18JUN96	0
136	WAMS Right - Piping isometrics & cut sheets	30	07MAY96	18JUN96	0
147	WAES Right - Piping isometrics & cut sheets	30	07MAY96	18JUN96	0
166	LAES Right - LVEA equipment arrangement dwgs	3	18JUN96	20JUN96	0
170	LAES - Cable tray layout & power plan	3	18JUN96	20JUN96	0
171	LAES - Instr/controls plan	3	18JUN96	20JUN96	0
159	LACS - Cable tray layout & power plan	5	18JUN96	24JUN96	0
166L	LAES Left - LVEA equipment arrangement dwgs	2	21JUN96	24JUN96	0
172	LAES - Instr/elect details	3	21JUN96	25JUN96	0
155	LACS - LVEA equipment arrangement dwgs	7	18JUN96	26JUN96	0
160	LACS - Instr/controls plan	7	18JUN96	26JUN96	0



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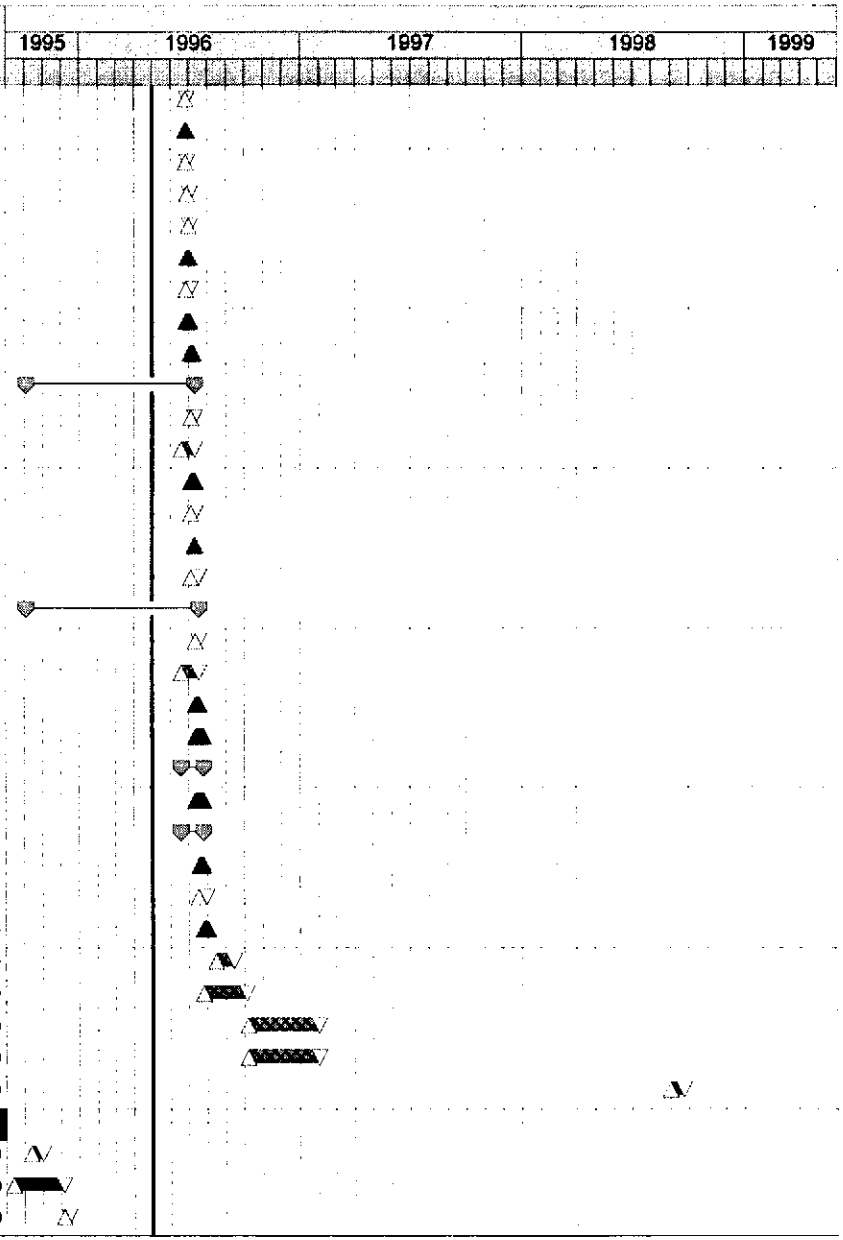
Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
174	LAES - Ion pump controller cabinet layout	2	26JUN96	27JUN96	0
166D	LAES Right - Equipment detail dwgs	3	25JUN96	27JUN96	0
173	LAES - Interface wiring design	3	26JUN96	28JUN96	0
167	LAES - Anchor bolt design	3	28JUN96	02JUL96	0
175	LAES - Instr/elect cable schedules	2	01JUL96	02JUL96	0
166DL	LAES Left - Equipment detail dwgs	3	28JUN96	02JUL96	0
161	LACS - Instr/elect details	5	27JUN96	03JUL96	0
155D	LACS - Equipment detail dwgs	5	27JUN96	03JUL96	0
168	LAES Right - Piping general arrangement dwgs	3	03JUL96	08JUL96	0
132	Washington Mid-Station Overall Design	192 *	04OCT95 A	10JUL96	75
163	LACS - Ion pump controller cabinet layout	4	05JUL96	10JUL96	0
136L	WAMS Left - Piping isometrics & cut sheets	15	19JUN96	10JUL96	0
157	LACS - Piping general arrangement design	5	05JUL96	11JUL96	0
162	LACS - Interface wiring design	5	05JUL96	11JUL96	0
168L	LAES Left - Piping general arrangement dwgs	3	09JUL96	11JUL96	0
156	LACS - Anchor bolt design	8	05JUL96	16JUL96	0
143	Washington End Station Overall Design	197 *	04OCT95 A	17JUL96	73
164	LACS - Instr/elect cable schedules	4	12JUL96	17JUL96	0
147L	WAES Left - Piping isometrics & cut sheets	20	19JUN96	17JUL96	0
169	LAES Right - Piping isometrics & cut sheets	5	12JUL96	18JUL96	0
114	Prepare packing lists	10	12JUL96	25JUL96	0
154	Louisiana Corner Station Overall Design	27 *	18JUN96	25JUL96	0
158	LACS - Piping isometrics	10	12JUL96	25JUL96	0
165	Louisiana End Station Overall Design	27 *	18JUN96	25JUL96	0
169L	LAES Left - Piping isometrics & cut sheets	5	19JUL96	25JUL96	0
116	CAA finalize model & design requirements	10	17JUL96	30JUL96	0
199	Final Issue of Final Design Package	5	26JUL96	01AUG96	0
181	Prepare cut sheets from piping isometrics	20	16AUG96	13SEP96	0
180	Procure piping materials	50	26JUL96	04OCT96	0
182	Fab/deliver WA pipe spools	80	07OCT96	31JAN97	0
183	Fab/deliver LA pipe spools	80	07OCT96	31JAN97	0
103	P&ID's - Issue As-Built	15	01SEP98 *	22SEP98	0
VACE - Vacuum Envelope					
279	Conduct a plasma welding investigation	10	13OCT95 A	31OCT95 A	100
202	Design BSC Vessels	45	13SEP95 A	05DEC95 A	100
291	Order Prototype BSC Flange Forgings	5	06DEC95 A	13DEC95 A	100



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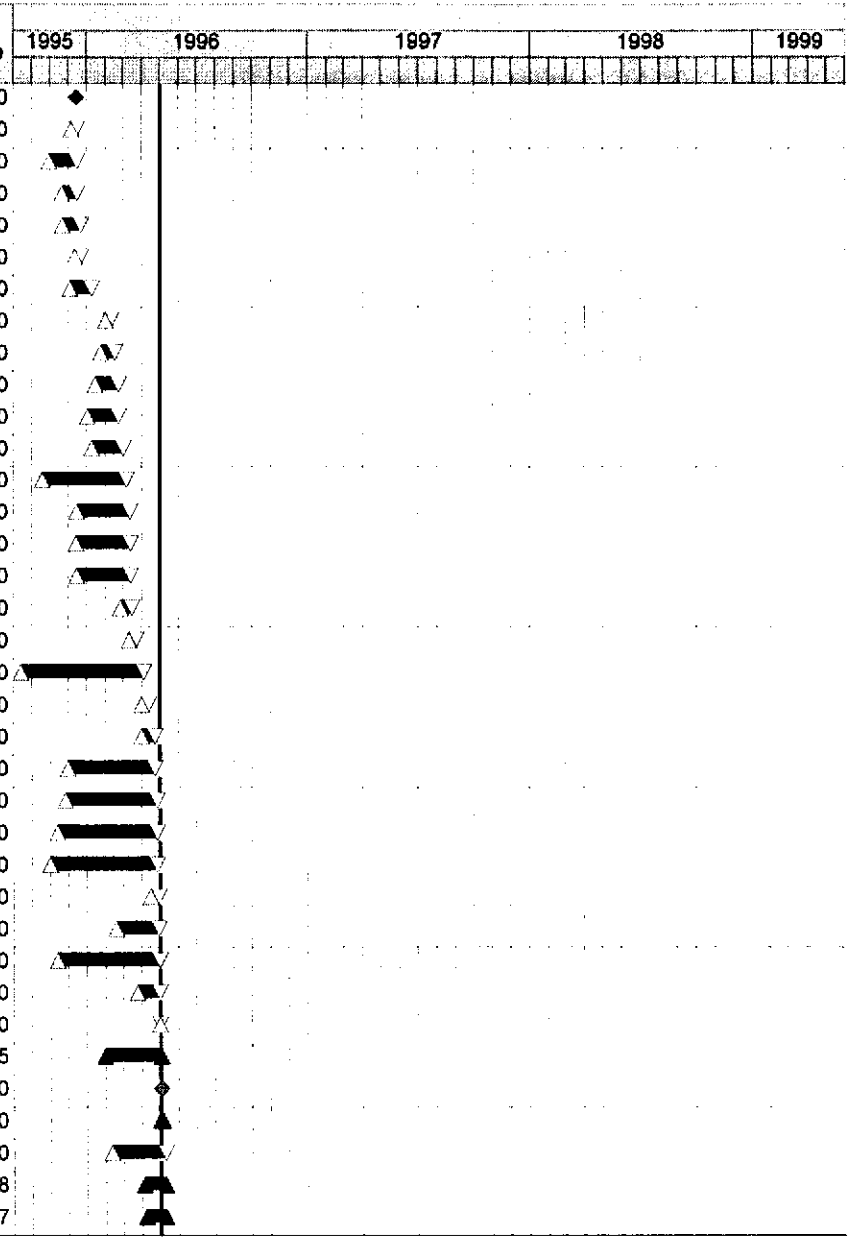
Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
16	Order First Article Material	0		14DEC95 A	100
293	Order Prototype BSC shell, head, & nozzle mat'l	5	06DEC95 A	14DEC95 A	100
214	Prepare a vessel fabrication specification	20	30OCT95 A	15DEC95 A	100
280	Procure a plasma welding machine	20	20NOV95 A	15DEC95 A	100
257	CO # 6 - Additional bracing on BSC chamber	15	21NOV95 A	21DEC95 A	100
258	CO #10 -Increase pumping surface clear aperature	9	12DEC95 A	21DEC95 A	100
260A	10" Benchscale Vessel - System Engineering	20	04DEC95 A	08JAN96 A	100
224	Bellows expansion joints - Prepare Purchase Spec	10	01FEB96 A	09FEB96 A	100
284	Procure cleaning equipment	20	24JAN96 A	16FEB96 A	100
222	Develop welding procedures	10	15JAN96 A	22FEB96 A	100
281	Qualify Welding Procedure for Plasma Welding	10	02JAN96 A	22FEB96 A	100
260B	10" Benchscale Vessel - Procure materials	30	09JAN96 A	01MAR96 A	100
262	CO #13 - BSC internal floor loading requirements	20	19OCT95 A	06MAR96 A	100
294	Fab & del Prototype BSC head, shell, nozzle matl	50	15DEC95 A	12MAR96 A	100
292	Fab and deliver Prototype BSC flange forgings	53	14DEC95 A	13MAR96 A	100
298	Order mat'l for test/ship covers for prototype	40	15DEC95 A	13MAR96 A	100
203	Design BSC chamber fab fixtures	15	26FEB96 A	15MAR96 A	100
260C	10" Benchscale Vessel - Fabricate vessel	10	11MAR96 A	22MAR96 A	100
201	Design HAM Vessels	96	13SEP95 A	04APR96 A	100
285	Conduct materials testing program	10	01APR96 A	12APR96 A	100
219	Develop a bakeout procedure	15	01APR96 A	22APR96 A	100
223	Design and specify test/shipping covers	25	01DEC95 A	22APR96 A	100
272	Design long 80K cryopump shroud	20	27NOV95 A	26APR96 A	100
273	Design short 80K cryopump vessel	50	13NOV95 A	26APR96 A	100
274	Design short 80K cryopump shroud	60	01NOV95 A	26APR96 A	100
215	Prepare a final cleaning procedure	10	16APR96 A	29APR96 A	100
217	Develop a leak test procedure	20	19FEB96 A	29APR96 A	100
204	Design long 80K cryopump vessels	30	13NOV95 A	30APR96 A	100
260E	10" Benchscale Vessel - Order matl/fab new sectn	15	25MAR96 A	30APR96 A	100
206	WACS - Prepare skid/pre-assy details	20	01MAY96	01MAY96	100
235	SS Vessel Mat'l - Bid & purchase total quantity	20	31JAN96 A	03MAY96	85
9C	Place PO for SS vessel material (main release)	0		03MAY96	0
295A	Prototype BSC Fab - Roll/weld shell (outside)	4	01MAY96	06MAY96	0
225	Bellows expansion joints - Bid/Purchase 69 items	20	12FEB96 A	10MAY96	60
240	Flange Forgings - Bid & purchase total quantity	25	05APR96 A	10MAY96	68
297	Fabricate chamber fab fixtures	15	08APR96 A	10MAY96	47



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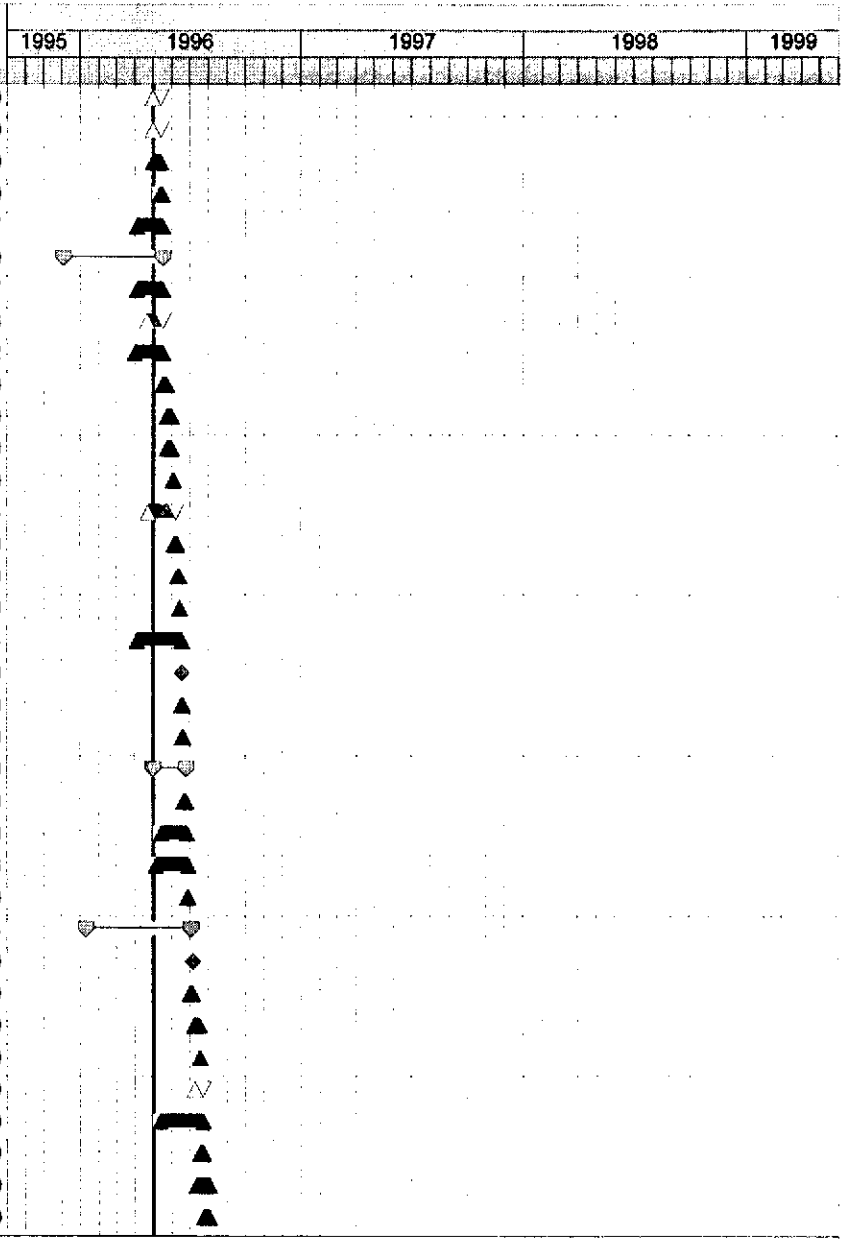
03MAY96	Final Design Pkg	PFH	REB

Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
207	WAMS - Prepare skid/pre-assy details	10	01MAY96	14MAY96	0
208	WAES - Prepare skid/pre-assy details	10	01MAY96	14MAY96	0
289	Short 80K Cryopump - Procure shroud mat'l (1)	10	01MAY96	14MAY96	0
295B	Prototype BSC Fab - Weld on heads (outside)	4	13MAY96	16MAY96	0
239	Vessel Heads - Bid & purchase total quantity	30	05APR96 A	17MAY96	57
260	10" Benchscale Vessel Program	116 *	04DEC95 A	17MAY96	89
266	1st Article HAM - Bid & award fabrication	30	05APR96 A	17MAY96	57
286	Conduct a viton investigation	15	22APR96 A	17MAY96	13
260D	10" Benchscale Vessel - Conduct test program	34	01APR96 A	17MAY96	62
295C	Prototype BSC Fab - Cut/weld nozzle necks	5	17MAY96	23MAY96	0
295D	Prototype BSC Fab - Machine flanges/blinds (out)	5	24MAY96	31MAY96	0
295E	Prototype BSC Fab - Stress relieve (outside)	5	24MAY96	31MAY96	0
295F	Prototype BSC Fab - Square off nozzles (outside)	2	03JUN96	04JUN96	0
226	Bellows expansion joints - receive/review v/dwgs	25	23APR96 A	07JUN96	24
295G	Prototype BSC Fab - Weld on flanges	4	05JUN96	10JUN96	0
295H	Prototype BSC Fab - Install welded attachments	3	11JUN96	13JUN96	0
295I	Prototype BSC Fab - Install internal floor suppt	1	14JUN96	14JUN96	0
265	1st Article HAM - Procure fab materials	50	05APR96 A	17JUN96	34
10	Begin Vessel Fabrication - Washington	0	18JUN96		0
295J	Prototype BSC Fab - Install annulus tubing & pmp	3	17JUN96	19JUN96	0
242	Release vessel material for shipment	3	18JUN96	20JUN96	0
295	Fabricate Prototype BSC Vessel	38 *	01MAY96	24JUN96	0
295K	Prototype BSC Fab - Clean chamber to spec	3	20JUN96	24JUN96	0
290	Short 80K Cryopump - Fab shroud for prototype	30	15MAY96	26JUN96	0
237	SS Vessel Mat'l - Fab & deliver 1st shipment	40	06MAY96	28JUN96	3
296A	Start prototype testing program	2	27JUN96	28JUN96	0
205	Design adapters and spool pieces	121 *	11JAN96 A	02JUL96	64
12A	Receipt of 1/3 of SS vessel material	0		05JUL96	0
296B	Prototype Test - Rough leak check	4	01JUL96	05JUL96	0
296C	Prototype Test - Bakeout	7	08JUL96	16JUL96	0
296D	Prototype Test - Perform dimensional check	1	17JUL96	17JUL96	0
210	LAES - Prepare skid/pre-assy details	10	09JUL96	22JUL96	0
241	Flange Forgings - Fab & deliver 1st shipment	50	13MAY96	23JUL96	0
296E	Prototype Test - Final leak check	4	18JUL96	23JUL96	0
209	LACS - Prepare skid/pre-assy details	15	12JUL96	01AUG96	0
296F	Prototype Test - Ultimate pressure test	7	24JUL96	01AUG96	0



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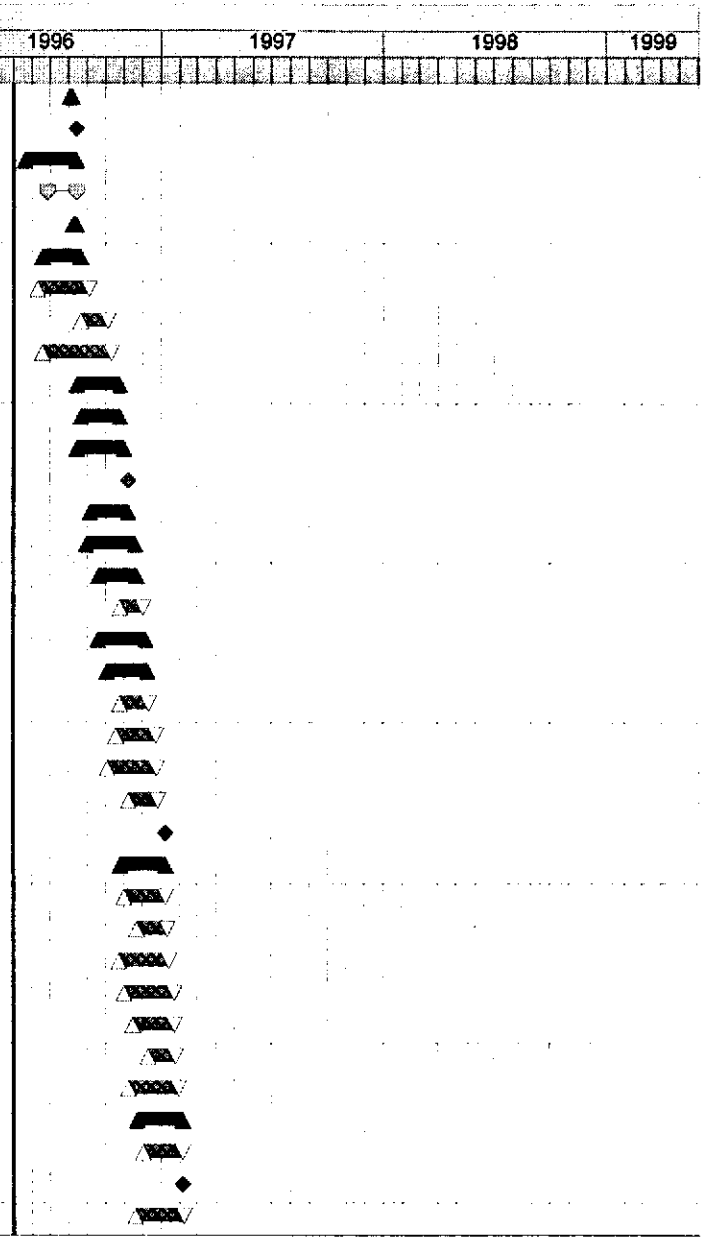
Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
296G	Prototype Test - Install cryopump shroud	4	02AUG96	07AUG96	0
19	Complete Prototype Vessel Tests	0		13AUG96	0
243	Vessel Heads - Fab & deliver 1st shipment	60	20MAY96	13AUG96	0
296	Test program for Prototype vessel	33 *	27JUN96	13AUG96	0
296H	Prototype Test - Vibration/boiloff test	4	08AUG96	13AUG96	0
WHAM01	WHAM1 - Outside fabrication	45	18JUN96	20AUG96	0
227	Bellows expansion joints - Fab & ship 69 items	60	10JUN96	03SEP96	0
WHAM01	WHAM01 - Final fab/clean/test/prep for ship	32	21AUG96	04OCT96	0
229	Order mat'l & fab test/shipping covers	80	18JUN96	09OCT96	0
WCP1F	WCP1 - Fabricate long 80k cryopump	50	14AUG96	24OCT96	0
WHAM12	WHAM12 - Outside fabrication	45	21AUG96	24OCT96	0
WBSC04	WBSC4 - Outside fabrication	55	14AUG96	31OCT96	0
12B	Receipt of 2/3 of SS vessel material	0		07NOV96	0
WHAM11	WHAM11 - Outside fabrication	45	05SEP96	07NOV96	0
WBSC07	WBSC7 - Outside fabrication	55	30AUG96	18NOV96	0
WHAM10	WHAM10 - Outside fabrication	45	19SEP96	21NOV96	0
WCP1T	WCP1 - Final clean/test/prep for ship long pump	25	25OCT96	02DEC96	0
WBSC08	WBSC8 - Outside fabrication	55	18SEP96	06DEC96	0
WHAM07	WHAM7 - Outside fabrication	45	03OCT96	09DEC96	0
WHAM12	WHAM12 - Final fab/clean/test/prep for ship	32	25OCT96	11DEC96	0
WHAM08	WHAM8 - Outside fabrication	45	18OCT96	23DEC96	0
WBSC01	WBSC1 - Outside fabrication	55	04OCT96	24DEC96	0
WHAM11	WHAM11 - Final fab/clean/test/prep for ship	32	08NOV96	26DEC96	0
13A	Complete fab on 1/3 of WA vessels	0		08JAN97	0
WCP2F	WCP2 - Fabricate long 80K cryopump	50	25OCT96	08JAN97	0
WHAM09	WHAM9 - Outside fabrication	45	01NOV96	08JAN97	0
WHAM10	WHAM10 - Final fab/clean/test/prep for ship	32	22NOV96	10JAN97	0
WBSC03	WBSC3 - Outside fabrication	55	23OCT96	13JAN97	0
WBSC04	WBSC4 - Final fab/clean/test/prep for ship	55	01NOV96	22JAN97	0
WHAM02	WHAM2 - Outside fabrication	45	15NOV96	22JAN97	0
WHAM07	WHAM7 - Final fab/clean/test/prep for ship	32	10DEC96	24JAN97	0
WBSC02	WBSC2 - Outside fabrication	55	08NOV96	29JAN97	0
WCP3F	WCP3F - Fabricate short 80K cryopump	50	22NOV96	05FEB97	0
WHAM03	WHAM3 - Outside fabrication	45	03DEC96	05FEB97	0
11	Begin Vessel Fabrication - Louisiana	0	06FEB97		0
WBSC07	WBSC7 - Final fab/clean/test/prep for ship	55	19NOV96	07FEB97	0



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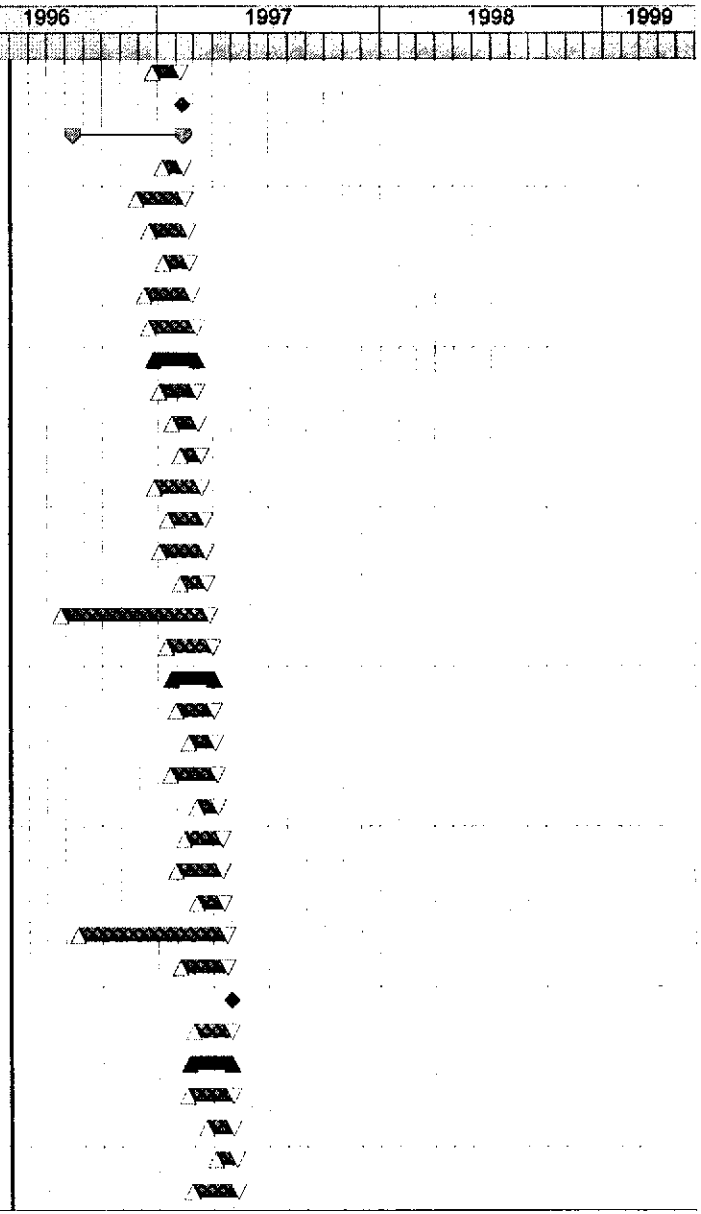
WHAM08	WHAM8 - Final fab/clean/test/prep for ship	32	24DEC96	07FEB97	0
12C	Receipt of All SS vessel material	0		10FEB97	0
250	Long 80K Cryopumps - Fab & test WA pumps (2)	125 *	14AUG96	12FEB97	0
WCP2T	WCP2 - Final clean/test/prep to ship long pump	25	09JAN97	12FEB97	0
WBSC06	WBSC6 - Outside fabrication	55	26NOV96	14FEB97	0
WHAM06	WHAM6 - Outside fabrication	45	17DEC96	19FEB97	0
WHAM09	WHAM9 - Final fab/clean/test/prep for ship	32	09JAN97	21FEB97	0
WBSC08	WBSC8 - Final fab/clean/test/prep for ship	55	09DEC96	25FEB97	0
WBSC10	WBSC10 - Outside fabrication	55	16DEC96	04MAR97	0
WCP4F	WCP4 - Fabricate short 80K cryopump	50	24DEC96	05MAR97	0
WHAM05	WHAM5 - Outside fabrication	45	02JAN97	05MAR97	0
WHAM02	WHAM2 - Final fab/clean/test/prep for ship	32	23JAN97	07MAR97	0
WCP3T	WCP3 - Final clean/test/prep to ship short pump	25	06FEB97	12MAR97	0
WBSC01	WBSC1 - Final fab/clean/test/prep for ship	55	26DEC96	13MAR97	0
WHAM04	WHAM4 - Outside fabrication	45	16JAN97	19MAR97	0
WBSC05	WBSC5 - Outside fabrication	55	03JAN97	20MAR97	0
WHAM03	WHAM3 - Final fab/clean/test/prep for ship	32	06FEB97	21MAR97	0
248	WA Beam Tube Manifolds / Spools / Adapters - Fab	170	24JUL96	26MAR97	0
WBSC03	WBSC3 - Final fab/clean/test/prep for ship	55	14JAN97	31MAR97	0
WCP7F	WCP7 - Fabricate short 80K cryopump	50	23JAN97	02APR97	0
WHAM13	WHAM13 - Outside fabrication	45	30JAN97	02APR97	0
WHAM06	WHAM6 - Final fab/clean/test/prep for ship	32	20FEB97	04APR97	0
WBSC09	WBSC9 - Outside fabrication	55	21JAN97	07APR97	0
WCP4T	WCP4 - Final clean/test/prep to ship short pump	25	06MAR97	09APR97	0
LHAM01	LHAM1 - Outside fabrication	45	13FEB97	16APR97	0
WBSC02	WBSC2 - Final fab/clean/test/prep for ship	55	30JAN97	16APR97	0
WHAM05	WHAM5 - Final fab/clean/test/prep for ship	32	06MAR97	18APR97	0
249	WA BTM/Spools/Adapters - Clean/test/prep to ship	170	21AUG96	23APR97	0
LBSC01F	LBSC1 - Outside fabrication	55	06FEB97	23APR97	0
13B	Complete fab on 2/3 of WA vessels	0		30APR97	0
LHAM02	LHAM2 - Outside fabrication	45	27FEB97	30APR97	0
WCP5F	WCP5 - Fabricate short 80K cryopump	50	20FEB97	30APR97	0
WBSC06	WBSC6 - Final fab/clean/test/prep for ship	55	17FEB97	02MAY97	0
WHAM04	WHAM4 - Final fab/clean/test/prep for ship	32	20MAR97	02MAY97	0
WCP7T	WCP7 - Final clean/test/prep to ship short pump	25	03APR97	07MAY97	0
LBSC03F	LBSC3 - Outside fabrication	55	24FEB97	09MAY97	0



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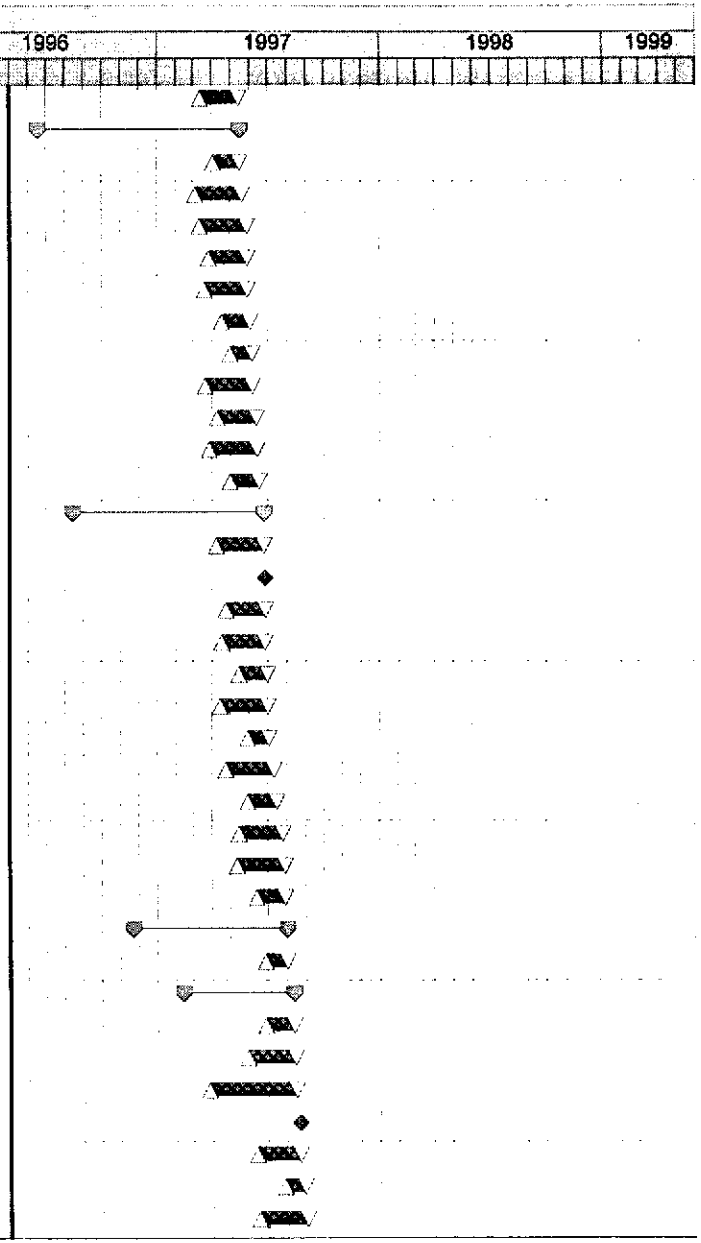
Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
LHAM03	LHAM3 - Outside fabrication	45	13MAR97	14MAY97	0
246	HAM's - Fab and test WA vessels (12)	232 *	18JUN96	16MAY97	0
WHAM13	WHAM13 - Final fab/clean/test/prep for ship	32	03APR97	16MAY97	0
WBSC10	WBSC10 - Final fab/clean/test/prep for ship	55	05MAR97	20MAY97	0
LBSC02F	LBSC2 - Outside fabrication	55	12MAR97	28MAY97	0
LHAM06	LHAM6 - Outside fabrication	45	27MAR97	29MAY97	0
WCP6F	WCP6 - Fabricate short 80K cryopump	50	20MAR97	29MAY97	0
LHAM01	LHAM1 - Final fab/clean/test/prep for ship	32	17APR97	02JUN97	0
WCP5T	WCP5 - Final clean/test/prep to ship short pump	25	01MAY97	05JUN97	0
WBSC05	WBSC5 - Final fab/clean/test/prep for ship	55	21MAR97	06JUN97	0
LHAM05	LHAM5 - Outside fabrication	45	10APR97	12JUN97	0
LBSC05F	LBSC5 - Outside fabrication	55	28MAR97	13JUN97	0
LHAM02	LHAM2 - Final fab/clean/test/prep for ship	32	01MAY97	16JUN97	0
244	BSC's - Fab and test WA vessels (10)	218 *	14AUG96	24JUN97	0
WBSC09	WBSC9 - Final fab/clean/test/prep for ship	55	08APR97	24JUN97	0
13C	Complete fab of all WA vessels	0		26JUN97	0
LHAM04	LHAM4 - Outside fabrication	45	24APR97	26JUN97	0
WCP8F	WCP8 - Fabricate short 80K cryopump	50	17APR97	26JUN97	0
LHAM03	LHAM3 - Final fab/clean/test/prep for ship	32	15MAY97	30JUN97	0
LBSC04F	LBSC4 - Outside fabrication	55	15APR97	01JUL97	0
WCP6T	WCP6 - Final clean/test/prep to ship short pump	25	30MAY97	03JUL97	0
LBSC01T	LBSC1 - Final fab/clean/test/prep for ship	55	24APR97	11JUL97	0
LHAM06	LHAM6 - Final fab/clean/test/prep for ship	32	30MAY97	15JUL97	0
LCP1F	LCP1 - Fabricate long 80K cryopump	50	15MAY97	25JUL97	0
LBSC03T	LBSC3 - Final fab/clean/test/prep for ship	55	12MAY97	29JUL97	0
LHAM05	LHAM5 - Final fab/clean/test/prep for ship	32	13JUN97	29JUL97	0
252	Short 80K Cryopumps - Fab & test WA pumps (6)	175 *	22NOV96	01AUG97	0
WCP8T	WCP8 - Final clean/test/prep to ship short pump	25	27JUN97	01AUG97	0
247	HAM's - Fab and test LA vessels (6)	127 *	13FEB97	12AUG97	0
LHAM04	LHAM4 - Final fab/clean/test/prep for ship	32	27JUN97	12AUG97	0
LBSC02T	LBSC2 - Final fab/clean/test/prep for ship	55	29MAY97	14AUG97	0
254	LA Beam Tube Manifolds / Spools / Adapters - Fab	100	27MAR97	15AUG97	0
14A	Complete fab on 1/3 of LA vessels	0		22AUG97	0
LCP2F	LCP2 - Fabricate long 80K cryopump	50	13JUN97	22AUG97	0
LCP1T	LCP1 - Final clean/test/prep to ship long pump	25	28JUL97	29AUG97	0
LBSC05T	LBSC5 - Final fab/clean/test/prep for ship	55	16JUN97	02SEP97	0



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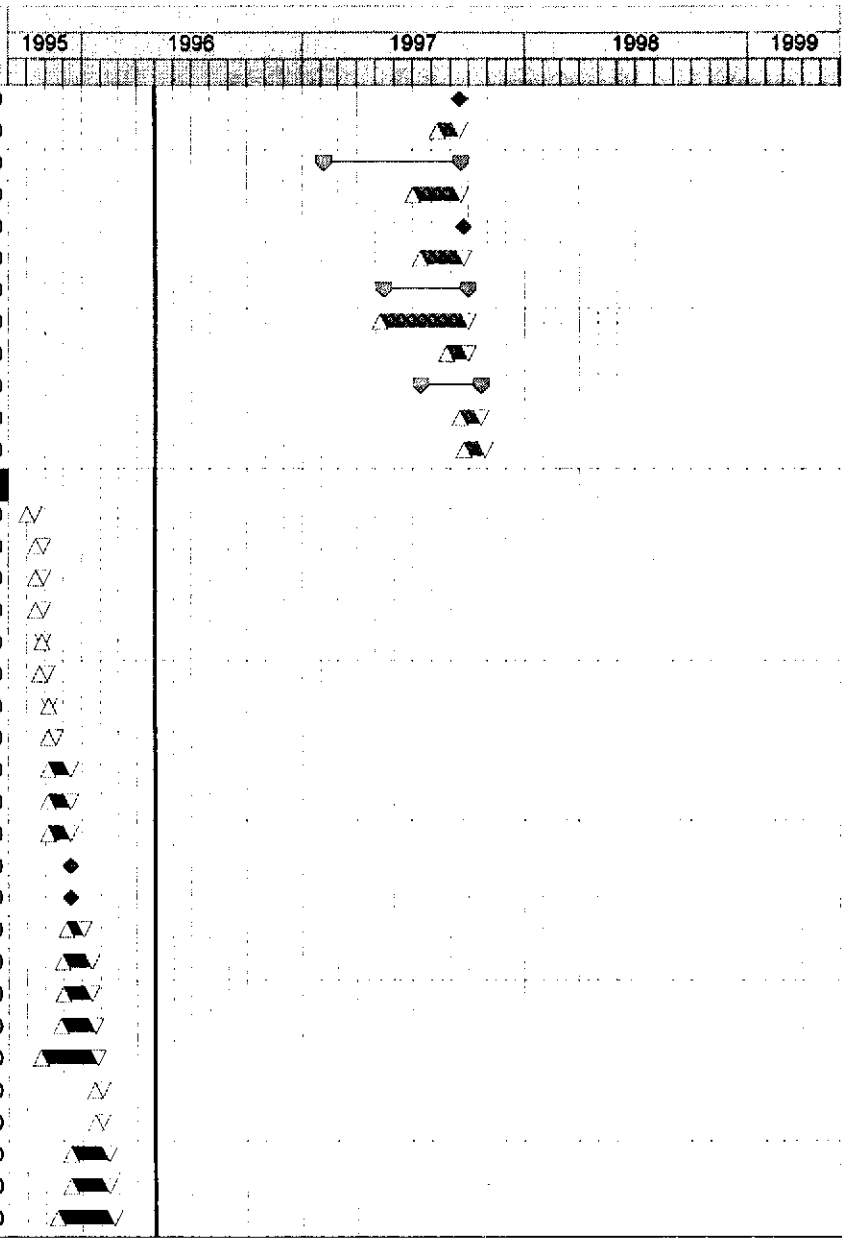
Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
14C	Complete fab of all LA vessels	0		15SEP97	0
LCP4F	LCP4 - Fabricate short 80K cryopump	25	11AUG97	15SEP97	0
245	BSC's - Fab and test LA vessels (5)	158 *	06FEB97	18SEP97	0
LBSC04T	LBSC4 - Final fab/clean/test/prep for ship	55	02JUL97	18SEP97	0
14B	Complete fab on 2/3 of LA vessels	0		22SEP97	0
LCP3F	LCP3 - Fabricate short 80K cryopump	50	14JUL97	22SEP97	0
251	Long 80K Cryopumps - Fab & test LA pumps (2)	95 *	15MAY97	29SEP97	0
255	LA BTM/Spools/Adapters - Clean/test/prep to ship	100	08MAY97	29SEP97	0
LCP2T	LCP2 - Final clean/test/prep to ship long pump	25	25AUG97	29SEP97	0
253	Short 80K Cryopumps - Fab & test LA pumps (2)	70 *	14JUL97	20OCT97	0
LCP4T	LCP4 - Final clean/test/prep to ship short pump	25	16SEP97	20OCT97	0
LCP3T	LCP3 - Final clean/test/prep to ship short pump	25	23SEP97	27OCT97	0
PUMP - Pumping System					
342	Perform cryopump process calculations	10	02OCT95 A	13OCT95 A	100
306	Main Roughing Pump - Issue specification	10	16OCT95 A	27OCT95 A	100
311	Main Turbo Pumps - Issue specification	10	16OCT95 A	27OCT95 A	100
318	Aux Turbo Pumps - Issue specifications	5	16OCT95 A	27OCT95 A	100
398	Prep/iss draft Beam Tube deliverable pkg to LIGO	3	27OCT95 A	27OCT95 A	100
301	Perform vacuum/backfill calculations	10	23OCT95 A	03NOV95 A	100
399	Review Beam Tube Deliverable documents with LIGO	1	07NOV95 A	07NOV95 A	100
327	All Ion Pumps - Issue specification	20	06NOV95 A	17NOV95 A	100
307	Main Roughing Pumps - Finalize bid & purchase (4	15	06NOV95 A	12DEC95 A	100
312	Main Turbo Pumps - Finalize bid & purchase (10)	15	06NOV95 A	12DEC95 A	100
319	Aux Turbo Pumps - Finalize bid & purchase (10)	15	06NOV95 A	12DEC95 A	100
9A	Place PO for Turbomolecular Pumps	0		12DEC95 A	100
9F	Place PO for Roughing Pumps	0		12DEC95 A	100
302	Develop line list and line sizing	30	06DEC95 A	03JAN96 A	100
364	C.O. #8 - Foundation design for LN2 dewars	11	30NOV95 A	16JAN96 A	100
400	Issue final Beam Tube deliverable pkg to LIGO	20	01DEC95 A	16JAN96 A	100
303	Develop piping specifications	13	27NOV95 A	22JAN96 A	100
362	C.O. #3 - Design/fab/install CS pipe bridge	20	24OCT95 A	26JAN96 A	100
343	LN2 System - Perform detail design	25	22JAN96 A	02FEB96 A	100
368	CO #15 - Add 8" port to main ion pumps (future)	5	23JAN96 A	02FEB96 A	100
313	Main Turbo Pumps - Recieve/review v/dwgs	30	13DEC95 A	13FEB96 A	100
320	Aux Turbo Pumps - Receive/review v/dwgs	30	13DEC95 A	13FEB96 A	100
328	Main Ion Pumps - Bid and purchase (18)	7	20NOV95 A	22FEB96 A	100



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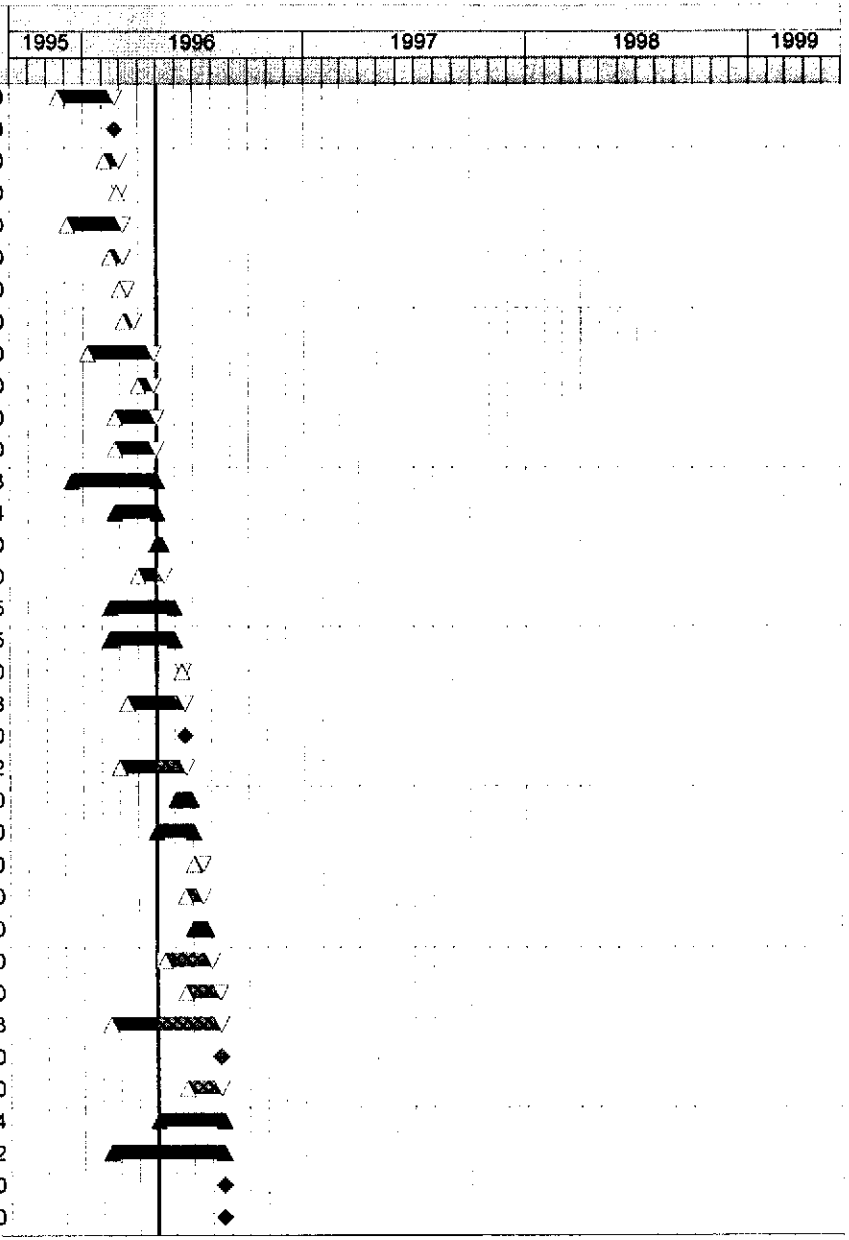
Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
333	Annuli Ion Pumps - Bid & purchase (43lg & 32sm)	4	20NOV95 A	22FEB96 A	100
9E	Place PO for Ion Pumps	0		22FEB96 A	100
344	LN2 System Components - Issue specifications	10	05FEB96 A	29FEB96 A	100
341	Design Main Ion Pump supports	20	26FEB96 A	01MAR96 A	100
366	CO #12 - Add freon cooling sys to BTD pump carts	25	05DEC95 A	06MAR96 A	100
370	CO #17 - Vacuum pump cart modifications	15	14FEB96 A	06MAR96 A	100
350	LN2 Dewars - Prepare specification	5	01MAR96 A	13MAR96 A	100
380	Freon Cooling Systems - Bid & purchase (6)	1	07MAR96 A	25MAR96 A	100
305	Prepare special material specifications	20	08JAN96 A	26APR96 A	100
355	VJ Lines - Prepare specification	10	01APR96 A	26APR96 A	100
329	Main Ion Pumps - Recieve/review v/dwgs	40	23FEB96 A	30APR96 A	100
334	Annuli Ion Pumps - Receive and review v/dwgs	40	23FEB96 A	30APR96 A	100
308	Main Roughing Pumps - Receive/review v/dwgs	30	13DEC95 A	02MAY96	93
378	Prototype BSC Test Ion Pumps - Fab & deliver (2)	50	22FEB96 A	03MAY96	94
335	Annuli Ion Pumps - Fab/deliver to Westboro (2)	8	01MAY96	10MAY96	0
381	Freon Cooling Systems - Receive & review v/dwgs	20	01APR96 A	14MAY96	50
316	Main Turbo Pumps - Fab/deliver to Westboro (2)	40	14FEB96 A	31MAY96	45
323	Aux Turbo Pumps - Fab/deliver to Westboro (2)	40	14FEB96 A	31MAY96	45
330T	Main Ion Pumps - Performance test for 1st pump	2	13JUN96	14JUN96	0
351	LN2 Dewars - Bid and purchase (12)	40	14MAR96 A	17JUN96	68
9H	Place PO for LN2 Dewars	0		17JUN96	0
345	LN2 System Components - Bid and purchase	60	01MAR96 A	19JUN96	42
338	Gather turbomolecular pump vibration data (CAA)	20	03JUN96	28JUN96	0
330	Main Ion Pumps - Fab/deliver to Westboro (1)	43	01MAY96	01JUL96	0
339	Gather Main Ion Pmp controls vibration data (CAA	10	02JUL96	16JUL96	0
356	VJ Lines - Assemble isos, bid, and purchase	20	18JUN96	16JUL96	0
340	Design main turbo pump cart vib dampeners	15	01JUL96	22JUL96	0
382	Freon Cooling Systems - Fab/deliver to WA (6)	54	15MAY96	31JUL96	0
352	LN2 Dewars - Receive & review vendor drawings	40	18JUN96	13AUG96	0
321	Aux Turbo Pumps - Fab/deliver to WA BTC (2)	110	14FEB96 A	14AUG96	33
15E	WA BTC Auxiliary Turbo Carts At Site	0		14AUG96	0
346	LN2 System Components - Rec/rvw v/dwgs	40	20JUN96	15AUG96	0
309	Main Roughing Pumps - Fab/deliver to WA BTC (2)	75	03MAY96	19AUG96	14
314	Main Turbo Pumps - Fab/deliver to WA BTC (4)	95	14FEB96 A	19AUG96	22
15A	WA BTC Main Roughing Pumps At Site	0		19AUG96	0
15C	WA BTC Turbo Molecular Pumps At Site	0		19AUG96	0



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Date	Revision	Checked	Approved
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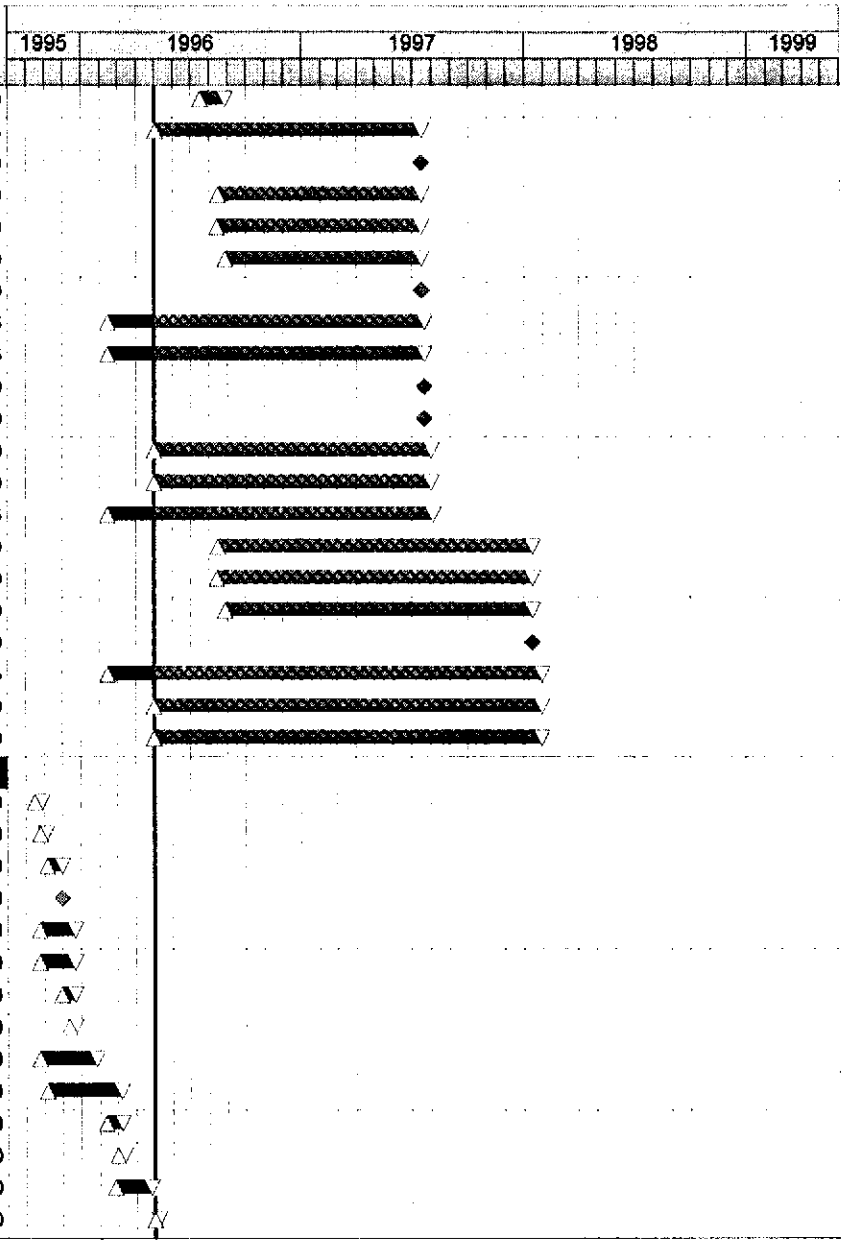
Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
357	VJ Lines - Receive and review vendor drawings	30	17JUL96	27AUG96	0
310	Main Roughing Pumps - Fab/deliver to LA BTC (2)	311	03MAY96	15JUL97	3
15B	LA BTC Main Roughing Pumps At Site	0		15JUL97	0
347	LN2 System Components - Fab/deliver to WA site	231	16AUG96	16JUL97	0
353	LN2 Dewars - Fab/deliver to WA site (8)	233	14AUG96	16JUL97	0
358	VJ Lines - Fab/deliver WA site lines (8 sets)	223	28AUG96	16JUL97	0
17F	WA LN2 Dewars Delivery At Site	0		16JUL97	0
315	Main Turbo Pumps - Fab/deliver to LA BTC (4)	330	14FEB96 A	21JUL97	6
322	Aux Turbo Pumps - Fab/deliver to LA BTC (2)	330	14FEB96 A	21JUL97	6
15D	LA BTC Turbo Molecular Pumps At Site	0		21JUL97	0
15F	LA BTC Auxiliary Turbo Pumps At Site	0		21JUL97	0
331	Main Ion Pumps - Fab/deliver to WA site (12)	318	01MAY96	01AUG97	0
336	Annuli Ion Pumps - Fab/deliver to WA site (48)	318	01MAY96	01AUG97	0
325	Aux Turbo Pumps - Fab/deliver to WA site (3)	340	14FEB96 A	04AUG97	6
348	LN2 System Components - Fab/deliver to LA site	357	16AUG96	14JAN98	0
354	LN2 Dewars - Fab/deliver to LA site (4)	359	14AUG96	14JAN98	0
359	VJ Lines - Fab/deliver LA site lines (4 sets)	349	28AUG96	14JAN98	0
17G	LA LN2 Dewars Delivery At Site	0		14JAN98	0
326	Aux Turbo Pumps - Fab/deliver to LA site (1)	465	14FEB96 A	30JAN98	5
332	Main Ion Pumps - Fab/deliver to LA site (5)	445	01MAY96	30JAN98	0
337	Annuli Ion Pumps - Fab/deliver to LA site (25)	444	01MAY96	30JAN98	0
VALV - Valve Subsystem					
402	Large Gate Valves - Issue specification	8	16OCT95 A	27OCT95 A	100
409	6/10/14" Gate Valves - Issue specification	8	25OCT95 A	03NOV95 A	100
403	Large Gate Valves - Finalize bid & purchase (32)	20	06NOV95 A	30NOV95 A	100
9B	Place PO for Beam Tube Large Gate Valves	0		30NOV95 A	100
450	C.O. #1 - Change lg gate valve actuation	20	24OCT95 A	21DEC95 A	100
452	C.O. #2 -Change LA midpoint valves from 48 to 44	20	24OCT95 A	21DEC95 A	100
456	C.O. #7 - 304L weld stubs for lg gate valves	1	30NOV95 A	21DEC95 A	100
458	C.O. No. 9 - Change all lg gates to 48" electric	10	12DEC95 A	21DEC95 A	100
454	C.O. #4 - Add fail safe gates to roughing pumps	20	24OCT95 A	26JAN96 A	100
410	6/10/14" Gate Valves - Final bid & purchase (37)	20	06NOV95 A	07MAR96 A	100
427	Small Valves - Issue specifications	30	12FEB96 A	08MAR96 A	100
415	Control Valves - Issue specifications	8	01MAR96 A	12MAR96 A	100
433	Design supports for gate valves	20	26FEB96 A	25APR96 A	100
421	Relief Valves - Issue specification	5	01MAY96	07MAY96	0



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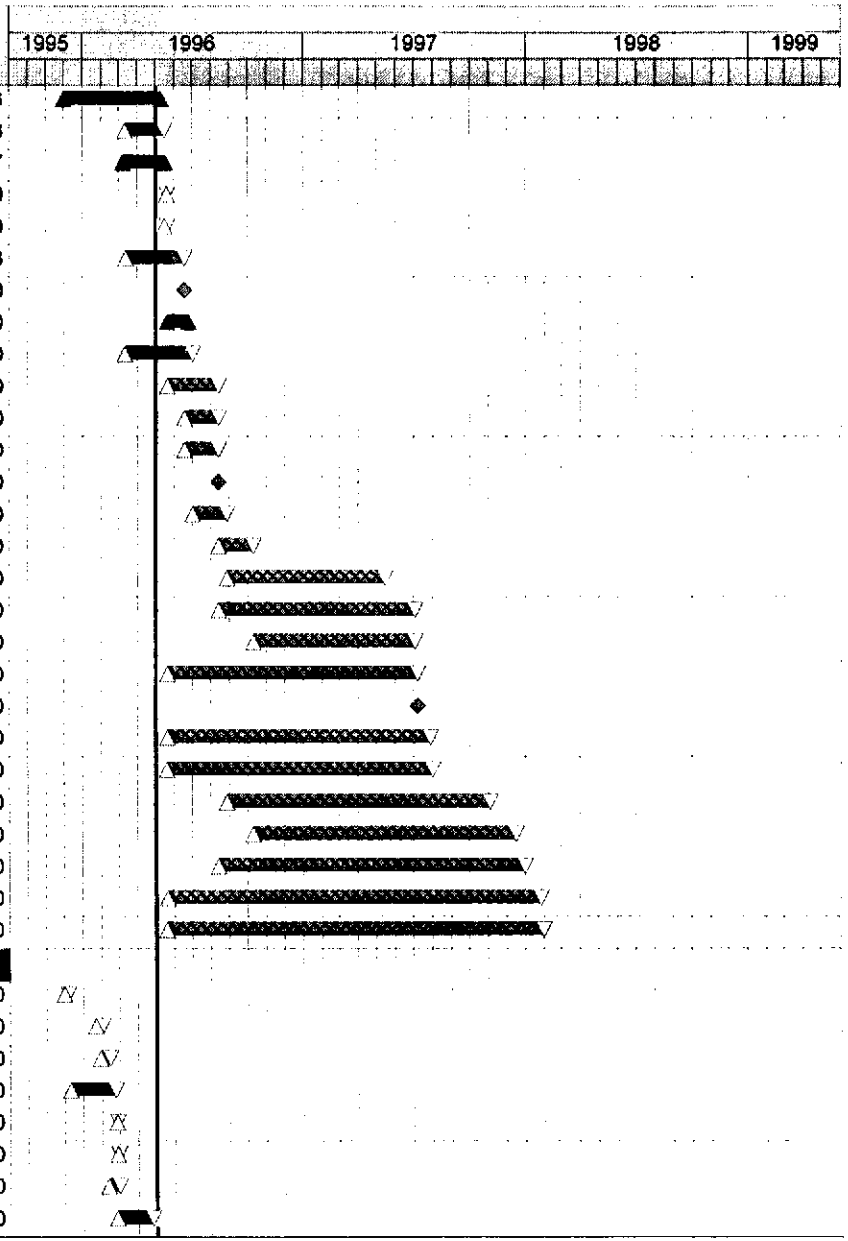
Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
404	Large Gate Valves - Receive & review v/dwgs	30	01DEC95 A	10MAY96	73
434	Large Gate Valves - Fab prototype large valve	25	12MAR96 A	15MAY96	88
411	6/10/14" Gate Valves - Receive & review v/dwgs	30	08MAR96 A	17MAY96	57
401	Gather large gate valve shock data (CAA)	1	20MAY96 *	20MAY96	0
435	Large Gate Valves - Cycle/shock test prototype	3	16MAY96	20MAY96	0
416	Control Valves - Bid & purchase	40	13MAR96 A	17JUN96	63
9D	Release for Remaining Large Gate Valves (Main)	0		17JUN96	0
412	6/10/14" Gate Valves - Fab/deliver to Wbro (5)	25	20MAY96	24JUN96	0
428	Small Valves - Bid and purchase	50	11MAR96 A	01JUL96	80
405	Large Gate Valves - Fab/deliver to WA BTC (8)	59	21MAY96	13AUG96	0
417	Control Valves - Receive & review vendor dwgs	40	18JUN96	13AUG96	0
422	Relief Valves - Bid & purchase	40	18JUN96	13AUG96	0
15G	WA BTC Large Gate Valves At Site	0		13AUG96	0
429	Small Valves - Receive & review vendor dwgs	40	02JUL96	27AUG96	0
423	Relief Valves - Receive & review vendor dwgs	40	14AUG96	09OCT96	0
430	Small Valves - Fab/deliver to WA site	180	28AUG96	14MAY97	0
418	Control Valves - Fab/deliver to WA site	225	14AUG96	03JUL97	0
424	Relief Valves - Fab/deliver to WA site	185	10OCT96	03JUL97	0
406	Large Gate Valves - Fab/deliver to LA BTC (6)	285	21MAY96	07JUL97	0
15H	LA BTC Large Gate Valves At Site	0		07JUL97	0
407	Large Gate Valves - Fab/deliver to WA site (12)	300	21MAY96	28JUL97	0
413	6/10/14" Gate Valves - Fab/deliver WA site (27)	305	20MAY96	01AUG97	0
431	Small Valves - Fab/deliver to LA site	300	28AUG96	03NOV97	0
425	Relief Valves - Fab/deliver to LA site	300	10OCT96	16DEC97	0
419	Control Valves - Fab/deliver to LA site	350	14AUG96	31DEC97	0
408	Large Gate Valves - Fab/deliver to LA site (6)	426	21MAY96	26JAN98	0
414	6/10/14" Gate Valves - Fab/deliver LA site (18)	431	20MAY96	30JAN98	0
CTRL - Instrumentation and Controls					
522	Residual Gas Analyzer - Prepare specification	10	01DEC95 A	07DEC95 A	100
501	Vacuum Gauges/Tees - Issue specification	5	22JAN96 A	01FEB96 A	100
513	I/E Cabinets - Determine size reqmts	10	29JAN96 A	14FEB96 A	100
523	Residual Gas Analyzer - Bid & purchase (2)	30	11DEC95 A	23FEB96 A	100
524	Residual Gas Analyzer - Receive & review v/dwgs	10	26FEB96 A	26FEB96 A	100
525	RGA's - Fab/deliver to Westboro/Prototype (2)	20	27FEB96 A	28FEB96 A	100
512	Establish control interface definitions	5	12FEB96 A	29FEB96 A	100
515	Ion Pump Controller Cabinets - Size and specify	20	26FEB96 A	24APR96 A	100



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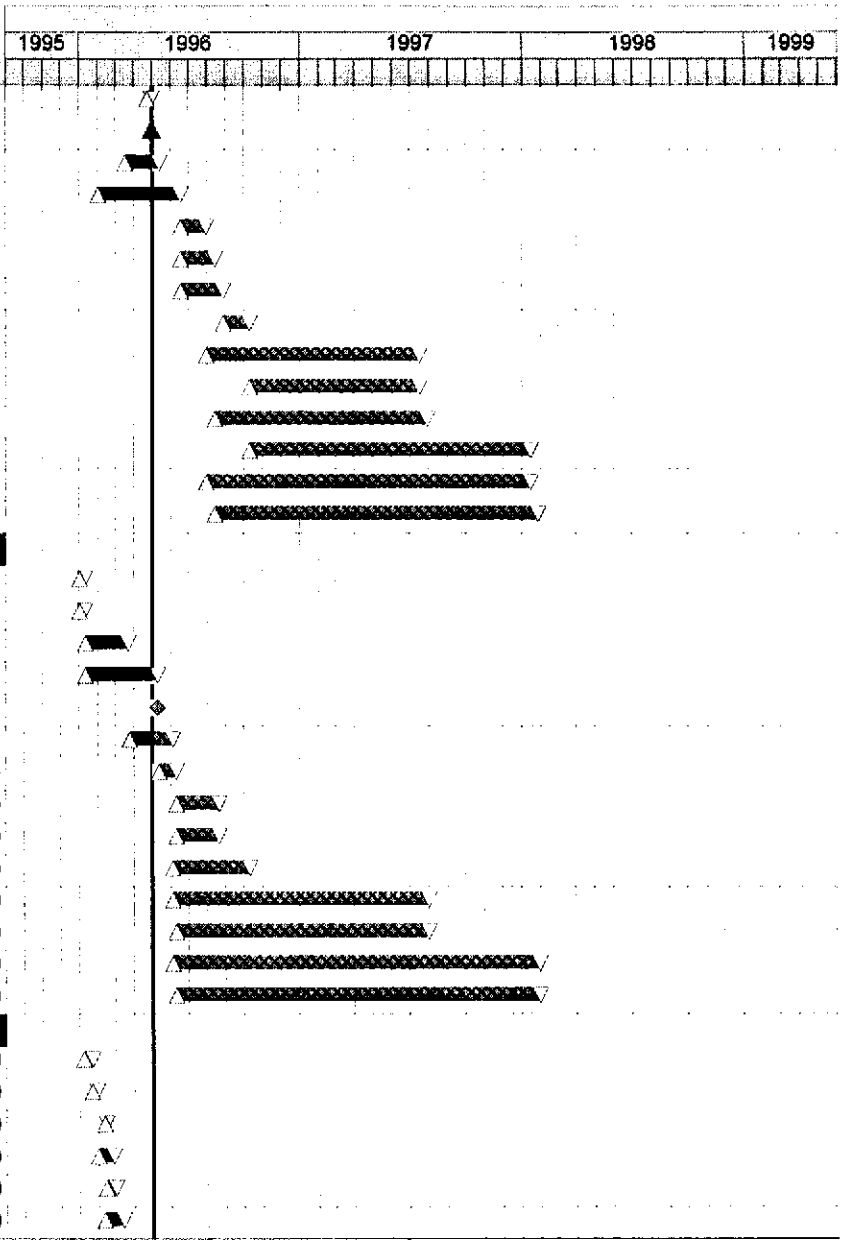
Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
506	Misc Instrumentation - Issue specifications	3	24APR96 A	30APR96 A	100
511	Develop logic lists	5	29APR96 A	03MAY96	40
599	LIGO Test Eqt & Cleanroom Training	40	18MAR96 A	13MAY96	78
502	Vacuum Gauges/Tees - Bid & purchase (43)	40	02FEB96 A	17JUN96	88
503	Vacuum Gauges/Tees- Receive/ review vendor dwgs	30	18JUN96	30JUL96	0
519	Cabinets/Racks - Bid and purchase	40	18JUN96	13AUG96	0
507	Misc Instrumentation - Bid & purchase	50	18JUN96	27AUG96	0
508	Misc Instrumentation - Receive & review v/dwgs	30	28AUG96	09OCT96	0
504	Vacuum Gauges - Fab/deliver to WA site (28)	243	31JUL96	16JUL97	0
509	Misc Instrumentation - Fab/deliver to WA site	193	10OCT96	16JUL97	0
520	Cabinets/Racks - Fab/deliver to WA site	242	14AUG96	29JUL97	0
510	Misc Instrumentation - Fab/deliver to LA site	319	10OCT96	14JAN98	0
505	Vacuum Gauges - Fab/deliver to LA site (15)	370	31JUL96	15JAN98	0
521	Cabinets/Racks - Fab/deliver to LA site	368	14AUG96	27JAN98	0
VENT - Vent and Purge Subsystem					
601	Air Supply Skids - Issue specification	12	02JAN96 A	10JAN96 A	100
608	Portable Cleanrooms - Issue specification	18	02JAN96 A	10JAN96 A	100
602	Air Supply Skids - Bid and purchase (8)	30	12JAN96 A	22MAR96 A	100
609	Portable Cleanrooms - Bid and purchase	20	12JAN96 A	10MAY96	60
9G	Place PO for Clean Rooms	0		10MAY96	0
603	Air Supply Skids - Receive & review vendor dwgs	50	25MAR96 A	04JUN96	52
610	Portable Cleanrooms - Receive & review v/dwgs	20	13MAY96	10JUN96	0
611	Portable Cleanroom - Fab/deliver to Westboro (2)	50	11JUN96	20AUG96	0
612	Portable Cleanrooms - Fab/deliver to Wstboro (2)	50	11JUN96	20AUG96	0
604	Air Supply Skids - Fab/deliver to Westboro (2)	90	05JUN96	10OCT96	0
605	Air Supply Skids - Fab/deliver to WA site (5)	294	05JUN96	01AUG97	0
613	Portable Cleanrooms - Fab/deliver to WA site (6)	290	11JUN96	01AUG97	0
606	Air Supply Skids - Fab/deliver to LA site (1)	420	05JUN96	30JAN98	0
614	Portable Cleanrooms - Fab/deliver to LA site (4)	416	11JUN96	30JAN98	0
BAKE - Bakeout Subsystem					
721	Prototype Bakeout Blankets - Issue specification	21	08JAN96 A	22JAN96 A	100
709	Bakeout System Controls - Issue specs	10	22JAN96 A	29JAN96 A	100
711	Bakeout System Controls - Receive/review v/dwgs	10	12FEB96 A	13FEB96 A	100
710	Bakeout System Controls - Bid and purchase	20	01FEB96 A	26FEB96 A	100
712	Bakeout System Controls - Fab/deliver to PSI	20	14FEB96 A	29FEB96 A	100
701	Prepare a bakeout system schematic	15	12FEB96 A	13MAR96 A	100



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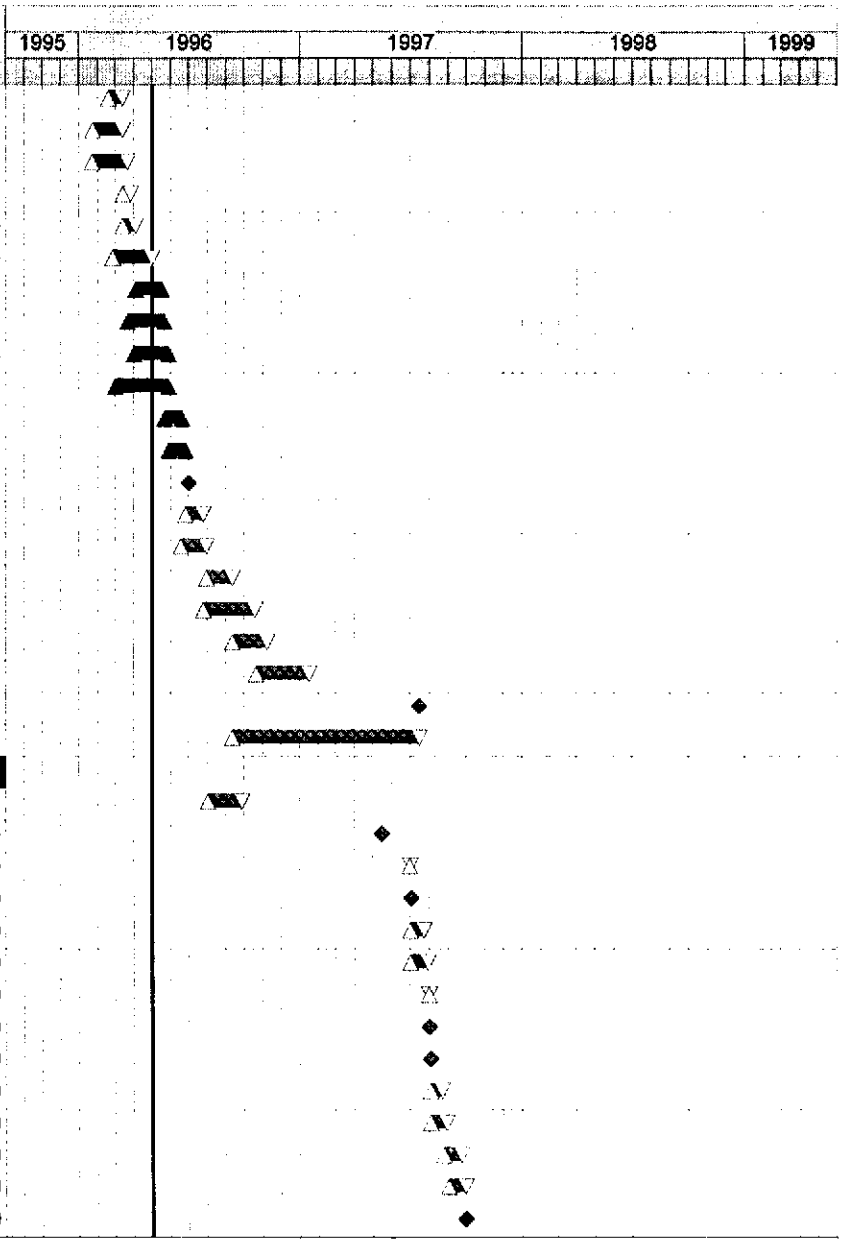
Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
702	Perform bakeout system calculations	30	19FEB96 A	13MAR96 A	100
717	Design bakeout cart(s) - Preliminary design	5	24JAN96 A	13MAR96 A	100
722	Prototype Bakeout Blankets - Bid & purchase (6)	20	23JAN96 A	21MAR96 A	100
726	Final design of bakeout carts	15	14MAR96 A	26MAR96 A	100
719	Bakeout Carts - Bid & award assembly of carts	15	14MAR96 A	03APR96 A	100
703	Bakeout Blankets - Issue specification	20	26FEB96 A	30APR96 A	100
720	Bakeout Carts - Assemble 1st cart	31	04APR96 A	17MAY96	58
723	Prototype Bakeout Blankets - Receive/rvw v/dwgs	15	22MAR96 A	21MAY96	0
718	Program PLC's for bakeout system	40	01APR96 A	28MAY96	53
727	Program PC's for Bakeout System	70	01MAR96 A	28MAY96	73
706	Bakeout Blankets - Fab/deliver to Westboro (6)	20	22MAY96	19JUN96	0
730	Bakeout Carts - Test 1st bakeout cart	20	29MAY96	25JUN96	0
9I	Place PO for Bakeout System/Blankets	0		01JUL96	0
731	Bakeout Carts - Procure materials for 5 carts	20	26JUN96	24JUL96	0
704	Bakeout Blankets - Bid and purchase system	30	18JUN96	30JUL96	0
705	Bakeout Blankets - Receive & review vendor dwgs	30	31JUL96	11SEP96	0
732	Bakeout Carts - Assemble 5 carts	60	25JUL96	18OCT96	0
707	Bakeout Blankets - Fab/deliver to Westboro (20)	40	12SEP96	07NOV96	0
733	Bakeout Carts - Test 5 carts	60	21OCT96	16JAN97	0
18	Delivery of Bakeout System to WA Site	0		16JUL97	0
708	Bakeout Blankets - Fab/deliver to WA site (30)	213	12SEP96	16JUL97	0
BILD - Systems Installation					
798	Bid & award Washington installation subcontract	40	02AUG96	27SEP96	0
17A	WA Corner Station Major Vessel Delivery	0		16MAY97	0
801	Conduct installation readiness review - WA site	1	01JUL97 *	01JUL97	0
17E	WA Mid Station Major Vessel Delivery	0		03JUL97	0
799	WA Site - Installation subcontractor mobilize	15	02JUL97	23JUL97	0
802	Verify interfaces & as-built site conditions -WA	20	02JUL97	30JUL97	0
803	Joint occupancy of WA site	1	01AUG97 *	01AUG97	0
17C	WA End Station Major Vessel Delivery	0		01AUG97	0
20	Begin Installation At Washington Site	0	04AUG97		0
811	WACS - Offload, clean, & position all components	15	04AUG97	22AUG97	0
818	WACS - Install mechancial room eqt/piping/wiring	20	04AUG97	29AUG97	0
812	WACS - Install vertex components	20	25AUG97	22SEP97	0
819	WACS - LN2 supply systems installation	20	02SEP97	29SEP97	0
17B	LA Corner Station Major Vessel Delivery	0		29SEP97	0



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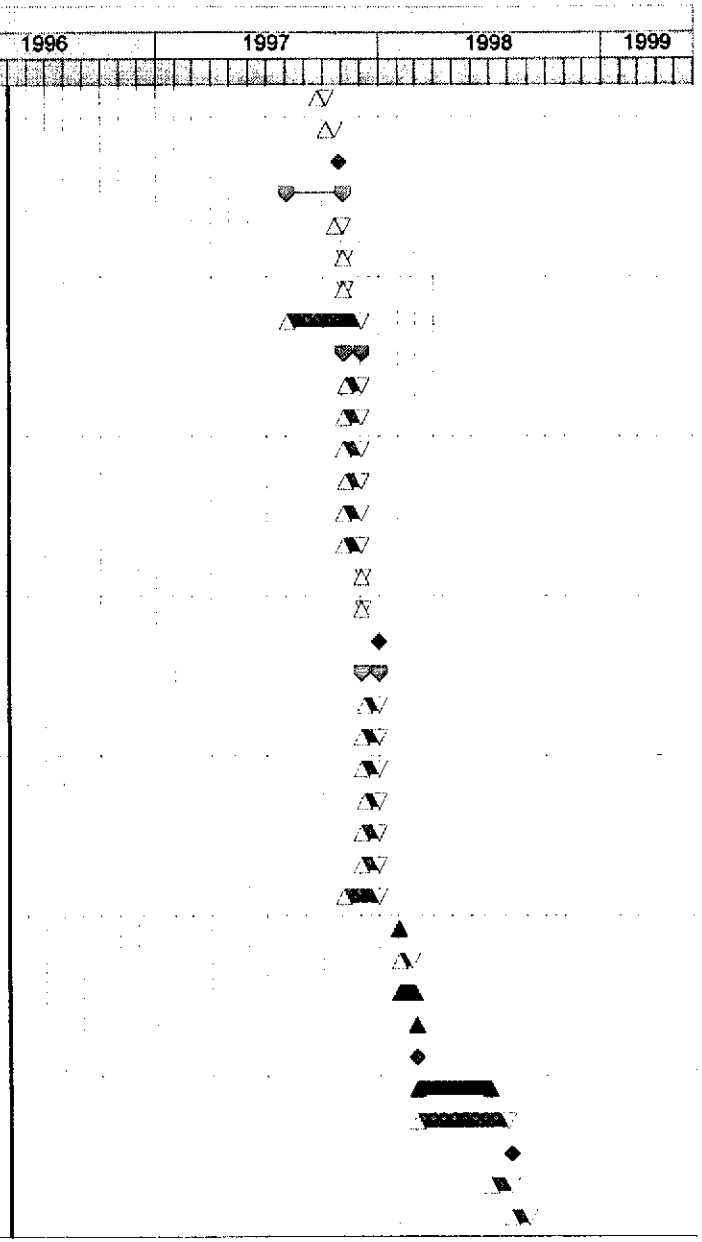
814	WACS - Install right beam manifold components	10	23SEP97	06OCT97	0
816	WACS - Install diagonal components	10	07OCT97	20OCT97	0
17D	LA End Station Major Vessel Delivery	0		27OCT97	0
810	WACS installation	65 *	04AUG97	03NOV97	0
817	WACS - Install left beam manifold components	10	21OCT97	03NOV97	0
821	Left WAMS - Offload, clean, position components	3	04NOV97	06NOV97	0
826	Left WAES - Offload, clean, position components	3	04NOV97	06NOV97	0
804	WA Site - Receive/store/set eqt in all stations	85	04AUG97	02DEC97	0
820	WA Arm 1 (left) - Install mid/end station eqt	20 *	04NOV97	02DEC97	0
822	Left WAMS - Install components	17	07NOV97	02DEC97	0
824	Left WAMS - Install mechanical room eqt/wiring	20	04NOV97	02DEC97	0
825	Left WAMS - LN2 supply systems installation	20	04NOV97	02DEC97	0
827	Left WAES - Install components	17	07NOV97	02DEC97	0
828	Left WAES - Install mechanical room eqt/wiring	20	04NOV97	02DEC97	0
829	Left WAES - LN2 supply system installation	20	04NOV97	02DEC97	0
831	Right WAMS - Offload, clean, position components	3	03DEC97	05DEC97	0
836	Right WAES - Offload, clean, position components	3	03DEC97	05DEC97	0
22	Mechanical Completion At Washington Site	0		31DEC97	0
830	WA Arm 2 (right) - Install mid/end station eqt	20 *	03DEC97	31DEC97	0
832	Right WAMS - Install components	17	08DEC97	31DEC97	0
834	Right WAMS - Install mechanical room eqt/wiring	20	03DEC97	31DEC97	0
835	Right WAMS - LN2 supply systems installation	20	03DEC97	31DEC97	0
837	Right WAES - Install components	17	08DEC97	31DEC97	0
838	Right WAES - Install mechanical room eqt/wiring	20	03DEC97	31DEC97	0
839	Right WAES - LN2 supply system installation	20	03DEC97	31DEC97	0
848	Bid & award Louisiana installation subcontract	40	04NOV97	31DEC97	0
851	Conduct installation readiness review - LA site	1	02FEB98 *	02FEB98	0
849	LA Site - Installation subcontractor mobilize	15	03FEB98	23FEB98	0
852	Verify interfaces & as-built site conditions -LA	19	03FEB98	27FEB98	0
853	Joint occupancy of LA site	1	02MAR98	02MAR98	0
21	Begin Installation At Louisiana Site	0	03MAR98		0
860	LACS installation	85	03MAR98	30JUN98	0
854	LA Site - Receive/store/set eqt in all stations	105	03MAR98	29JUL98	0
23	Mechanical Completion At Louisiana Site	0		03AUG98	0
870	LA Arm 3 (left) - Install end station eqt	23	01JUL98	03AUG98	0
872	LA Arm 4 (right) - Install end station eqt	20	04AUG98	31AUG98	0



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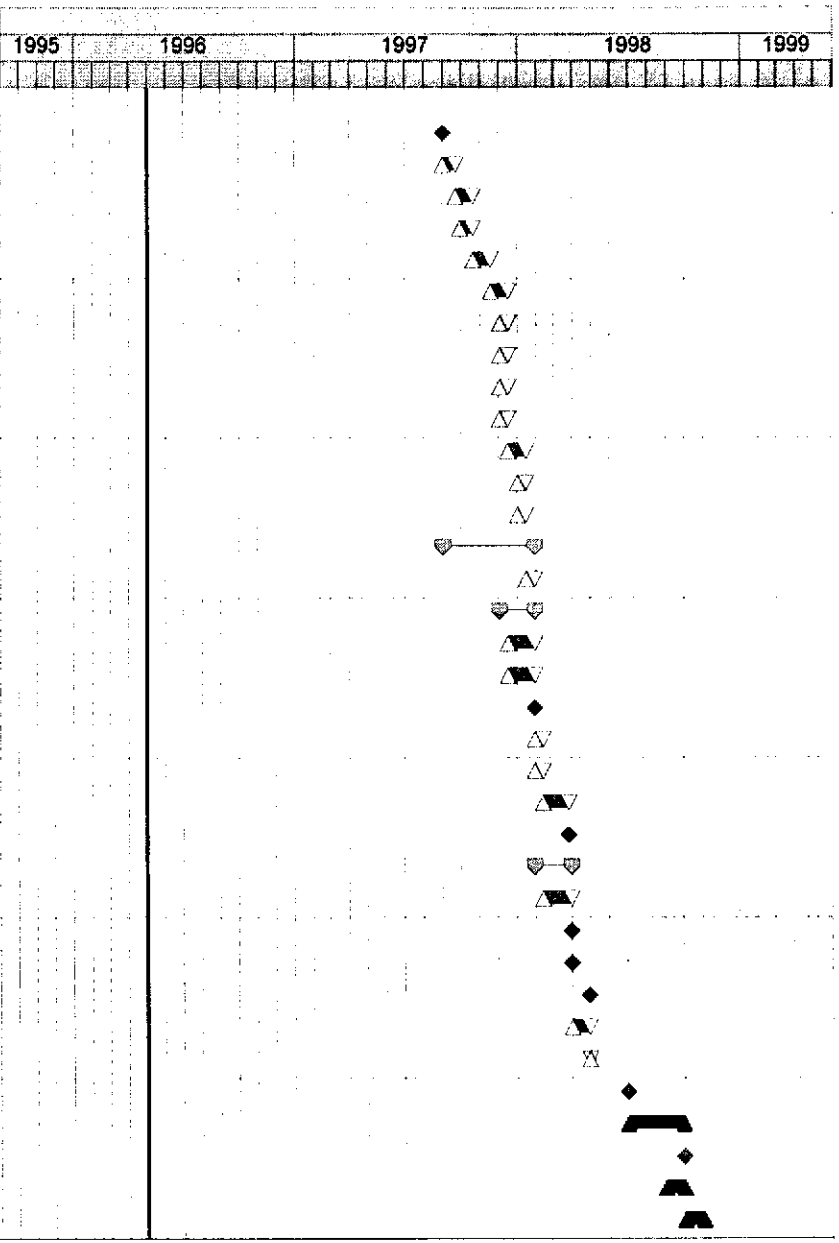
Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
CACT - Commissioning and Acceptance Testing					
24A	Start Acceptance Testing At Washington Site	0	02SEP97		0
918	WACS - Test/commission mechanical room equipment	15	02SEP97	22SEP97	0
912	WACS - Test/commission vertex section	20	23SEP97	20OCT97	0
919	WACS - Test/commission LN2 supply systems	15	30SEP97	20OCT97	0
914	WACS - Test/commission right beam manifold	20	21OCT97	17NOV97	0
916	WACS - Test/commission diagonal section	20	18NOV97	16DEC97	0
924	Left WAMS - Test/commission mechanical room eqt	10	03DEC97	16DEC97	0
925	Left WAMS - Test/commission LN2 supply systems	10	03DEC97	16DEC97	0
928	Left WAES - Test/commission mechanical room eqt	10	03DEC97	16DEC97	0
929	Left WAES - Test/commission LN2 supply system	10	03DEC97	16DEC97	0
917	WACS - Test/commission left beam manifold	20	17DEC97	15JAN98	0
935	Right WAMS - Test/commission LN2 supply systems	10	02JAN98	15JAN98	0
939	Right WAES - Test/commission LN2 supply system	10	02JAN98	15JAN98	0
910	WACS - Test/commission station	105 *	02SEP97	29JAN98	0
911	WACS - Complete station commissioning	10	16JAN98	29JAN98	0
920	WA Arm 1 (left) - Test/commission mid/end sta's	40 *	03DEC97	29JAN98	0
922	Left WAMS - Test/commission station components	30	17DEC97	29JAN98	0
927	Left WAES - Test/commission station components	30	17DEC97	29JAN98	0
24C	Complete Acceptance Test - WA Corner Station	0		29JAN98	0
934	Right WAMS - Test/commission mechanical room eqt	10	30JAN98	12FEB98	0
938	Right WAES - Test/commission mechanical room eqt	10	30JAN98	12FEB98	0
932	Right WAMS - Test/commission station components	30	13FEB98	26MAR98	0
24E	Complete Acceptance Test - WA Mid Stations	0		26MAR98	0
930	WA Arm 2 (right) - Test/commission mid/end sta's	43 *	30JAN98	31MAR98	0
937	Right WAES - Test/commission station components	33	13FEB98	31MAR98	0
940	Complete acceptance testing - WA site	0		31MAR98	0
24F	Complete Acceptance Test - WA End Stations	0		31MAR98	0
25	Complete WA Acceptance Test Review Package	0		28APR98	0
945	Prepare acceptance test report for WA site	20	01APR98	28APR98	0
946	Conduct acceptance review meeting - WA site	1	29APR98	29APR98	0
24B	Start Acceptance Testing At Louisiana Site	0	01JUL98		0
960	LACS - Test/commission station	64	01JUL98	30SEP98	0
24D	Complete Acceptance Test - LA Corner Station	0		30SEP98	0
970	LA Arm 3 (left) - Test/commission end station	22	01SEP98	01OCT98	0
972	LA Arm 4 (right) - Test/commission end station	22	02OCT98	02NOV98	0



PSI

Early start point
Early finish point
Early bar
Progress bar
Critical bar
Summary bar
Progress point
Critical point
Summary point
Start milestone point
Finish milestone point

Process Systems International, Inc.

LIGO Vacuum System Project

Early Finish

17Aof18A

Data date 01MAY96

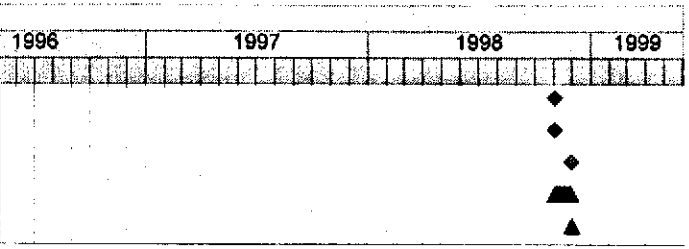
Run date 03MAY96

Filter All Activities

Layout Early finish sort

Date	Revision	Checked	Approved
03MAY96	Final Design Pkg	PFH	REB

Activity ID	Description	Orig Dur	Early Start	Early Finish	Percent Complete
980	Complete acceptance testing - LA site	0		02NOV98	0
24G	Complete Acceptance Test - LA End Stations	0		02NOV98	0
26	Complete LA Acceptance Test Review	0		30NOV98	0
985	Prepare acceptance test report for LA site	19	03NOV98	30NOV98	0
986	Conduct acceptance review meeting - LA site	1	01DEC98	01DEC98	0



PSI

Early start point
Early finish point
Early bar
Progress bar
Critical bar
Summary bar
Progress point
Critical point
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Start milestone point
Finish milestone point

Process Systems International, Inc.

LIGO Vacuum System Project

Early Finish

Data date 01MAY96
Run date 03MAY96
Filter All Activities
Layout Early finish sort

Date	Revision	Checked	Approved
03MAY96	Final Design Pkg	PFH	REB

ATTACHMENT 3

WORK BREAKDOWN STRUCTURE

ATTACHMENT 4

PROJECT Q.A. PLAN V049-2-029

SPECIFICATION FOR

PROJECT QUALITY ASSURANCE PLAN

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

MANUFACTURING ENGINEER: Phillip Falcon

QUALITY ASSURANCE: Alan L Bradbook

TECHNICAL DIRECTOR: D A M I W Allen

PROJECT MANAGER: Richard Bagley

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
Ø	4/24/96		RELEASED PER DEO 137

PROCESS SYSTEMS INTERNATIONAL, INC.				SPECIFICATION	
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number A V049-2-029	Rev. 0
	ALB	4-24-96	REB	4/24/96		

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1.0 Purpose

2.0 General

3.0 Responsibilities

4.0 Procedure

Number

Rev.

SPECIFICATION

Number A V049-2-029 Rev.

1.0 PURPOSE

The purpose of the QA Plan is to establish the quality requirements for the scope of work intended. This plan contains the PSI quality standards that will be imposed on the LIGO High Vacuum System.

2.0 GENERAL

The outlined plan will be imposed at PSI as well as all major component vendors.

3.0 RESPONSIBILITIES

The manager of Quality Assurance and the assigned Project Manager are responsible for the implementation of this plan.

4.0 PROCEDURE

4.1 Quality Review And Planning

4.1.1 Prior to fabrication the Quality Assurance Engineer will establish the hold/witness points from the Customers specification; the PSI inspection points and the applicable PSI procedures for the contract. From this information, the QAE will prepare a PSI Quality Plan, for each chamber or assembly built at PSI. The Quality Plan will define all of the inspection steps that require witness and/or verification during the course of manufacturing and assembly at PSI. Subcontractual work will be subject to the same planning, by the subcontractor, at his plant with witnessed HOLD points and inspections by PSI.

4.2 Receiving Inspection

4.2.1 All raw materials that are procured with Material Test Reports will be receipt inspected prior to use.

4.2.2 Procured components and items will be inspected at the vendor's plant. If inspection is not performed at the vendors plant, they will be receipt inspected upon arrival.

4.3 Material Certification

4.3.1 All vacuum chamber and flange materials will be procured with Material Test Reports. Other nozzle, small parts, small flange nozzles and bolting materials will be procured with a Certificate of Compliance. At receiving inspection, the materials will be verified against the Purchase Order for quantity, material markings and the Material Test Report will be verified to the applicable ASME and/or ASTM material specification for compliance.

4.3.2 If primary vacuum boundary materials are purchased from foreign (outside of USA), PSI will conduct independent lab analysis to verify material composition.

4.4 In-Process Inspection

4.4.1 QA/QC will verify material traceability throughout the manufacturing cycle. They will monitor the quality of welding and the qualifications of personnel, verify the final cleaning and verify/witness the testing required by the customers specification.

4.5 Cleaning

4.5.1 All materials will be cleaned free of grease, oil, rust and foreign matter prior to welding. After the welding and machinery operations, the assemblies will be cleaned to the required level, for the intended service.

4.5.2 Final cleaning will be performed in accordance with the LIGO cleaning procedure.

4.6 Welding

4.6.1 All welding exposed to the vacuum will be performed by the PAW or the GTAW (TIG) welding process, with a 100% Argon shield gas or plasma arc welding with 100% Argon shield gas. All open or closed root, butt welding will be purged with 100% Argon (backing gas). Slip-on-flanges and lap joint designs that allow for fillet welds will not require baking gas. All vacuum welding will performed utilizing ASME Section IX qualified welding procedures and qualified welders.

4.6.2 Welding operations will be monitored on a daily basis by the QA/QC department for compliance with the LIGO Project Procedures and the applicable codes.

4.7 Final Inspection

4.7.1 Final inspection will be accomplished on all components prior to shipment. This inspection will include but is not limited to the following: serialization of components, final cleaning, final acceptance testing and packaging for shipment.

4.8 Testing

4.8.1 Vacuum components shall meet pumpdown and helium leak rates per the LIGO Project Procedures.

4.8.2 Pumps and valves will be performance tested at the vendor plant. These tests will be witnessed by PSI.

4.8.3 All testing will be performed in accordance with LIGO Project procedures. All shop testing performed will be witnessed/verified by QA/QC.

4.8.4 Written test reports will be generated for all testing and will be included in the final documentation package.

4.9 Documentation

4.9.1 Final documentation on this project will consist of signed off Quality Plans, Material Test Reports for vacuum chamber and flange materials, certificates of conformance of all nozzle materials, small parts and bolting materials, final cleaning certificate, Helium leak test reports, pumpdown test report and a Certificate of Conformance to the codes and standards.

4.10 Vendor Surveillance

4.10.1 Prior to fabrication, each vacuum vessel fabricator shall submit quality plans to PSI for approval. PSI QA and engineering will set mandatory hold points and perform periodic inspections at the vendor's plant. The vendor shall provide final documentation as detailed in the procurement specification for all PSI fabricated components, documentation shall be provided as shown in Attachment 1 "Final Documentation Summary".

4.10.2 For major purchased components, QA requirements are detailed in "QA Requirements Summary" form attached to each procurement specification.

4.11 Engineering Plan Review

4.11.1 QA will be part of the design review team as the design develops.

4.12 Procurement Specification Review

4.12.1 QA will be part of the review team for all major component specifications.

Attachment 1
V049-2-029

LIGO VACUUM EQUIPMENT
FINAL DOCUMENTATION SUMMARY

Component
Model No.:
Serial No.:

Date:
Prepared By:

1. Quality Plan Doc. No.: _____ Rev. _____
2. Material Test Reports: _____ Date _____
   _____ _____
   _____ _____
   _____ _____
3. Certification of Conformance: _____ _____
   _____ _____
   _____ _____
   _____ _____
4. Heat Treat Charts: _____ _____
   _____ _____
5. Final Cleaning Certification: _____ _____
6. Bakeout Certification: _____ _____
7. Final Vacuum Leak Reports: _____ _____
8. Non-Conformance Reports: _____ _____
9. Certificate of Conformance: _____ _____

Notes:

SPECIFICATION		
Number A	V049-2-029	Rev.

Number
Rev.

ATTACHMENT 5

PROJECT SAFETY PLAN V049-2-023

PROJECT SAFETY PLAN

FOR

LIGO VACUUM EQUIPMENT

Hanford, Washington
and
Livingston, Louisiana

QUALITY ASSURANCE: Allan L Bradbrook

LIGO SAFETY OFFICER:

PROJECT MANAGER: Richard Boyle

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
Ø	4/24/96		RELEASED PER DEO 137

PROCESS SYSTEMS INTERNATIONAL, INC.			SPECIFICATION	
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	JMS 15 APR 96	RCB 4/24/96		

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1.0 Purpose
2.0 Scope
3.0 Applicable Documents
4.0 Plan Maintenance
5.0 Safety Philosophy
6.0 Safety Objections
7.0 Maintenance of Safety Controls
8.0 Site Safety Plan

ATTACHMENTS

1. PSI Safety Manual

1.0 PURPOSE

This plan defines and establishes the safety requirements for the LIGO Project vacuum equipment supply and installation. The program requirements include safety management systems as well as safety engineering controls necessary to ensure the identification and resolution of all safety issues relative to this project.

This program provides for the review and approval of all operations, facilities equipment, and manpower application for safety and environmental controls necessary to provide maximum protection and to minimize risk of personnel, facilities, and hardware/equipment, etc.

2.0 SCOPE

The requirements as stated herein, will apply to all PSI facilities and construction sites.

3.0 APPLICABLE DOCUMENTS

The current revisions of the following documents dictate the requirements relative to the implementation of this plan.

a. 29 CFR Occupational Safety and Health Administration (OSHA) General Industry Standards

b. 40 CFR Environment Protection Agency (EPA) Protection of Environment

c. 49 CFR Department of Transportation (DOT) Transportation

d. National Fire Protection Association (NFPA) Fire Codes, Handbook Of Fire Protection, Life Safety Code Handbook, National Electrical Code.

e. American National Standards Institute (ANSI) Safety Standards.

f. National Safety Council (NSC) Accident Prevention Manual for Industrial Operations.

g. Toxic Substances Control Act (TSCA).

PSI has in place safety policies to meet general OSHA, Government and State requirements (regulations) which have been qualified by implementations/audits and by on-site visitation of these agencies.

4.0 PLAN MAINTENANCE

During the execution of this program, PSI's safety philosophy will be dictated by its Safety Policy Statement.

PSI is committed to providing a safe workplace for all employees. Program objectives are the prevention of injury, an the prevention of injury, and the prevention of employee and visitor exposure to hazardous conditions or materials. In order to achieve these objectives, environmental health and safety issues will be addressed as integral components of our business strategy. Our goal is to provide quality products and services while actively conserving our human and natural resources. It is our belief that accidents and undesirable environmental incidents are preventable by active participation from each employee.

All managers and leaders are responsible for ensuring that each employee receives the training and instruction necessary to perform his job safely. Each employee has the responsibility to comply with the company work rules following safe work practices and procedures established to protect the environment, and for reporting to leaders and managers all unsafe acts and hazardous conditions which may impact the environment. PSI's scope of operations range from manufacturing facilities to administrative offices. Therefore, safety programs will be tailored to each situation.

All PSI employees are required to read and follow the PSI Safety Manual as a condition of employment. (See Attachment I.)

6.0 SAFETY OBJECTIVES

6.1 To carry out the PSI safety policy, the following objectives have been identified relative to the Safety Program.

a. All work will be performed in the safest possible manner to reduce accidents involving personal injury, environmental impact, and equipment, facility or product damage.

b. A formal safety program has been established to define safety responsibilities, safety management controls, procedures, industrial safety requirements, industrial hygiene requirements, environmental functions, and other provisions to meet regulatory agency requirements. (See PSI Safety Manual.)

c. The PSI Safety program has the active support of all PSI employees. All levels of management will support the program and the concept of individual responsibility for safe operations will be established and reinforced.

d. The primary responsibility for safe operations will rest with the supervisor, who supported by the Safety Committee, is charged with conducting assigned tasks in the safest possible manner. Each supervisor will assure that organizational procedures provide safe working conditions and that team members comply with all Safety Committee requirements associated with the task.

e. The value of personnel training and certification as an accident preventive measure will be emphasized. Employees will be trained to be familiar with the systems, equipment and facilities which are required for the safe performance of their assigned tasks.

f. The Safety Program will be responsible for all safety related contractual directions.

g. To ensure site safety programs comply with PSI Safety Standards.

6.2 Organization

To accomplish the safety objectives relative to this program, a Safety Committee has been established at PSI. The Safety Committee has been designated and charged with the responsibility of coordinating the safety program to meet company and contractual safety requirements. The committee reports to the President of PSI. There are 12 to 14 people on the safety committee representing each PSI department including Humor Resources. The committee normally meets every two weeks. Special meetings may be called by the chairman if required.

6.3 Responsibilities

Throughout the performance of this project, responsibilities have been established to carry out the requirements of this plan. The Safety Committee chairman (or individual members) are responsible for informing the President of PSI if an unsafety condition is allowed to exist at PSI after it has been identified.

a. Each PSI department has the responsibility for identifying potential hazardous operations, facilities and equipment; for providing required documentation and information incorporating safety requirements for continuing the safe conduct of activities; and for developing procedures and controls necessary for the safe processing of fabricated articles/items throughout all phases of manufacturing and delivery of products.

b. Supervisors/Team Leaders are responsible for assuring safe workmanship practices, including training, certification and qualification of personnel to approved training requirements.

c. All involved personnel are responsible for reporting to any potential unsafe condition throughout the performance of their duties/responsibilities - to the Safety Committee Chairman for resolution.

7.0 MAINTENANCE OF SAFETY CONTROLS

7.1 The Safety Manual, which is available to all personnel, will be revised/updated when new information is obtained, or when new development of processes/equipment dictate changes, and for training/qualification of personnel as determined by growth/expansion/development, etc.

7.2 Safety meetings will be held based on a "need to know" basis and as a minimum quarterly.

8.0 SITE SAFETY PLAN

Weekly safety meetings are mandatory on all PSI jobsites, and are administered by the PSI site manager. PSI subcontractors will be required to maintain a formal safety program. Site specific safety plans will be developed inconjunction with the selected PSI installation contractor. This will result in a cohesive document that has been proved to be successful in application. It also results in more familiarity by the people performing and supervising the work.

V049-2-023

ATTACHMENT 1

PSI SAFETY MANUAL

SAFETY MANUAL

PROCESS SYSTEMS INTERNATIONAL, INC.

PROCESS SYSTEMS INTERNATIONAL, INC.

SAFETY MANUAL

JUNE 1994

1. INTRODUCTION

This manual provides a comprehensive description and approach to PSI's Safety Program. The Program has been designed with one major goal; to ensure that every employee is provided the opportunity to work in a facility that does not endanger his health. The manual will be updated from time to time to incorporate both new and revised OSHA and state regulations.

The safety and health rules documented in this manual are intended to comply with OSHA regulations for general industry. Where a plant practice or rule conflicts with OSHA, the latter will dominate.

The management of the company intends to comply with both the spirit and letter of laws and regulations pertaining to employee safety at the work place. TO THIS END ALL EMPLOYEES ARE NOT ONLY URGED, BUT REQUIRED TO BE FAMILIAR WITH THE PROGRAMS OUTLINED IN THIS MANUAL, AND BRING TO THE ATTENTION OF THE SAFETY COMMITTEE OR THEIR SUPERVISOR ANY INFORMATION RELATING TO CONDITIONS OR SITUATIONS WHICH COULD RESULT IN SAFETY HAZARDS.

Remember that safety is a full-time job and your participation in the program is essential.

All employees are expected to learn all the safety aspects of their jobs and cooperate with both supervision and other employees in complying with our safety rules.

All employees and temporary contract personnel will be provided with a copy of PSI's Safety Manual.

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5. Safety Emphasis and Training
6. Safety Equipment
7. Safety Glasses Program
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9. Safety Shoe Program
10. Housekeeping
11. Discipline
12. Fire Lanes and Common Aisleways
13. Fire Extinguishers
14. Storage of Flammables
15. Storage of Gas Bottles
16. Hazardous Material
17. Forklifts
18. Cranes and Lifting Devices
19. X-Ray
20. General Welding Safety
21. Emergency Procedures
22. Emergency Coordinator
23. Illegal Drugs, Narcotics and Alcohol
24. Environment, Health and Safety Policy
25. Safety Manual Modifications

2. COMMON SENSE

The keynote to any Safety Program is common sense. Employees are required to know and follow the written safety policies. However, where no firm fast rule applies to a given situation, it is expected that employees will act prudently and reasonably.

Personal equipment must comply with all safety related standards.

The fact that a safety item may not be addressed in this manual does not relieve each and every employee from using common sense and employing safe practices and procedures in the performance of his or her work.

For example, when carrying or handling pipe or when using grinders it is expected that employees will avail themselves of safety gloves and other safety equipment provided by the company.

3. THE PSI SAFETY COMMITTEE

The PSI Safety Committee as an advisory board, will monitor all safety and occupational health-related subjects, and will advise Management on necessary corrective action to maintain a satisfactory level of safety throughout the company.

They will interpret governmental safety and health regulations as they apply to PSI, and conduct general inspections.

The Safety Committee consists of a Chairman, Secretary and other concerned employees who, as a unit, represent manufacturing and office areas. From time to time, a vacancy may occur on the Committee and such a vacancy will be announced by posting a notice on the bulletin board.

The remaining Committee members will, at a scheduled meeting attended by all the remaining members, review the list of interested applicants and vote to elect a new member to fill the vacancy.

The Company is a member of the Central Massachusetts Chapter of the National Safety Council and will continue to utilize the programs and benefits of this organization to its fullest extent.

Duties and Responsibilities of the Chairman

1) Schedule and preside over committee meetings.

2) Appoint members to special projects and programs, and follow up on reports and recommendations.

3) Act as company liaison with outside representatives, such as State Inspectors, insurance investigators, and OSHA Compliance Officers.

4) Coordinate the activities of the Safety Committee.

5) Issue reports of unsafe or housekeeping conditions to management.

6) Make available all committee minutes, inspection reports, and other documents relating to the safety program to interested employees.

7) Consult with and advise individuals or groups on safety matters, and keep management informed on basic safety principles and OSHA regulations.

Duties and Responsibilities of the Secretary:

1) Take and issue all minutes of the Safety Committee.

2) Act for the Chairman or as designated by the Chairman as company liaison with outside representatives, such as State Inspectors, insurance investigators, and OSHA Compliance Officers.

3) Issue reports to management of unsafe or housekeeping problems.

4) Maintain all committee minutes, inspection reports, and other documents relating to the safety program.

Duties of the Other Members are as Follows:

1) Conduct educational programs to employees on safety including, but not limited to, periodic safety films.

2) Transmit safety recommendations from other employees and from department managers and supervisors to the Safety Committee.

3) Consider the merits of all safety recommendations and assist in their implementation.

4) Carry out special projects as assigned by the Chairman.

5) Assist in general safety inspections.

The Goals of the Safety Committee are:

1) To ensure that PSI maintains a healthy and safe working environment for all employees.

2) To report safety suggestions to managers or appropriate supervisors.

3) To communicate and train each employee on an ongoing basis to do the job in the safest way.

4. TREATMENT AND REPORTING OF INJURIES

All injuries, no matter how minor, require treatment to prevent infection or to forestall complications.

Work related injuries/illness must be reported immediately to the employee's supervisor who will notify Health Services. The decision as to whether professional treatment is required should be made by the Company Doctor, Company Nurse or in their absence an employee who has passed the Red Cross First Aid Course, if available. A list of such employees will be maintained on the bulletin board. When in doubt, the injured employee should be sent for professional treatment.

A public or private ambulance service should be utilized in all cases which require emergency treatment and in which there appears to be imminent danger to an employee's health or well-being or where there is evidence of chest pains, cardiac symptoms or respiratory distress.

Other than emergency situations, in cases where it becomes necessary to transport a sick or injured person to a medical facility for further treatment, a Company vehicle should be utilized. If possible, the driver should be accompanied by another person.

An employee and/or his supervisor must report the details of any accident to the Personnel Department and/or Health Services either in person or by phone. After receiving professional treatment, the employee should discuss the details of the accident, and the doctor's findings as to whether the injury will result in lost time from work with the Personnel Department. This information is required for personal safety, work scheduling, insurance and OSHA purposes. Employees and/or their supervisor are required to promptly complete an accident report on a form and in the format required by the company. This form must be signed and forwarded to the company nurse within two (2) working days after the date of the accident.

All employees requiring professional medical treatment due to a work-related accident or illness may, at the sole discretion of the company, be seen by the Company Doctor, regardless of whether they are under their own doctor's care.

Employees injured on the job must submit a physician's statement, noting the length of disability and the expected work date to the Personnel Department prior to returning to work.

The injured employee should receive all follow-up treatment from the attending physician unless circumstances warrant treatment by another physician or nearest hospital.

Following a work related injury, your doctor may allow you to return to work with restrictions. As soon as possible, forward your Medical Status Report or Doctor's note to your supervisor in order to develop adjusted work duties. You are not allowed to resume working without a medical status report.

Employees who do not return to work on the day specified in the physician's statement may be scheduled for a follow-up visit with the attending physician and/or the Company Doctor to determine any change in the original recommendation for a return to work date.

All industrial accidents involving personal injury and illness other than basic first aid, will be subject to a formal follow-up investigation conducted by the employees' supervisor. The completed request will be forwarded to the Personnel Dept. within 3 working days. Discussion of the findings and action to be taken to correct the problem and eliminate a similar accident in the future will be handled by the Safety Committee.

5. SAFETY EMPHASIS AND TRAINING

It is the intent of PSI to ensure that safety is of utmost importance. To this end, no work shall be performed in the manufacturing, testing and facilities areas unless there are at least two (2) people physically present in the building.

Each supervisor is responsible to orientate new employees on safe practices, procedures and the hazards of chemicals, if any, in their work area. Further, each supervisor is responsible for the day-to-day safety of all personnel and equipment and for the continued enforcement of all safety policies and practices. All visitors are the responsibility of the PSI host.

Periodic training sessions on equipment operation, test procedures and safety are conducted by PSI supervisors and occasionally by outside consultants

Training will be implemented from time to time when results of shop inspections or other factors indicate a need for such training.

Additional training will be offered periodically to ensure that there are adequate personnel trained and certified to render First Aid and Emergency Treatment.

6. SAFETY EQUIPMENT

Employees working in manufacturing, painting and testing areas where their jobs require special safety apparatus such as face shields, gloves, ear protectors, respirators, face masks, etc. will be required to wear such items.

All major purchases of safety equipment will be made through the Operations Manager or his designee. Procurement of specialty safety items may be recommended by the Safety Committee. The Operations Manager will coordinate purchase requests to ensure that proper equipment is being purchased and that unnecessary duplication is avoided.

First aid kits and eyewash stations will be placed in strategic locations around the building. Employees are encouraged to use them as needed. Health Services and/or the Safety Committee is responsible for maintaining these kits and replenishing supplies. Please alert the Health Service or Safety Committee if supplies are needed in the kit in your department or area.

7. SAFETY GLASSES PROGRAM

PSI supports the policy of providing proper eye protection to all employees who by the nature of their job or working area require such protection. Individual supervisors have the responsibility of supporting and enforcing this policy for their employees.

Certain areas of the facility have been specified as safety glass areas, identified as such in writing or by posted signs. All production areas are designated as safety glass areas.

All employees will be provided with OSHA approved industrial type safety glasses. The cost of these glasses, including prescription glasses, but excluding eye examinations, will be borne by PSI. Thereafter, PSI will pay for the full cost of replacement glasses, provided that replacement is due to change of prescription, normal wear or industrial damage. In other cases, such as loss of glasses or non-industrial damage, the employee may be required to replace the glasses at his expense. The Company reserves the right to disapprove purchase of safety glasses if the policy appears to be abused.

Employees who do not normally work in safety glass areas, but who may periodically pass through these areas are also required to wear eye protection. However, temporary-type visitor glasses may be worn in such cases. This also applies to customers and other visitors. It is the duty of the hosting PSI employee to provide glasses for visitors. These may be obtained at all designated entrances to the shop production areas.

Lenses which become pitted or scratched lose their impact resistance and thus diminish their effectiveness as protection. In these instances, new safety glasses shall be obtained from the tool room. Prescription replacement lenses, however, can be obtained from the Company's designated optician.

An employee requiring prescription lenses will be issued a pair of prescription safety glasses through the designated optician. Regular prescription glasses do not provide adequate protection and should not be worn in lieu of safety glasses. Employees should obtain a form from health services which must be approved by their immediate supervisor. This form, together with the employee's prescription, will be forwarded to the designated optician. Employees will be required to pick up their own prescription glasses.

A representative from the Company's designated optician will visit PSI periodically to adjust safety glasses and advise employees in their use.

8. RESPIRATORS

In order to control potential occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, the Company's primary objective shall be to prevent atmospheric contamination, in as far as feasible. This is normally done by accepted engineering control measures including an enclosed paint spray booth, wall fans and air scrubbers or filters.

In cases where the use of these controls are not feasible, it is the Company's policy to require the use of respirators which are suitable for the protection of the health of the employee. In particular and with respect to potential airborne lead, PSI requires the mandatory use of respirators by all employees when painting or performing operations incident to painting.

PSI Health Services will supervise its respirator program and perform, as required by OSHA, qualitative or quantitative fit tests at the time of initial fitting and periodically thereafter.

At regular intervals, evaluations will be conducted by the Safety Committee to determine the continued effectiveness of the program and to assure that respirators are properly selected, used, cleaned and maintained.

Written standard operating procedures governing the selection, use, training, inspection and maintenance of respirators are on file in the tool room and with the Company Nurse.

9. SAFETY SHOE PROGRAM

PSI supports the policy of providing proper foot protection in order to protect its employees in the work place.

Employees in the maintenance, stockroom, shipping, production, and test areas or whose duties require them to work periodically in such areas, as well as all Field Service Engineers, are required to wear approved protective footwear. Newly-hired employees who are employed in the above areas should report to work with safety footwear.

Foot protectors are available in the Tool Room for visitors use.

Approved footwear normally follows the guidelines of being boot-like in nature to cover the ankles, having a reinforced steel toe, and having soles of a rubber base (neoprene or gum), not leather. The Personnel Department may advise employees of other guidelines to be followed in selecting safety footwear.

Safety footwear may be ordered through PSI. However, employees have the option of purchasing their own safety shoes from a store of their choice.

An employee who is required to wear safety footwear and wishes to purchase it on his own should obtain approval from his supervisor and submit the receipt to the Accounting Department for reimbursement. Reimbursement/payment by the Company will be made upon presentation of proper receipts and is limited to the cost of the shoes up to a maximum set by PSI. The Company reserves the right to disapprove purchase of safety shoes if the policy appears to be abused.

10. HOUSEKEEPING

Employees are expected to keep their work areas clean and neat and void of safety hazards. This includes, but is not limited to, disposing of trash in proper receptacles, electrical wires and cords pulled out of pathways, keeping desks and file drawers closed when not in use, keeping items away from electrical space heaters, turning off such equipment when not in use, cleaning up liquid spills in office areas and hallways, and returning tools and equipment to the proper storage area.

A shop-wide cleanup is encouraged to be done on a weekly basis. Both scheduled and unscheduled plant inspections are made by members of the Safety Committee from time to time to ensure a safe working environment.

11. DISCIPLINE

A disciplinary program has been established to ensure compliance with PSI's Safety Program. An employee who violates safety rules will be given a written warning. This form will be sent to the Personnel Manager for filing. A progressive series of disciplinary measures may be administered up to and including termination. EMPLOYEES SHOULD BE AWARE THAT IN CERTAIN CIRCUMSTANCES, SUCH AS A SERIOUS INFRACTION OF A SAFETY RULE, WARNINGS MAY NOT FOLLOW A PROGRESSIVE SYSTEM AND MAY RESULT IN SUSPENSION OR DISCHARGE.

Individual supervisors are the primary individuals responsible for the enforcement of proper discipline and compliance with all safety policies and regulations, however, group leaders, managers and the safety committee are also responsible for enforcement of safety policies and procedures.

12. FIRE LANES AND COMMON AISLEWAYS

Employees should park only in prescribed parking lines in the parking lot. All other areas are designed as fire and emergency access lanes.

Employees should keep all common aisleways accessible and free from clutter and storage of material. Designated aisleways will be properly marked.

13. FIRE EXTINGUISHERS

Fire extinguishers have been strategically placed throughout the plant and each location marked and identified. It is imperative that all fire extinguishers be accessible at all times. If a fire extinguisher is being blocked, it should be reported to any supervisor or safety committee member.

All fire extinguishers throughout the plant are routinely inspected on a monthly basis and serviced when necessary by PSI's maintenance personnel. The accessablity, proper functioning of these extinguishers and keeping of necessary records is the responsibility of the Maintenance Department.

14. STORAGE OF FLAMMABLES

In accordance with OSHA regulations, all flammable and combustible chemicals are stored by PSI in a separate outside shed or approved storage cabinets.

Certain small quantities of flammables and combustibles may be kept in work areas when actually being used provided proper safety containers are used and properly labeled.

15. STORAGE OF GAS BOTTLES

All gas cylinders are stored in a covered designated area which is well protected, well ventilated, dry and located no less than 20 feet from highly combustible materials, sparks, open flames and excessive heat.

Cylinders connected for use must be lashed or chained to prevent them from toppling over. When cylinders are not connected for use, valve protection caps must be in place.

Partially used tanks are to be properly marked.

Inside storage of oxygen cylinders must be separated from stored fuel gas cylinders or combustible material by at least 20 feet or by a noncombustible barrier, said barrier to be at least 5 feet high and have a fire resistance rating of one-half hour.

Employees using gas bottles will be expected to return them to the designated storage area, properly marked, with a cap and chain properly secured to said bottles.

16. HAZARDOUS MATERIAL

In cases where employees may be potentially exposed to chemicals such as liquid, vapors, dust, etc., which may be hazardous to their health, it is their supervisor's responsibility to ensure that they are provided with adequate and proper protective equipment and that they are notified of such potential exposure.

The company supports current regulations pertaining to hazardous and toxic chemicals and has implemented a compliance program to ensure all requirements are met.

PSI is considered to be a very small generator of hazardous waste and maintains an EPA identification number of MAD004378782.

A hazardous waste technician is responsible to ensure that collections, temporary storage and shipment of this material is in strict compliance with all regulations.

Specific programs are in place which comply fully with Massachusetts Regulation 310CM30, OSHA 29 CFR 1910, resourse conservation recovery act and the federal landfill ban of Nov. 7, 1986.

17. FORKLIFTS

The operation of forklifts is restricted to those employees who have passed the forklift operator training course and who have been found qualified by a certified training instructor to operate forklifts. Any unauthorized employee operating a forklift will be subject to disciplinary action.Forklift operators must obey all OSHA rules and standards as specified in the Code of Federal Regulations (Section 1910.178).

New employees will be instructed in the proper use of forklifts and tested periodically by certified training instructors.

18. CRANES AND LIFTING DEVICES

All cranes and associated lifting equipment (slings, chains, etc.) shall be inspected every 6 months by a qualified inspector. A log shall be maintained and all equipment have a tag attached showing date inspected and date due.

19. X-RAY

All x-rays at PSI are performed by properly experienced and certified personnel. Currently all x-rays are performed by independent contractors at our facility.

It is the policy of PSI to have all x-rays performed after normal working hours and after such work areas have been roped off. Signs are placed at the entrance to all affected areas.

20. GENERAL WELDING SAFETY

Essentially welding is not a hazardous occupation if proper precautionary measures are always observed. This requires continuous awareness of possibilities of danger and habitual safety precaution by the welder. In addition, it requires that the supervisor be alert, responsible and tough in enforcing safety regulations. The following safety precautions should always be practiced when welding and cutting:

Make sure your welding equipment is installed properly and grounded and is in good condition.

Always wear protective clothing suitable for the welding to be done.

Always wear proper eye protection, when welding, grinding or cutting.

Keep your work area clean and free of hazards. Make sure that no flammable, volatile or explosive materials are in or near the work area.

Handle all compressed gas cylinders with extreme care. Keep caps on when not in use.

Make sure that compressed gas cylinders are secured to the wall or to other structural supports, or the machine.

When compressed gas cylinders are empty, close the valve and mark the cylinder "EMPTY" and return empty to appropriate area.

Do not weld in a confined space without extra special precautions.

Do not weld on containers that have held combustibles without taking extra special precautions.

Do not weld on sealed containers or compartments without providing vents and taking special precautions.

Use mechanical exhaust at the point of welding when appropriate, e.g., flux core, aluminum, brazing, etc.

When it is necessary to weld in a damp or wet area, wear rubber boots and stand on a dry insulated platform.

When the electrode holder is not in use, hang it on brackets provided. Never let it touch a compressed gas cylinder.

Dispose of electrode stubs in proper container since stubs on the floor are a safety hazard.

Shield others from the light rays produced by your welding arc.

Do not weld near degreasing operations.

When working above ground make sure that scaffold, ladder or work surface is solid, with appropriate safety equipment in place.

When welding in high places without railings, use safety belt or lifeline.

When using water-cooled equipment, check for water leakage.

Before disconnecting the welding machine, make sure the main power disconnect on wall is turned off.

21. EMERGENCY PROCEDURES

A separate written contingency plan is on file in the Personnel Department and copies have been forwarded to all group managers. This plan will be utilized to minimize health hazards to employees or visitors from imminent or potential danger associated with a fire, bomb threat, chemical spill or other hazard. This will include a procedure to evacuate the facility or affected area and notification to local police, fire department, D.E.Q.E. and other regulatory authorities.

Emergency exit routes are posted on all bulletin boards.

Emergency phones for outgoing calls are maintained on each floor. Refer to telephone list.

In the event of a power failure, a Safety Committee Representative or the Maintenance Department will be responsible to assess the damage and report the same to the President or person in charge at the time who will decide the course of action to be implemented.

22. EMERGENCY COORDINATOR

The duties of the emergency coordinator or his designee will include the following:

Evaluate the nature of the emergency and notify management.

Coordinate emergency response, both in-house and with outside assistance.

Ensure evacuation procedures are carried out and that all personnel are accounted for.

ATTACHMENT 5
PROJECT MANAGEMENT PLAN
OUTSIDE CONSULTANTS

1. **Steve Dangel**
   Dangel Robots and Machinery
   Area: Machine Design/Robots

2. **Barry Newark**
   Consultant
   Area: Welding and Metallurgical Engineering

3. **Prof. Dennis Manos**
   College of William and Mary
   Area: Material Scientist and UHV Design

4. **Dr. Norman Peacock**
   Consultant
   Area: Viton O-Ring Design and UHV Design

5. **Metrowest Engineering Inc.**
   Civil Engineering/Surveying
   Area: Laser Alignment/Surveying